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Longevity of posterior restorations

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SUMMARY

The efficacy of restorative dentistry is dependent on a number of factors, including material quality, operator proficiency and the oral hygiene of the patient. The sum effect of all factors can be measured by recording the longevity of the restorations. Many studies focus on the age of restorations at the time of failure, others include the longevity of restorations which remain *in situ*. The surveys may be either longitudinal, prospective or retrospective, or cross-sectional retrospective studies of dental records. They are all hampered by the lack of uniform criteria defining when to place and replace restorations and by variations in decision-making between clinicians. The present review paper shows that the longevity of amalgam restorations has been studied most frequently. About 50 per cent of all amalgam restorations exceed 8–10 years in age, cast gold restorations may last longer and multisurfaced composite restorations have a shorter life-span. Glass ionomer cements lack the physical properties needed for large posterior restorations. The results of detailed longevity studies should be the basis for selection of materials and techniques in operative/conservative treatment. The cost of dental treatment should be related to the expected lifetime of the tooth rather than to the immediate cost of a simple restoration.

The treatment of caries has traditionally involved the removal of diseased tissues and the replacement of these by restorative materials. Despite the promising results from controlled oral hygiene procedures[1], and the potential to arrest carious lesions by non-operative treatment[2], placement, replacement, and re-replacement of restorations still constitute the major workload in general practice. However, the efficacy of restorative dentistry has not been seriously examined until the last decade. In this examination, Elderton[3] has indicated the need for a reconsideration of the use of resources towards more active preventive, rather than operative, care. Interest has focused on analyses of reasons for replacements and the longevity of restorations. These analyses have in some instances culminated in statements inferring the initiation of a vicious circle created by the insertion of the first restoration in a tooth, referred to as 'the countdown' by Lutz *et al.*[4].

The cost/effectiveness of restorative dentistry is dependent on a number of factors, including material quality, operator proficiency and the oral hygiene of the patient. The sum of all factors can be measured by recording the longevity of the restorations. Subdivisions based on single variables, e.g. the type of restorative material or the oral hygiene of the patient, may provide more detailed information. Despite the importance of the longevity of restorations as a parameter for success in restorative dentistry, few, and sometimes no, data are available to demonstrate the efficacy of different types of treatments.

The longevity of restorations may be registered in longitudinal, prospective or retrospective studies, or it may be assessed in cross-sectional, retrospective studies of dental records, provided such are available to show the complete treatment performed over many years. The lack of uniform criteria for decisions to place and replace restorations, coupled with the variations in decision making between different clinicians, complicate the studies[5]. Although controlled, longitudinal, prospective studies would be best when studying the longevity of restorations, it is unrealistic to expect such investigations to exceed 10 years. These studies are also hampered by other problems, e.g. limited numbers of restorations, selection of patients, loss of patients and few, often specially trained, dentists being involved[6]. Knowing that many restorations last for more than 10 years, the approach

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of choice may often be cross-sectional, retrospective studies based on records in dental practice. In this way, information can be collected for numerous restorations inserted by many different dentists on a broad spectrum of patients. However, it must be realized that many variables often cannot be controlled in such studies, e.g. the brand of material used, the clinical conditions at the time of treatment and the quality of the original restoration.

By far the most frequently used posterior restorative material is amalgam. During the last 10–15 years, resin-based materials have been increasingly used in posterior teeth, but they are still rather infrequent. Cast gold restorations for inlays, crowns and bridges are also fairly common, but minimal information on their longevity is available. Special restorations such as ceramic or plastic inlays are infrequently used, but no data are available on their longevity. The present review will, therefore, focus on amalgam and resin-based posterior restorations. Some preliminary data on the longevity of restorations placed in general practice will be referred to. These data were taken from the dental records of individuals who had attended the same practice for at least the last 10 years, and preferably much longer.

Longevity of failed restorations

Publications on the longevity of restorations have focused on the ages of restorations that need replacement due to failure[7–11]. This information alone is not suitable for cost/benefit analyses, because it does not take into account the ages of the restorations that remain *in situ*. However, studies of failed restorations do show differences depending on the materials used, the type of restoration, the age of the patient, the teeth treated and the reason for failure (*Figure 1*). Thus, failed amalgam restorations in general are older than failed composite restorations. At every yearly interval up to five, more amalgam than resin-based restorations were functional[12], even though most of the amalgam restorations were multisurfaced and stress-bearing, while most of the resin restorations were single surfaced. Thus for Class II restorations about 75 per cent of the amalgam restorations and about 55 per cent of those made of resin-based materials remained functional after 5 years. Similar trends were seen in a recent Danish report[13].

