

Five-year study of Class II restorations in permanent teeth using amalgam, glass polyalkenoate (ionomer) cermet and resin-based composite materials

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ABSTRACT

The aim of this study was to compare the clinical performance of an amalgam, a glass polyalkenoate (ionomer) cermet material and a resin-based composite material used in small Class II cavities in permanent teeth. All restorations were inserted under rubber dam. They were examined yearly for 3 years. One clinician continued the study up to 5 years. The clinical examination focused on two criteria: clinically acceptable and failure. In addition, impressions were taken of the prepared cavities immediately before restoration and at each clinical examination using an elastomeric material. The study comprised 274 Class II restorations (88 amalgams, 95 cermets and 91 resin composites) placed in 142 adolescent patients. One hundred and sixty-seven restorations were in molar and 107 in premolar teeth. Patient dropout after 5 years resulted in the loss of 161 restorations, evenly distributed for restorative material and type of tooth involved. Four amalgam restorations, 22 glass ionomer cermet and nine resin composite restorations failed. The glass ionomer cermet and amalgam restorations failed primarily due to bulk fractures, while the resin composite restorations failed due to secondary caries and bulk fractures.

KEY WORDS: Operative dentistry, Conservative dentistry, Cavity preparation, Restorations, Longevity, Failure rates

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INTRODUCTION

Amalgam is the most commonly used general-purpose restorative material for all types of restorations in posterior teeth, ranging from small fillings to large pin-retained restorations involving cusp replacements. Resin-based composite materials, the most frequently used tooth-coloured restorative materials, are suitable for small Class II restorations, especially in premolar teeth, provided the patient has good oral hygiene and minimal wear of their natural dentition (Hendriks, 1985). Glass polyalkenoate (ionomer) cements were initially marketed and clinically tested as tooth-coloured materials particularly suited for Class V restorations involving little or no tooth preparation (Wilson and McLean, 1988). They have

been used in Class II situations in primary molar teeth with mixed success (Fuks *et al.*, 1984; Engelsman *et al.*, 1988; Walls *et al.*, 1988; Hickel and Voss, 1990; Forsten and Karjalainen, 1990; Östlund *et al.*, 1992). Clinical studies of glass ionomer restorations in permanent teeth indicate a 50% failure rate of Class II restorations after 2 years (Hickel *et al.*, 1988), and as Class I restorations performing less favourably than restorations of amalgam and resin composite (Smales *et al.*, 1990).

Cross-sectional studies have established that secondary caries is the main reason for the failure of amalgam and resin composite restorations in permanent teeth, including Class II restorations (Qvist *et al.*, 1990a, b). Secondary caries is rarely a reason for failure of glass ionomer

Table I. Distribution of Class II restorations among the three clinicians (A, B and C) according to the restorative material used

Clinician	Dispersalloy		Ketac Silver		P-10		Sum
	n	%	n	%	n	%	
A	23	42	12	22	20	36	55
B	25	32	28	34	26	33	79
C	40	29	55	39	45	32	140
Sum	88	32	95	35	91	33	274

Table II. Distribution of Class II restorations among the three clinicians (A, B and C) and the number of dropouts after 1 year, and the number of dropouts and failures after 3 years and 5 years (Clinician C)

Clinician	Start	1yr		3yr		Failed		5yr		Failed	
		n	%	n	%	n	%	n	%	n	%
A	55	10	18	41	75	4	7	51	93		
B	79	4	5	39	49	8	11	71	89		
C	140	8	6	22	16	23	16	39	28	26	19
Total	274	22	8	102	37	35	13	161	59		

restorations, because glass ionomers release fluorides (Wilson and McLean, 1988; Forsten, 1990). The second most frequent reason for the replacement of Class II restorations in permanent teeth is bulk fracture (Qvist *et al.*, 1990a, b).

Increased restoration longevity can be obtained by using materials that reduce or prevent secondary caries, and have sufficient physical properties to resist bulk fracture. Metal-reinforced glass ionomer cements—cermets—may exhibit such properties.

