An in vivo study of glass ceramic (Dicor®) inlays

Preliminary report

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For the purpose of evaluating the clinical quality of glass ceramic (Dicor®) inlays 15 patients with 37 inlays were examined 1 to 22 months after placement. In addition to certain periodontal variables, the inlays were rated by two independent examiners using the California Dental Association (CDA) quality evaluation system. The results of the present study showed that dental plaque was seen less often on proximal surfaces with inlays than on homologous proximal surfaces. Three patients reported hypersensitivity of the dental pulp. The examination using the CDA criteria showed that 54% of the inlays had a slight color mismatch, and slightly roughened surfaces were occasionally seen (35.5%). In nearly 30% of the inlays there was visible evidence of ditching along the margins. At present, no judgement can be made about the longevity of ceramic inlays. □ *Clinical performance; dental ceramics; dental materials; prosthetics*

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The increasing demand for esthetic dentistry during recent years and a certain patient resistance to the use of metallic restorative materials have resulted in further development of non-metallic dental restorative materials and in expanded indications for their clinical use. Apart from composite resins and glass polyalkeonate (GPA) cements, ceramic materials have aroused substantial interest because of their esthetic qualities. However, because of the brittle nature of porcelain, the use of traditional porcelains in posterior regions is highly questionable. More recently developed ceramic materials with improved mechanical properties may have the capacity to fulfill the demands of a future posterior restorative dental material. Thus, the flexural strength of a castable glass (Dicor®) proved to be significantly higher than pressure-formed ceramics (Cerestore®), porcelains for metal bonding (Biodent® and Ceramco®), and a high-alumina reinforced porcelain (Vita Hi Ceram®) (1).

Although the material is mainly used for single crowns, the manufacturer of a castable glass ceramic (Dicor®, DeTrey Dentsply, Wiesbaden, FRG) suggests its use for inlays as well. Owing to more favorable mechanical properties Dicor may have the potential to function more effectively than the traditional porcelains as an inlay material. When it comes to clinical longevity, however, the predictability of laboratory studies is very poor. Results from clinical studies are therefore of the greatest importance for predicting the clinical usefulness of a material and/or a method. From the results of a 6-month pilot study Cavel et al. (2) concluded that properly made and placed Dicor inlays in conjunction with a dual-cure light-activated cement offer patients clinically acceptable, esthetic, and durable restorations. However, to our knowledge, no published results of long-term clinical studies on Dicor inlays exist. Thus, the aim of the present study was to assess the clinical quality of Dicor inlays previously placed by general practitioners and to establish a basis for a subsequent longitudinal study.

Materials and methods

Two licensed Dicor laboratories (Jonson Dentallaboratorium AB, Umeå, and Medelpads Tandteknikertjänst AB, Sundsvall, Sweden) were questioned about their Dicor inlay production. In this manner four dentists who had placed Dicor inlays were located and asked whether they would agree to having their patients participate in the study. All four dentists initially agreed to participate, but later two withdrew from the study. These two dentists were unable to state the number of Dicor inlays they had produced. As a result the total Dicor inlay production of 2 dentist/dental technician teams (A and B) was examined—that is, 15 patients with 37 inlays. The mean and median ages of the 12 female patients were 42.9 and 43.5 years, respectively (range, 22–62 years). The ages of the three male patients were 40, 42, and 49 years.

The examination was carried out by the authors after discussion of criteria and careful calibration. Information about the cementation technique and luting cement and about complications during and after the placement was obtained from patient records.

The following anamnestic data were recorded: 1) medical history, including medication and allergies; 2) symptoms such as headaches, sore mouth, metallic taste, and bleeding gums; and 3) smoking habits. The examination included the status of the oral mucosa, the temporomandibular joint (TMJ), and the masticatory muscles; the margin index (3); and certain periodontal variables in accordance with Lenox & Kopczyk (4). For comparison, the periodontal variables were recorded on both restored and 25 available homologous teeth. The restorative status of the homologous teeth was also recorded. Because of the relatively small number of buccal and lingual surfaces, calculations of the presence of dental plaque and gingival bleeding were based on proximal surfaces only.