The median lifespan of restorations requiring replacement varies somewhat depending on the reason for their replacement (*Figures 1* and *2*). Within 10 years between 51 and 75 per cent of all amalgam restorations were replaced in Swedish adults in 1978[7]. In Danish adults the corresponding range was between 42 and 64 per cent in 1988[13]. The median longevity of all failed restorations was similar in the two studies. However, differences in longevity were dependent on the reason for replacement (*Figures 1* and *2*). While 21 per cent of the fractures occurred within 4 years in the

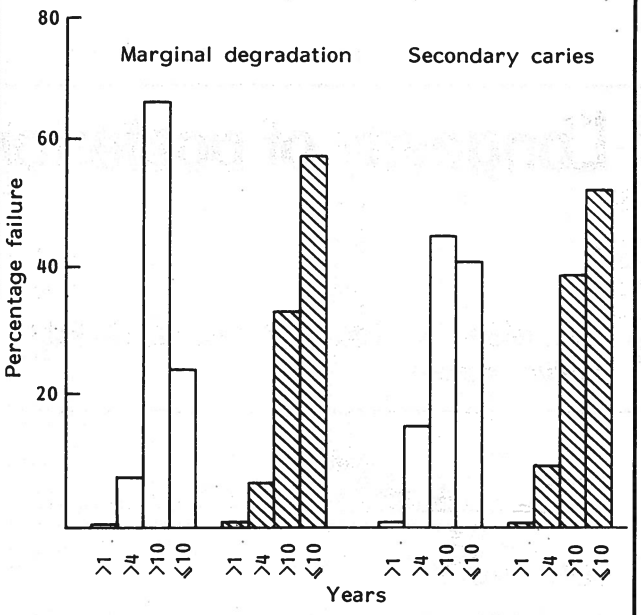

Figure 1 The age of amalgam restorations which failed due to marginal degradation and secondary caries in an adult Swedish population (open columns) recorded in 1978[7] and in an adult Danish population (hatched columns) recorded in 1988[13].

Age de restaurations à l'amalgame qu'il a fallu remplacer pour cause de dégradation marginale et de caries secondaires dans une population de Suédois adultes (colonnes ouvertes) enregistré en 1978[7] et dans une population de Danois adultes (colonnes hachurées) enregistré en 1988[13].

Das Alter von Amalgamfüllungen, die durch Randabtragung und Sekundärkaries bei einer schwedischen Erwachsenenpopulation (weiße Säulen) 1978 ermittelt wurden[7], sowie bei einer dänischen Erwachsenenpopulation (schraffierte Säulen), ermittelt 1988[13].

Edad de las restauraciones de amalgama que fracasaron debido a degradación marginal y caries secundaria, en una población adulta Sueca (columnas abiertas) registradas en 1978[7] y en una población Danesa adulta (columnas rayadas) registradas en 1988[13].

Danish study, only 10 per cent of the fractures in the Swedish survey had occurred at that time. The difference in bulk fracture cannot be attributed to differences in cavity preparation designs[14]. An unexpected finding was that bulk fracture of restorations was not a characteristic primarily seen during the first year of service. These findings support the notion that inappropriate cavity preparation was not the primary reason for the fracture of restorations in permanent teeth. More likely, there were material defects such as progressive corrosion of the amalgam or inadequate strength of the base material employed.