The aim of the present study was to evaluate the feasibility and efficacy of a cermet glass ionomer cement as a restorative material in small conventionally prepared Class II preparations in permanent teeth by comparing it to similar restorations of amalgam and resin composite.

MATERIALS AND METHODS

The project was approved by the School Dental Service Authority in Oslo, Norway, and three clinicians volunteered to participate. The aim was to complete approximately 100 Class II restorations using each of the following materials: Dispersalloy (Johnson & Johnson Ltd, New Brunswick, NJ, USA, batch nos 112684A/4L864 and 082481C/1H838), Ketac Silver (ESPE, Seefeld/Oberbay, Germany, batch no. M217/M225) and P-10 (3M Dental Products, St Paul, MN, USA, batch nos 70-2005-0435-5/9302(032985)). The study was planned to last for a minimum of 3 years, but if possible to extend to 5 years. However, it was anticipated that the patient dropout would be high as children moved to other schools, and thus changed dental school clinics at the age of 17. Consequently, patients of 12 years of age or younger at the start of the study were preferred.

Each clinician used the three different restorative materials, but the number of restorations inserted varied. A total of 274 Class II restorations were placed in 142 adolescents with an average age of 13 years (Table I).

The clinicians were asked to include only small Class II restorations in the treatment of primary caries, small cavities being defined as having enamel surrounding the cavity margin and with restricted buccolingual extensions of the interproximal and occlusal sections. An impression, using an elastomeric material (Xantopren Blue and Optosil, Bayer, Leverkusen, Germany), was taken of the prepared tooth immediately before inserting the restorative material. To allow detailed characterization of the preparations (Jokstad, 1989) the impression was recorded prior to acid etching when using resin composite preparations.

The clinicians were instructed to use the materials according to manufacturers' instructions. The enamel margins were acid etched after covering the exposed dentine with a base, when using the resin composite. All restorations were inserted under rubber dam. They were polished within a few days—this time will be referred to as the start of the study or day 0.

The restorations were then reviewed after 6 months, 1 year and thereafter annually. Impressions were recorded at each clinical examination using an elastomeric material (Xantopren Blue and Optosil, Bayer) to facilitate retrospective studies of restorative material degradation. The clinical examination focused on diagnosing the restorations as acceptable or as having failed, according to the USPHS criteria (Cvar and Ryge, 1971), but without calibration of the clinicians' decisions.

The survival of the restorations was estimated as a function of the restorative material. A one-way analysis of variance was used to assess differences in cavity size for the three types of restorations.

RESULTS

Due to the low incidence of caries, it was difficult to find patients sufficiently young to permit 3-year reviews. The

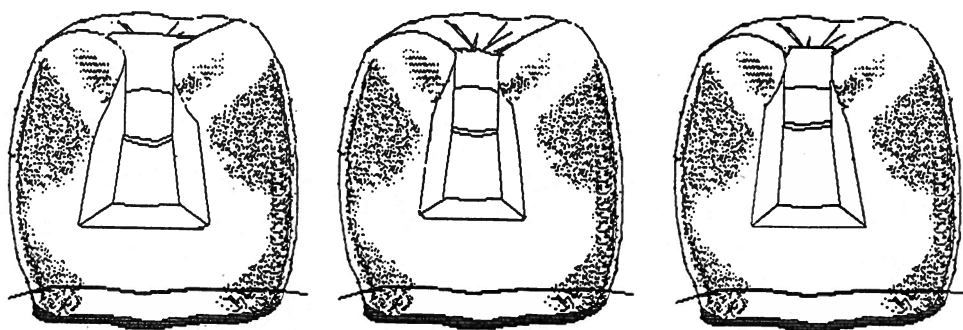


Fig. 1. Illustration of the average size of the cavity preparations for amalgam (left), cermet (middle) and resin composite restorations (right). The average size of the cavities prepared for amalgam were significantly larger than for the other materials, while the cavities for the cermet material were the smallest of the three.

dropout of patients was small after 1 year, but increased to 37% after 3 years (Table II). One clinician completed 5-year reviews with a moderate loss of patients. Although the patient dropout varied with the clinician, it was evenly distributed regarding the restorative material employed and the teeth involved (Table III).