The restorations were examined in accordance with the California Dental Association's (CDA) quality evaluation systems (5). The CDA criteria focus 'Surface and Color', 'Anatomic Form', and 'Margin Integrity', and every restoration is given a rating representing one of four ranges: 1) range of excellence, 2) range of acceptability, 3) replace or correct for prevention, and 4) replace immediately. Restorations within the ranges of excellence and acceptability are considered 'satisfactory'.

Table 1. Distribution of Dicor inlays related to surfaces restored

Type	*n*
Class I	1
Class II	
MO	5
OD	5
MOD	22
MOB	1
DOB	1
MODB	1
MODBL	1
Total	37

Results

The distribution of the inlays was 12 in the molar region and 25 in the premolar region. The distribution of the Dicor inlays related to surfaces restored is shown in Table 1. Thirty mesial and 30 distal surfaces were restored. The distribution of the inlays with ragard to their time of function is given in Fig. 1. The median age of the 37 inlays

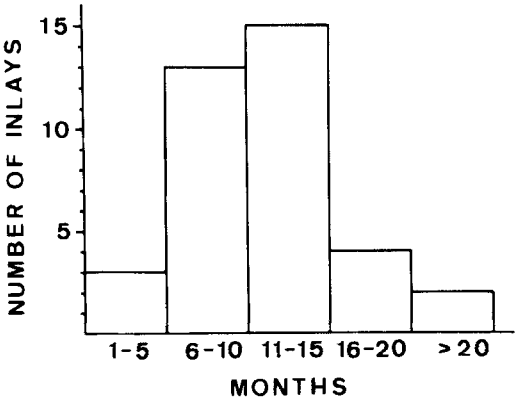

Fig. 1. Distribution of inlays in relation to functional time (months).

Table 2. Distribution of restorations on available homologous teeth

Type of restoration	No. of proximal surfaces restored
Amalgam	12
Composite (direct)	14
Composite (indirect)	4
Dicor (crowns)	12
Metal ceramic (crowns)	6
Not restored	2
Total	50

Table 4. Relative number and percentages of proximal surfaces with plaque (4)

	Restored surfaces (n = 60)		Homologous surfaces (n = 50)	
Surface	Relative no.	%	Relative no.	%
Mesial	19/30	63.3	20/25	80
Distal	20/30	66.7	20/25	80
Total	39/60	65.0	40/50	80

was 11 months (range, 1–22 months). The median age of the inlays produced by team A and team B was 12 and 9.5 months, respectively. Eight inlays were cemented with Dicor light-activating composite resin (Dicor Light Activating Cement), 9 inlays were cemented with a zinc–phosphate cement (Dicor Zinc Phosphate Cement), and 20 inlays were cemented with a glass polyalkeonate (GPA) cement (Fuji Type I). The distribution of restorations on homologous teeth is presented in Table 2. Anamnestic findings of relevance in relation to treatment with Dicor ceramic inlays are presented in Table 3. Furthermore three patients reported a temporary and slight hypersensitivity after placement of inlays; a GPA cement (Fuji Type I) had been used in these cases.

The clinical examination showed that one patient had leukoplakia of the upper lip without any relation to a Dicor inlay (Table 3). Two patients had clicking sensations from the TMJ, and five patients showed tenderness on palpation from the masticatory muscles. Proximal dental plaque was seen more often on homologous surfaces than on Dicor surfaces (Table 4). A somewhat less prominent difference was seen between restored and homologous teeth with regard to the presence of bleeding on probing (Table 5). However, the occurrence of bleeding was almost twice as common on mesial restored surfaces as on mesial homologous surfaces, whereas it was nearly three times as common on distal homologous surfaces as compared with distal restored surfaces. Nearly 50% of the inlay margins were placed subgingivally (Table 6).