It was encouraging to note that the longevity of restorations replaced due to marginal degradation had increased in the two studies conducted 10 years apart (see *Figure 1*). The difference may reflect the use of non-gamma-two amalgams in the more recent study. A similar decrease in the early development of

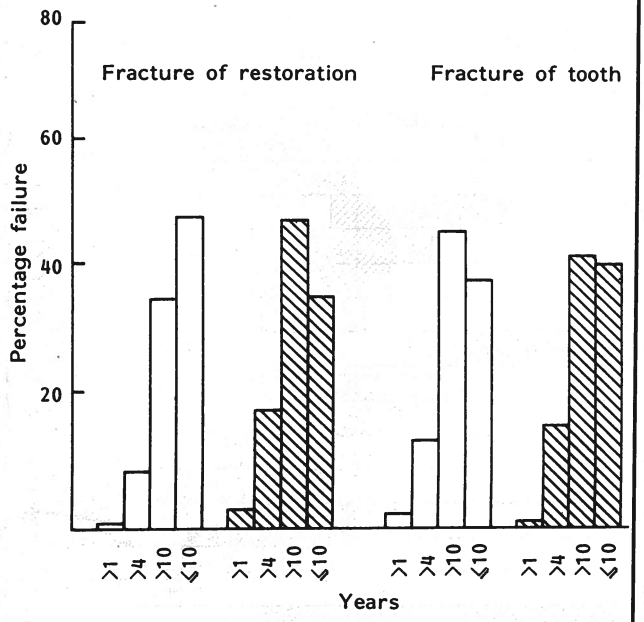

Figure 2 The age of amalgam restorations that failed due to bulk fracture of the restorations and fracture of the teeth in an adult Swedish population (open columns) recorded in 1978[7] and in an adult Danish population (hatched columns) recorded in 1988[13].

Âge de restaurations à l'amalgame qu'il a fallu remplacer en raison de fractures du corps des restaurations et de fractures des dents dans une population de Suédois adultes (colonnes ouvertes) enregistré en 1978[7] et dans une population de Danois adultes (colonnes hachurées) enregistré en 1988[13].

Das Alter von Amalgamfüllungen, die infolge Fraktur im Füllungskörper bzw. Zahnfraktur bei einer schwedischen Erwachsenenpopulation (weiße Säulen) ausfielen, ermittelt 1978[7], sowie bei einer dänischen Erwachsenenpopulation (schraffierte Säulen), aufgezeichnet 1988[13].

Edad de las restauraciones de amalgama que fallaron debido a fractura por expansión de las restauraciones y fractura de los dientes en une población adulta de Suecia (columna abiertas) registradas en 1978[7] y en una población adulta Danesa (columnas rayadas) registradas en 1988[13].

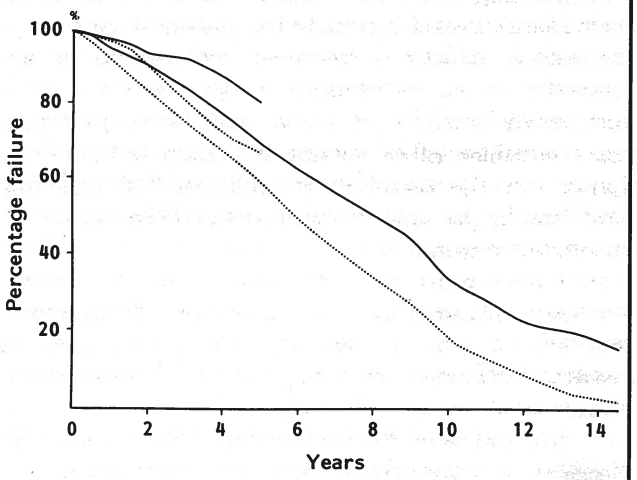

Figure 3 Cumulative failures of amalgam (solid lines) and composite (dotted lines) restorations. The majority of the amalgam restorations were class II restorations, while the composites were mainly class III and class V. The 5-year data are from the USA[12], and the long-term data are from Denmark[13].

Motifs cumulés d'échec de restaurations à l'amalgame (lignes pleines) et en composites (lignes pointillées). La majorité des restaurations à l'amalgame était du type II alors que les composites étaient surtout classe III et classe V. Les données sur 5 ans viennent des Etats Unis[12] et les données à long terme viennent du Danemark[13].

Zusammenfassung der Mißerfolge bei Amalgam- (durchgehende Linien) und Kompositfüllungen (punktierte Linien). Bei der Mehrheit der Amalgamfüllungen handelte es sich um Klasse-II-Restaurationen, während die Komposits hauptsächlich Klasse-III- und Klasse-V-Füllungen waren. Die Fünfjahresbefunde stammen aus den USA[12] und die langfristigen Befunde aus Dänemark[13].