The mean intercuspatal width of the preparations was 5.6 ± 0.7 mm and a proximal circumference width of 12.5 ± 1.2 mm. However, the cavity preparation dimensions varied with the restorative material used. A one-way analysis of variance identified significantly larger cavity preparations for the amalgam compared to the cermet and resin composite restorations (Fig. 1). The preparations for the cermet restorations were smaller than the cavities prepared for the resin composite.

Most restoration replacements were due to bulk fractures of the restorations, with the remainder being diagnosed as having failed due to secondary caries (Fig. 2). However, the elastomeric impressions revealed that several cermet and P-10 restorations had surface and margin discrepancies, which if rated strictly by the USPHS criteria would have been classified as unacceptable. This finding indicates that the dentists involved in this study share a treatment philosophy that advocates observations rather than immediate operative intervention when restoration discrepancies are observed, as recommended by a consensus symposium on the placement and replacement of restorations (Anusavice, 1989).

Fractures were mainly associated with the cermet material, while secondary caries occurred mainly in connection with the resin composite restorations. The failures after 6 months were, with one exception, bulk

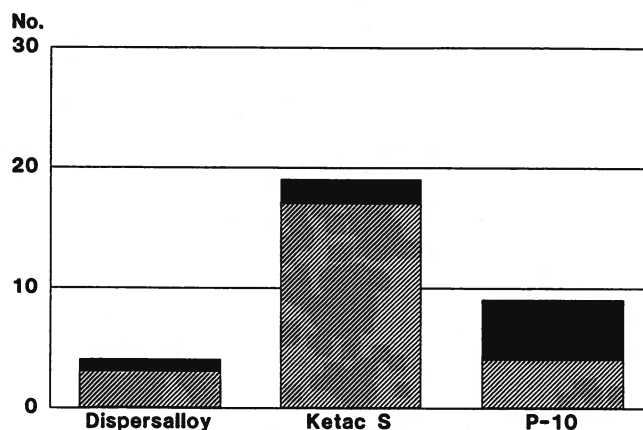


Fig. 2. Number of failed amalgam (Dispersalloy), glass ionomer cermet (Ketac Silver) and resin-based composite (P-10) restorations after 3 years ($n = 32$). ▨, Bulk fractures; ■, secondary caries.

fractures, while secondary caries associated with the resin-based material were diagnosed later in the study (Fig. 3). The estimated survival of the three types of Class II restorations is shown in Fig. 4.

The distribution of the bulk fractures of the cermet restorations in premolar and molar teeth shows that the fractures prevailed in the upper molars (Fig. 5). The preparations for the fractured cermet restorations ($n = 20$) were examined for features that could elucidate any relationship between cavity design and the fracture mechanism. No significant differences in cavity dimensions were noted (Table IV), nor were the prevalence of other cavity design discrepancies, such as acute axio-gingival line angles, diverging axial walls, etc., different in the two subgroups.

Table III. Distribution of the different types of Class II restorations in premolars (P) and molars (M) and the dropouts after 5 years

Material	Start			Dropouts		P		M	
	n	P	M	n	%	n	%	n	%
Dispersalloy	88	23	65	55	62	12	52	43	66
Ketac Silver	95	41	54	51	54	27	66	24	44
P-10	91	43	48	55	60	34	79	21	44
Total	274	107	167	161	59	73	68	88	53

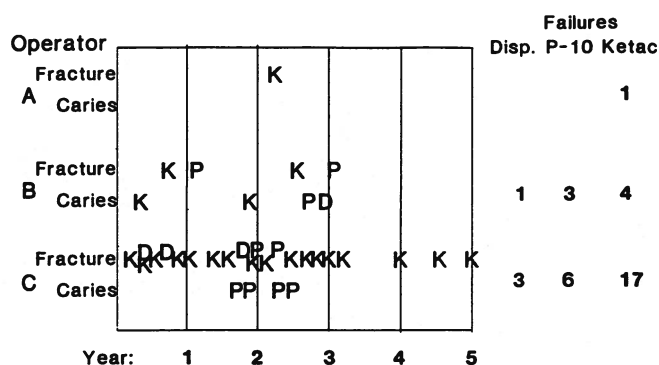


Fig. 3. The incidence of replacement for each clinician according to failure reason. Each letter represents one replacement. D, Dispersionalloy; K, Ketac Silver; P, P-10.