Table 3. Number of patients with anamnestic findings

Findings	Patients
Drugs	3 (analgetics, 2; β-2 stimulator, 1)
Allergy	6 (penicillin, 2; nickel, 2; nuts, 1; birch pollen, 1; unspecific, 1)
Metallic taste	1
Sore mouth	2
Tobacco consumption	6 (cigarettes, 5; snuff tobacco, 1)

The examination using the criteria of the CDA showed excellent ratings for Surface and Color in 32.5% of the inlays; for Anatomic Form in 43.3%; and for Margin Integrity in 67.6% of the inlays. The number of inlays that did not receive an excellent CDA rating is presented in Table 7. A common finding was a slight color mismatch between restoration and tooth structure, SMM (54%). This means that 46% of the inlays were rated excellent with regard to color match. Slightly roughened surfaces were also occasionally seen, in which case the porcelain surface had been removed by grinding. With the exception of one fractured inlay, represented by the ratings TPX and VFR in Tables 7 and 8, all inlays not rated excellent with regard to Anatomic Form and Margin Integrity were within the range of acceptability.

The relationship among luting cement, Margin Integrity (SCR), and age of the inlays is shown in Table 8. Of the inlays rated SCR, those cemented with a zinc phosphate cement had the shortest time of function (Table 8). One inlay cemented with Dicor Light Activated Cement was rated TPX,

Table 5. Relative number and percentage of proximal surfaces with bleeding (4)

Surface	Restored surfaces ($n = 60$) Relative no.	%	Homologous surfaces ($n = 50$) Relative no.	%
Mesial	6/30	20.0	3/25	12
Distal	4/30	13.3	9/25	36
Total	10/60	16.7	12/50	24

Table 6. Margin index scores (3) of restored proximal surfaces

Surface	Score 0	Score 1	Score 2	Score 3
Mesial ($n = 30$)	4	6	6	14
Distal ($n = 30$)	4	4	7	15

Score 0 = restoration margin >2 mm above the gingival margin; score 1 = <2 mm above the margin; score 2 = at the gingival margin; and 3 = restoration margin below the gingival margin.

having an undercontoured interproximal area likely to cause tissue damage, and was also rated VFR, showing a fracture.

The median age of the inlays rated excellent with regard to Margin Integrity was 10 months. The median age of those not rated excellent was 12.5 months. The relationship between the quality ratings and dentist/dental technician teams A and B is shown in Table 9, in which a clear difference between the two teams can be seen, team A generally producing less satisfactory results.

Table 7. Number and percentage of inlays that did not receive an excellent CDA rating* ($n = 37$)

	Surface and Color		Anatomic Form					Margin Integrity	
	SRO	SMM	SUCO	SOCO	SMR	SCO	TPX	SCR	VFR
n	5	20	8	4	7	1	1	11	1
%	13.5	54.0	21.6	10.8	18.9	2.7	2.7	29.7	2.7

* SRO = surface of restoration is slightly rough or pitted, can be polished; SMM = slight mismatch between restoration and tooth structure within the normal range of tooth color, shade, and/or translucency; SUCO = restoration is slightly undercontoured; SOCO = restoration is slightly overcontoured; SMR = marginal ridges slightly undercontoured; SCO = contact slightly open; TPX = interproximal cervical area slightly undercontoured; SCR = visible evidence of ditching along the margin not extending to the DE junction; VFR = restoration is fractured.

Table 8. The age of inlays rated SCR* with regard to luting cement

Luting cement	SCR, *n*	Age, months	Median age, months
Dicor Light Activated Cement ($n = 8$)	2	14, 18	16
Dicor Zinc Phosphate Cement ($n = 9$)	4	12, 12, 12, 12	12
Fuji Type 1 ($n = 20$)	5	10, 12, 13, 18, 18	13
All inlays rated SCR	11		12

* SCR is explained in Table 7. Within parentheses, the number of inlays cemented with each cement.

Table 9. Percentage distribution of inlays ($n = 37$) which did not receive an excellent CDA rating* with regard to dentist/dental technician team

		Surface and Color		Anatomic Form					Margin Integrity	
Team	*n*	SRO	SMM	SUCO	SOCO	SMR	SCO	TPX	SCR	VFR
A	27	5.4	51.4	18.9	5.4	18.9	2.7	2.7	27.0	2.7
B	10	8.1	2.7	2.7	5.4	0.0	0.0	0.0	2.7	0.0

* The abbreviations of the ratings are explained in Table 7.