Fallos acumulativos de las restauraciones de amalgama (líneas continuas) y composite (líneas discontinuas). La mayoría de las restauraciones de amalgama eran de clase II, mientras los composites eran mayoritariamente clases III y V. Los datos de 5 años son de USA[12] y los datos de largo plazo son de Dinamarca[13].

secondary caries was noted, possibly reflecting the general decline in caries progression.

All in all, from the large number of cross-sectional, retrospective surveys on the ages of failed amalgam restorations, the median age varied from less than 5 years to more than 11 years and with 7–8 years being commonly recorded. These restorations were mainly class I and class II cavities. The data on composite restorations indicate that those that fail have a median age of about 5–6 years. These were mainly class III and class V restorations.

Restorations in deciduous teeth have a much shorter functional period, which is dependent to a large extent on the age of the patient at the time of treatment[15,16]. The median age of failed amalgam restorations in deciduous teeth has been reported to be about 2 years[8] and that of composite restorations less than 1 year[9]. However, the replacement rate is generally much lower in the primary than in the permanent dentition.

Ages of restorations remaining *in situ*

Information on the longevity of restorations should be decisive in the selection of materials, operative techniques and patient instructions related to prognosis and long-term cost. Remuneration systems, whether through private insurance companies or government agencies, must also regard information on longevity as essential for their budgeting.

Longitudinal, prospective studies and retrospective analyses of dental records are the only feasible tools to use in registering the ages of restorations *in situ*, i.e. restorations not requiring replacement. A wealth of

data are present in dental offices around the world, but their collection and especially the statistical analyses of the data is difficult[17]. However, information on the longevity of all restorations is decisive for a valid cost/benefit analysis of dental restorative treatment and as a parameter for success and failure of operative/conservative dental treatment. Despite the relatively short median life-span of failed restorations, individual amalgam restorations requiring replacement have been *in situ* 38 years[8] and 46 years[13]. The two oldest amalgam restorations not requiring replacement, reported to one of the authors (I.A.M.) by an American colleague, were 92 years old, both in sisters who died at the ages of 102 and 103.

A longitudinal, retrospective study of the longevity of single and multisurface amalgam restorations and mainly single surface composites, indicated that about two-thirds of all restorations would survive at least 22 years, and more single surface restorations remained functional than multisurface restorations[18]. Crabb[19], on the other hand, indicated that only 37 per cent of class II and MOD amalgams survived more than 10 years.

Longevity of amalgam restorations

Amalgam is used almost exclusively for class I and class II restorations, including large build-ups. It is also used in class V and class III cavities, if aesthetics are not important. In general, amalgam is considered to be a technique-insensitive material. However, in extreme situations single factors like material quality play a significant role in the longevity of restorations.

A comparison of two conventional amalgams, one with high and one with low creep values, showed that after only 3 years more than 30 per cent of the class II restorations with high creep were replaced as compared with 3 per cent of those with low creep[20]. In long-term, longitudinal studies using selected patients (dental students and University staff), the survival of class I and class II restorations was up to 96 per cent after 5 years and 84 per cent after 7 years[11]. In a study in which a limited number of restorations prepared from three different amalgams were reviewed with regard to marginal and bulk fracture after 8 years, about 50–90 per cent survived depending upon the material used[21]. In a longitudinal study of class II amalgam restorations in progress at NIOM – Scandinavian Institute of Dental Materials, 14 per cent of the restorations have failed after 8–9 years. A retrospective study with up to 17 years observation time indicated 90 per cent survival after 7 years and 78 per cent after 17 years[22]. Preliminary data from a cross-sectional, retrospective survey indicate that the median age of functioning class II amalgam restorations in adults was 10–12 years, while class I restorations were about 15 years.