The incidence and reasons for restoration replacement after 3 years were comparable with the 5-year data for one clinician (Fig. 6).

DISCUSSION

Dropout of patients and thus the loss of restorations for reasons unrelated to study variables is a fundamental problem in clinical research. In the present study, the dropout was not skewed regarding the type of restorative material or teeth involved. The age of the patients and details regarding the preparations were also similar for the three materials, although the preparations for the amalgam restorations were slightly larger than those for the other two materials. It is, therefore, likely that the modes of restoration failure could be related to the materials involved.

The difference in dropout of patients noted between the clinicians was primarily due to differences in the age of the patients, which reflect the caries incidence in the different clinicians' patient populations. On the other hand, the different dropout incidences may also reflect the

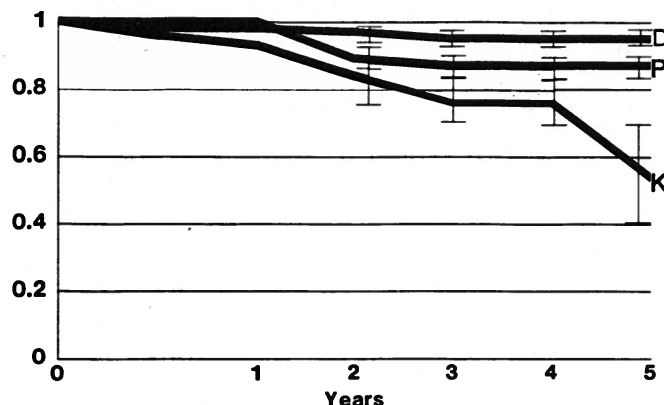


Fig. 4. The estimated survival curves as a function of the restorative material used. The vertical lines show the 95% confidence intervals. D, Dispersionalloy; K, Ketac Silver; P, P-10.

interest or enthusiasm of the three dentists involved. In addition, their willingness to use alternative materials for restoring Class II cavities may have differed. Finally, the diagnostic ability may have varied, e.g. it is difficult to conceive how a glass ionomer restoration, which releases fluoride, could be diagnosed as having secondary caries 6 months after insertion. Such observations confirm the uncertainty associated with the clinical diagnosis of secondary caries (Elderton and Nuttall, 1983; Söderholm *et al.*, 1989).

The higher incidence of secondary caries associated with the resin composite restorations may be explained on the basis of microbiological findings (Svanberg *et al.*, 1990). A significantly higher proportion of *Streptococcus mutans* was found at the cavity margins of the resin composite restorations than for the other two materials.

The preparations in the present study were smaller than those in another study, where cavities due to primary caries were prepared to receive amalgam (Jokstad *et al.*, 1989). The slightly larger size of the preparations for amalgam than for the two other materials, is considered

Table IV. Dimensions of the cavities, expressed in millimetres, of fractured ($n = 20$) and non-fractured ($n = 73$) cermet restorations

	Non-fractured	Fractured
Occlusally		
Buccolingual width at the axiokingival line angle	1.8	1.8
Maximum buccolingual width	2.5	2.3
Distance, maximum buccolingual width : axial wall	1.1	0.7
Minimum buccolingual width	1.6	1.8
Distance, minimum buccolingual width : axial angle	0.4	0.2
Mesiodistal extension	2.3	1.4
Mean depth	1.7	1.6
Mean depth at the axiokingival line angle	1.6	1.5
Proximally		
Buccolingual width at the axiokingival line angle	2.9	3.0
Buccolingual width at the gingival margin	3.7	4.0
Axiocervical extension gingival margin	2.9	2.9
Mean depth	1.5	1.4
Mean depth at the axiokingival angle	1.8	1.9