Discussion

There are two main reasons for a patient to request a non-metallic restoration. The first, and probably the most frequent, reason is esthetic improvement. Then, there are some patients who want to replace amalgam fillings with non-metallic restorations to eliminate discomfort such as experiencing a metallic taste. In patients with disorders and/or discomfort allegedly caused by corrosion, metallic taste is the most frequent discomfort in the oral cavity (6). In the present study amalgam fillings were successfully replaced by glass ceramic restorations to eliminate metallic taste in 1 of 15 patients. The other 14 patients demanded non-metallic restorations for esthetic reasons. Apart from being non-metallic and having excellent esthetics, several other advantages have been claimed for the cast glass ceramic material (Dicor), such as marginal accuracy, ease of adjustment, and resistance to bacterial growth (7).

The results of the present study showed that the esthetics, monitored as color match, were 100% acceptable but only 46% excellent (Table 7). Many of the mismatched inlays had been adjusted in the occlusal area, leaving a surface stripped of its colored glazing, exposing the opaque glass. In some cases these adjustments were not followed by polishing, which explains the occurrence of slightly rough surfaces, SRO (Table 7). Improper coloring probably due to dentist error is another possible explanation for the not excellent esthetics of 54% of the inlays.

Ceramic inlays are difficult to adjust without risking chipping off or fracturing inlay margins. To reduce this risk it has been suggested that this adjustment be deferred until after the inlay has been cemented (2). However, this means that the colored surface will in part be removed and the esthetics will be impaired. On the other hand, to avoid esthetic deterioration, adjustment may be performed before coloring, which requires an extra appointment, and would result in an increased risk of fracturing the inlay.

The results for Margin Integrity (Table 7) showed that nearly 70% of the inlays were excellent, whereas almost 30% showed visible evidence of ditching. As marginal accuracy is greatly influenced by the luting medium, it might be supposed that the best marginal accuracy would be found with the composite resin cement and the poorest with zinc phosphate cement. This assumption was to a certain extent verified (Table 8). The 11 inlays rated SCR were only slightly older (Table 8) than the whole group of 37 inlays. Therefore, in the short perspective, there does not seem to be any time-dependent relationship between marginal deterioration and functional time.

The findings from the present in vivo study with regard to margin integrity are to a certain extent in agreement with in vitro studies (see, for example, Refs. 8, 9), in which Dicor inlays luted with phosphate cement were found to have poor margins in comparison with composite resin in connection with etching and silanization. Moreover, Cavel et al. (2) found 100% excellent margins in an in vivo study after 6 months when Dicor inlays were luted with a dual-cure resin cement. However, the adhesive techniques are very technique-sensitive (7), and without meticulous restoration procedures operator errors are almost inevitable. Therefore, a somewhat more simplified luting technique that reduces operator errors may be achieved by

using a glass polyalkeonate cement for luting ceramic inlays. One disadvantage of GPA cement might be a postoperative hypersensitivity (10), which in the present study was reported in 3 of 20 cases in which GPA cement had been used as luting medium. However, factors related to the restorative procedures may, through a contribution of mechanical trauma, bacterial invasion, microleakage, or shrinkage stresses, result in pulpal inflammation (11), and thus the luting medium per se may not be the only reason for the hypersensitivity reported.

In the present study dental plaque was seen more often on homologous teeth than on Dicor teeth (Table 4). This is in agreement with information from the dental literature, in which Dicor inlays have been claimed to have an inherent resistance to bacterial growth (see, for example, Refs. 7, 12). This difference in plaque accumulation on proximal Dicor surfaces as compared with proximal homologous surfaces is somewhat difficult to explain but may be due to different material surface properties. Moreover, the differences might depend on patient factors. Therefore, from the results of the present study it might be concluded that Dicor possibly possesses some advantage with regard to resistance to plaque accumulation.