A summary of the survival times in clinical, longitudinal studies reported by various authors after 5 and 10 years is presented in *Figure 4*[3,15,18,23–33]

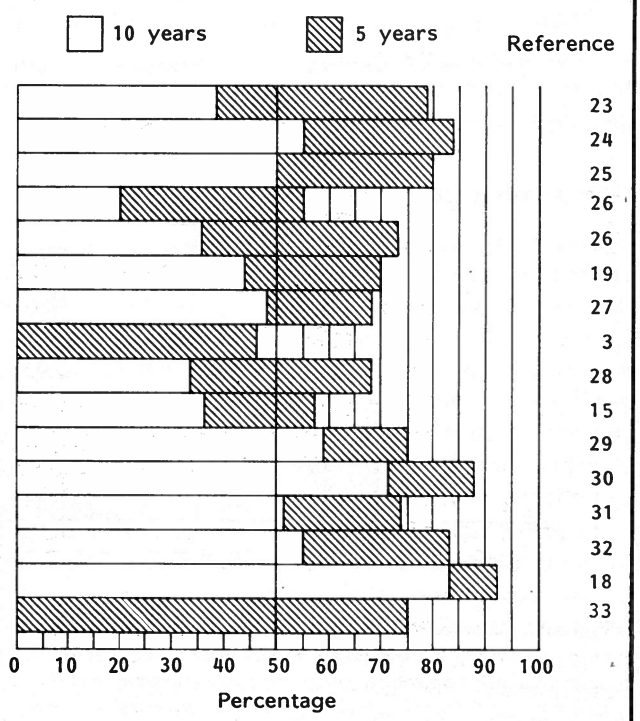

Figure 4 Survival of amalgam restorations in longitudinal studies after 5 and 10 years.

Etudes longitudinales de longévité de restaurations à l'amalgame après 5 et 10 ans.

Haltbarkeit von Amalgamfüllungen bei Longitudinalstudien nach 5 und 10 Jahren.

Supervivencia de las restauraciones de amalgama en estudios lonjitudinales después de 5 y 10 años.

Cast restorations

Limited data on the longevity of gold inlays are available. On occasions they are reported in combination with the longevity of crowns and bridges. It should also be kept in mind that sometimes only patients with optimal oral hygiene are selected for treatment with cast restorations using gold alloys.

Discouraging results for gold inlays were reported by Crabb[19], who indicated that only 42 per cent survived 10 years, which was slightly less than that of amalgam restorations. East German studies have also shown that the time of function of cast restorations, including those made of base metal alloys, is less than for amalgam[34,35]. However, Bentley and Drake[30] found cast restorations to last significantly longer than amalgam and composite restorations and found that over 90 per cent survived for 10 years. Our preliminary data indicate a median age of 13 years for functioning MOD gold inlays.

Glantz[36] has reported on the survival of fixed prostheses after 7 years and found that about 19 per cent were technical failures (loss of retention, fractures of the appliance or of the teeth). In addition,

a number of complications, i.e. secondary caries, endodontic and periodontal problems and aesthetic considerations, were reported after 7 years. The failure of bridges with cantilever pontics was much greater than that of bridges with no single pontics[36].

Composite restorations

Posterior composite restorations have come into limited use during the last decade. However, their use seems to be more limited to the clinicians involved than to specific dental indications, i.e. some clincians select composite materials rather than amalgam as the routine material in molars and premolars. In general, few data are available on the longevity of posterior composite restorations from general practice.

Improvements in the quality of composites for use in the posterior region have led to the development of an 'Acceptance Program' for these composites by the American Dental Association. A similar programme has been developed by the NIOM – Scandinavian Institute of Dental Materials. The ADA programme requires a minimum of 90 per cent remaining acceptable for colour matching ability and interfacial staining after 5 years and that the degradation/wear should not exceed 250 µm with 90 per cent showing no observable loss of interproximal contours. A few brands of material fulfil these requirements today, which in itself is an indication of their usefulness and longevity. However, these studies have been done under optimal conditions.

Moffa[12] reported that 80 per cent of class I composite restorations survive 5 years, while just over half of the class II composite restorations were functional after the same period. Reports of 10-year data for composite restorations have underlined the difference between single surface restorations and those having more than one surface. For multiple surface composite restorations, about 40 per cent survived 10 years, compared with about 60 per cent of single surface restorations[30]. Our preliminary data indicate a median age of 4 years for functioning MOD composite restorations in Scandinavia. However, since these types of restorations have been in use for a relatively short period of time, the longevity data may not yet be valid.

Glass ionomer cements

Glass ionomer cements are not considered to have the mechanical properties required for general posterior use[37]. Preliminary studies at NIOM of small class II restorations in permanent teeth have shown that the frequency of failure after an observation period of about 2 years is higher than for composite and amalgam, but still only at a 6 per cent level compared with 2–3 per cent for amalgam and composite restorations. In deciduous teeth, these cements have been used more successfully for class II restorations[38,39].