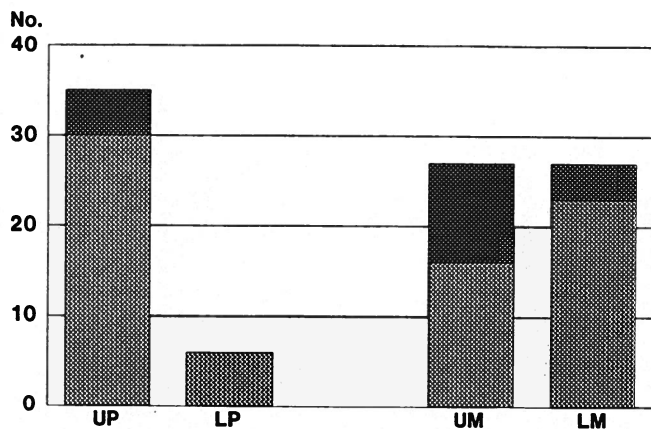


Fig. 5. Number of glass ionomer cermet restorations in upper (U) and lower (L) premolars (P) and molars (M). The dark part of the column shows the restorations failed due to bulk fracture after 3 years.

an impact of decades of teaching Black's principles for cavity preparation.

The physical properties of amalgam resin composite and glass ionomer materials vary markedly. If values for compressive and tensile strengths are compared for these materials, they may be summarized as follows. Amalgam has the highest strength values. Modern resin composites may approach the strengths of the weaker, but acceptable amalgams. The restorative types of glass ionomer materials, including the reinforced cermet type, exhibit strength values as low as a third of that of amalgam. The high incidence of bulk fractures of the cermet restorations in the present study suggests that the physical properties for use in conventional Class II cavities are inadequate, even when placed in small cavities. This finding confirms results from similar studies of glass ionomer materials used in Class II cavities in deciduous (e.g. Östlund *et al.*, 1992) and permanent teeth (Hickel *et al.*, 1988; Croll and Phillips, 1991). Smales *et al.* (1990) have suggested that some clinicians find the glass ionomer restorative material difficult to handle. This problem was also encountered in the present study, as one of the clinicians expressed a dislike of handling the cermet glass ionomer cement.

The failure of 19 of the 95 Class II cermet restorations reviewed after 3 years and of 17 out of 55 restorations reviewed after 5 years may be considered acceptable for restorations in permanent teeth of young teenagers and for deciduous teeth. Data from cross-sectional surveys in general practice have shown that the median longevity of failed amalgam restorations (mainly Class I and II) in permanent teeth of individuals 16 years or younger is less than 4 years and in deciduous teeth less than 2 years (Qvist *et al.*, 1990a). The corresponding median longevity for failed resin composite restorations (mainly Class III and V) was less than 2 years for permanent teeth in young individuals and less than 1 year for deciduous teeth (Qvist *et al.*, 1990b). In such a perspective, the expected median longevity of Class II cermet glass ionomer restorations based on the present observations, make this material a

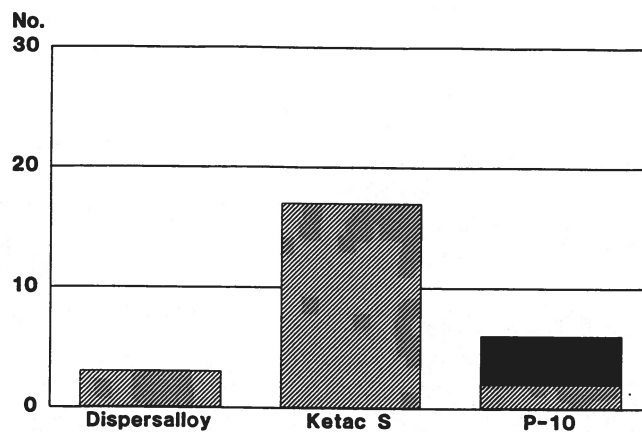


Fig. 6. Number of failed amalgam (Dispersalloy), glass ionomer cermet (Ketac Silver) and resin-based composite (P-10) restorations after 5 years for one clinician ($n = 26$). ▨, Bulk fractures; ■, secondary caries.

possible alternative restorative material for use in deciduous and permanent teeth of adolescents, and in patients with a high caries incidence, at any age, due to the potential benefits from the leachable fluoride.