With regard to bleeding on probing, a more complex relation to other periodontal factors emerged. No clear differences between restored and homologous proximal surfaces were seen. Moreover, as to dental plaque and bleeding no correlation could be observed between the presence of subgingival margins and bleeding on probing (Tables 5 and 6). This indicates that various factors influence bleeding as a characteristic of gingival inflammation, and therefore no relevant conclusions could be drawn from the presence of bleeding in relation to the restorative material used.

Hypersensitivity of the dental pulp in connection with the use of GPA cement was reported by three patients in the study, but none asked for any measures to be taken, indicating that the symptoms were very slight. The leukoplakia found in the mucosa of the upper lip of one of the patients had no topographic relation to a Dicor inlay, and it is therefore suggested that the glass ceramic material studied may not have had any irritating effect on the oral mucosa. Seven of 15 patients had moderate signs of dysfunction of the craniomandibular system, but there is no reason to believe that the inlays per se could be the reason for the signs occurring in these patients.

There was a clear difference between dentist A and dentist B with regard to clinical quality, evaluated in accordance with the CDA criteria (5) (Table 9). The deviation from excellence was apparently greater for team A than for team B. The average functional time of the inlays made by team A was greater than that of team B. This difference in functional time might have influenced the clinical quality. However, it should be borne in mind that the quality of prosthodontic work depends on the combined skill of both dentist and dental technician. It is therefore our decided impression that, to meet the high demands of esthetics from the public, excellence of work is required from both dentist and laboratory technician.

To sum up, the present study showed that, by means of the CDA criteria (5), 36 of 37 Dicor inlays studied 1–22 months after placement were rated as being in the range excellent–acceptable. This indicates that Dicor inlays might be expected to perform well clinically, but owing to the rather short observation time, no definite judgement of the longevity of the ceramic inlays could be reached. Also, the number of patients was relatively small, which, together with the fact that the procedures used by the two dentist/dental technician teams were outside our control, might have affected the validity of the data obtained. It is our intention that the present data, and the present patient material, will serve as a basis for a subsequent longitudinal study.

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References

1. Øilo G. Flexural strength and internal defects of some dental porcelains. Acta Odontol Scand 1988; 46:313–22.

2. Cavel WT, Kelsey WP, Barkmeier WW, Blankenau RJ. A pilot study of the clinical evaluation of castable ceramic inlays and a dual-cure resin cement. Quintessence Int 1988;19:257–262.
3. Silness J. Periodontal conditions in patients treated with dental bridges. J Periodontol 1970;5:60–8.
4. Lenox JA, Kopzcyk RA. A clinical system for scoring a patient's oral hygiene performance. J Am Dent Assoc 1973;86:849–52.
5. Quality evaluation for dental care. Guidelines for the assessment of clinical quality and professional performance. Los Angeles: California Dental Association, 1977.
6. Johansson BI, Stenman E, Bergman M. Clinical registration of charge transfer between dental metallic materials in patients with disorders and/or discomfort allegedly caused by corrosion. Scand J Dent Res 1986;94:357–63.
7. Malament KA, Grossman DG. The cast glass-ceramic restoration. J Prosthet Dent 1987;57:674–83.
8. Geppert W, Roulet J-F. In vitro marginal integrity of MOD inlays luted with adhesive techniques [Abstract]. J Dent Res 1986;56(spec iss):731.
9. Roulet J-F, Rosansky J, Geppert W. In vitro marginal seal of MOD Dicor inlays luted with adhesive techniques [Abstract]. J Dent Res 1988;67(spec iss):310.
10. Charbenau GT, Klausner LH, Brandau HE. Glass ionomer cements in dental practice: A national survey [Abstract]. J Dent Res 1988;67(spec iss):283.
11. Council on dental materials, instruments and equipment. Biocompatibility and postoperative sensitivity J Am Dent Assoc 1988;116:767–8.
12. Savitt ED, Malament KA, Socransky SS, Melcer AJ, Backman KJ. Effects on colonization of oral microbiota by a cast glass-ceramic restoration. Int J Periodont Restor Dent 1987;2:23–35.

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