Conclusion

Any increase in the longevity of restorations means more durable and improved restorative care. Thus studies on the longevity of restorations are important for the individual clinician, dental insurance companies, public dental health programmes and patients. However, criteria defining when restorative work is needed, should first of all be agreed upon, with due respect for the potentials of preventive dentistry and the remineralization of carious lesions. Once in place, criteria for failed, acceptable, and ideal restorations must then be defined, e.g. as in the USPHS system[40]. The progress of less than ideal, but acceptable, restorations must be determined. Attention must be focused on the calibration of clinicians at all levels, i.e. clinical dental school faculty, groups of clinicians as well as undergraduates and those in continuing educational programmes.

The clinical diagnosis 'secondary caries' must be subjected to detailed analysis, e.g. to differentiate between secondary caries and crevices, to study the progress of the lesion and to assess the impact of preventive programmes on early secondary caries.

Detailed longevity studies should provide the basis for the selection of materials and techniques in operative/conservative treatment. The cost of dental treatment should be considered for the expected lifetime of the tooth, i.e. for a period of 50–70 years rather than for the immediate cost of a single restoration.

F

DURÉE D'EXISTENCE DES RESTAURATIONS POSTÉRIEURES

RÉSUMÉ

L'efficacité de la dentisterie restauratrice est fonction d'un certain nombre de facteurs incluant la qualité du matériau, l'habileté de l'opérateur et l'hygiène dentaire du patient. L'effet global de tous ces facteurs peut se mesurer à la durée d'existence des restaurations. Beaucoup d'études se focalisent sur l'âge de la restauration lorsqu'elle cède, d'autres intègrent la longévité des restaurations restées *in situ*. Les analyses peuvent être longitudinales, prospectives ou rétrospectives ou consister en études

rétrospectives transversales de dossiers dentaires. Elles sont gênées par le manque d'uniformité des critères définissant le moment de poser ou de retirer une restauration et par les variations dans la prise de décision existant entre cliniciens. Cet article montre que c'est la longévité des restaurations à l'amalgame qui a été le plus souvent étudiée. Environ 50% de la totalité des restaurations à l'amalgame dépassent de 8 à 10 ans d'âge, les restaurations à l'or coulé peuvent durer plus longtemps et les restaurations en composites multifaces ont une moindre durée de vie. Les ciments à l'ionomère de verre n'ont pas les propriétés physiques que réclament les restaurations postérieures importantes. Les résultats des études détaillées de longévité devraient servir de base à la sélection des matériaux et techniques pour les traitements opératoires/conservateurs. Le coût d'un traitement dentaire devrait être évalué en fonction de la durée de vie escomptée de la dent plutôt que du coût immédiat de la simple restauration.

D

HALTBARKEIT VON FÜLLUNGEN IM SEITENZAHNBEREICH

ZUSAMMENFASSUNG

Die Effizienz der restaurativen Zahnheilkunde hängt von einer Reihe Faktoren ab, zu denen die Materialqualität, die Tüchtigkeit des Behandlers und die Mundhygiene des Patienten gehören. Der Gesamteffekt aller Faktoren kann durch eine Aufzeichnung der Dauerhaftigkeit von Restaurationen ermittelt werden. Viele Studien gehen beim Alter der Restaurationen von der Zeit ihrer Funktionsfähigkeit aus, andere bestimmen die Haltbarkeit von Restaurationen nach ihrem Verbleib *in situ*. Die Untersuchungen können entweder longitudinal, prospektiv oder retrospektiv bzw. als retrospektive Querschnittsstudien von zahnärztlichen Befundaufzeichnungen ausgeführt werden. Bei allen mangelt es an einheitlichen Definitionskriterien, wann Restaurationen zu legen und zu ersetzen sind, auch wirken sich negativ die variierenden Entscheidungen der Untersucher aus. Die vorliegende Übersicht zeigt, daß die Dauerhaftigkeit von Amalgamfüllungen sehr häufig untersucht wurde. Etwa 50 Prozent aller Amalgamfüllungen liegen länger als 8–10 Jahre, Goldgußfüllungen können noch länger halten, dagegen haben mehrflächige Kompositfüllungen eine kürzere Lebensdauer. Glasionomerzementen fehlen die physikalischen Eigenschaften, die für umfangreiche Seitenzahnfüllungen erforderlich sind. Die Ergebnisse detaillierter Haltbarkeitsstudien sollten die Grundlage für die Auswahl von Materialien und Methoden der restaurativen Behandlung bilden. Die Kosten der zahnärztlichen Behandlung sollten eher zu der erwarteten Lebensdauer des Zahnes als zu den direkten Kosten einer einfachen Füllung in Relation gesetzt werden.