CONCLUSION

The cermet type of glass ionomer cement used for restoring small conventionally prepared Class II cavities in permanent teeth in young individuals showed a higher frequency of bulk fractures than similar restorations of amalgam or resin-based composite materials. Secondary caries and bulk fractures were the main reasons for failure of the Class II resin composite restorations. The few Class II amalgam restorations that failed were mainly due to bulk fracture during the first 6 months after insertion.

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Book Review

Advanced Osseointegration Surgery: Maxillofacial Applications.

P. Worthington and P.-I. Branemark. Pp. 404. 1992. New Malden, Quintessence. Hardback, £100.00.

Tissue Integration in Oral, Orthopaedic and Maxillofacial Reconstruction.

W. R. Laney and D. E. Tolman. Pp. 393. 1991. New Malden, Quintessence. Hardback, £56.00.

Advanced Osseointegration Surgery is not for the beginner. Its intended readership is the experienced surgeon who is already involved and its purpose is to present a state-of-the-art text in this rapidly advancing field. It comprises five textual divisions: Fundamentals, Mandibular Surgery, Maxillary Surgery, Special Situations and Prosthodontics, and Further Aspects of Osseointegration Surgery, and is a compilation of the work of nearly 40 authors. The initial section, Fundamentals, considers such topics as biomechanics, bacteria-host interactions, the influence of age on healing and the surgical principles of osseointegration and reminds the reader of the scientific and clinical basis on which the subsequent surgical sections of the book are predicated. The sections devoted to severe atrophy of the mandible and maxilla include detailed descriptions of advanced surgical techniques designed to deal with these problems, including bone grafting, nerve transposition, and grafting to the maxillary sinus and floor of nose among others. It is emphasized that some of these techniques are not fully established and should be undertaken with due caution. The fourth section deals with a wide variety of clinical problems ranging from single tooth replacement to the rehabilitation of patients with dental implants following cancer surgery, including extraoral applications. The surgical and prosthodontic aspects of these problems are covered. The final section deals with non-surgical topics related to osseointegration surgery, such as psychological and medicolegal aspects, soft tissue problems and other postsurgical complications.

This book is an important landmark in a rapidly expanding clinical field. Problems are discussed in detail, with each chapter appropriately referenced. Clinical procedures are described clearly and are well illustrated with case histories. The book is produced to the customary superb standards of Quintessence Publications. Inevitably, in a rapidly changing field, there are omissions. In particular, no consideration is given to the use of biomaterials instead of autogenous bone in alveolar ridge augmentation procedures. There is no doubt that such biomaterials will play an important role in implant surgery in the future, and it is to be hoped that the second edition of this book, which will surely follow, will address this. Meanwhile, this book is essential reading for all those surgeons who are involved with advanced osseointegration surgery.

The purpose of the 2nd International Congress on Tissue Integration was to evaluate the current status of the science and clinical applications of tissue-integrated prostheses. Held at the Mayo Clinic in September 1990, the Congress comprised verbal and poster presentations, group discussions and the deliberations of four consensus panels on individual aspects of implantology. This book is a compilation of the conference proceedings and contains over 50 papers devoted to topics relating to osseointegration in intraoral, maxillofacial and orthopaedic applications. The scope is wide ranging and apart from their intrinsic value suggests many topics for further research. Unfortunately, some of the papers are presented only as abstracts, which diminishes the book somewhat. However, a large majority are full papers, and these are accompanied by an appropriate bibliography. They serve, therefore, not only as an exposition of current developments in a given topic, but also as a useful reference source. For colleagues who have only recently become involved in implantology, this book will serve primarily as an excellent reference for individual topics, but for those who have a major interest in osseointegration, it is essential reading.

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