E

LONGEVIDAD DE LAS RESTAURACIONES POSTERIORES

RESUMEN

La eficacia de la odontología restauradora depende de varios factores, incluyendo calidad del material, habilidad del operador y la higiene oral del paciente. La suma de los efectos de todos los factores puede ser medida registrando la longevidad de las restauraciones. Muchos estudios se centran en la edad de las restauraciones en el momento del fallo, otras incluyen la longevidad de las que permanecen *in situ*. Los estudios de los registros dentales pueden ser lonjitudinales, prospectivos o retrospectivos, o retrospectivos seccionales-cruzados. Todos están amparados por la falta de criterio uniforme que defina cuando colocar y reemplazar las restauraciones, y por las variaciones entre los clínicos para tomar la decisión. El presente artículo de revisión, muestra que la longevidad de las restauraciones de amalgama es la que ha sido estudiada con mayor frecuencia. Aproximadamente el 50 por ciento de todas las restauraciones de amalgama exceden los 8–10 años de edad, las restauraciones de oro colado pueden durar más tiempo y las restauraciones de composite con multisuperficies tienen un periodo de vida más corto. Los cementos ionómeros de vidrio carecen de las propiedades físicas necesarias para las grandes reconstrucciones posteriores. Los resultados de los estudios de longevidad detallada deberían ser la base para la selección de materiales y técnicas en el tratamiento operativo/conservador. El coste del tratamiento dental debería estar relacionado a la expectativa de vida del diente, más que al coste inmediato de una restauración simple.

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Motivating your patients: marketing dental services

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SUMMARY

In most industrialized countries the issues of unemployment or under-employment are becoming more critical for the members of the dental associations. In some countries this is creating greater competition between the private practitioners and public health dentists as well as between private dental practitioners themselves. Modern marketing, especially service marketing theory and models, can provide dentists and dental associations with tools to improve their position in relation to patients, political decision makers and other public agencies. However, marketing has to be understood correctly as a philosophy providing a means of approaching the establishing, maintaining and enhancing patient or customer relationships and not as a narrowly defined set of tools. As long as marketing is considered to be external campaigns, such as advertising and not much else, it is bound to fail. Other dimensions of marketing, such as interactive marketing and internal marketing, are of much greater importance to dental practitioners.

The main goal of this article is to describe the principles of modern marketing, acceptable to the dental profession and their associations, as well as to provide guidelines for implementation.

The principles, therefore, address the special nature of dental services, the ethical obligations and the attitudes of society in general, as well as the limitations of different legal systems in a variety of countries. Beyond this, the principles have to take into account the standards of living expected in relation to the education and skills of dentists and auxiliary personnel. The dental profession in industrialized countries is facing reductions in oral diseases and an apparent oversupply of dental personnel, both of which suggest that there is a need to find and accept new approaches to dental services.

Marketing, and especially modern service marketing, is both a philosophy and a tool capable of helping to improve the oral health of the population as well as to enhance the survival and attractiveness of the dental profession.

The nature of marketing

In general terms, marketing can be described as the task of establishing, maintaining and enhancing customer relationships, at a profit, in order that the goals of the customer, the firm or organization, and society are achieved[1,2]. For example, the goal of a customer (the patient) may be attractive teeth, limited pain in receiving necessary dental treatment; the goals of the firm (practice) may be to provide professional service and to earn a reasonable income; while the goal of society may be to achieve reasonable oral health status for the population. All of these can be achieved simultaneously.

Marketing as a philosophy and as a set of activities can be used on different levels and in different ways depending on the goals of the dental association and/or the dentist. The total marketing function can be divided into three sub-areas: external marketing, interactive marketing and internal marketing[3].

Typical external marketing methods are the various types of advertising, each of which may have unique

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