11-Year assessment of class-III resin restorations completed with two restorative procedures

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Qvist V, Strøm C. 11-Year assessment of class-III resin restorations completed with two restorative procedures. Acta Odontol Scand 1993;51:253–262. Oslo. ISSN 0001–6357.

This randomized clinical trial was initiated to study the effect of two restorative procedures on the clinical quality and longevity of class-III resin restorations. The material consisted of 52 pairs of class-III restorations in the microfilled resin Silar completed with two modifications of the conventional acid-etch restorative procedure: A) beveling of the margins of the cavity preparations, and B) treatment of the etched butt-joint cavities before filling with the dentin-adhesive NPG-GMA/ethanol together with re-etching and surface coating of the finished restorations with low viscous resin. The restorations were examined at base line and after 2, 4, 6, and 11 years. The cumulative 11-year survival rate for both types of restorations was 84%. Marginal discolorations, marginal discrepancies, and secondary caries were most often recorded corresponding to the beveled type-A restorations, whereas the esthetic quality of the two types of restorations was almost identical. Surface discolorations were most often recorded among smokers, and significant correlations were found between the patients' consumption of alcoholic beverages and corpus discoloration, surface discoloration, and surface wear of restorations. □ *Acid etching; adhesives; clinical trials; composite resins; dental restoration, permanent*

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Since the middle of the seventies it has been common practice to use gap-preventive restorative procedures in the placement of resin restorations. However, recent cross-sectional studies show that about two-thirds of the resin restorations that are replaced fail because of secondary caries, marginal discrepancies, marginal discolorations, or poor retention (1–4). The longevity of restorations replaced because of these defects is generally shorter than that of restorations replaced for other reasons, such as corpus discoloration (3). Gap formation and its clinical consequences are therefore still important reasons for the relatively short durability of resin restorations.

The explanation for this must be that the acid-etch technique, which on the basis of many in vitro experiments generally is considered very important, only has a limited gap-preventive effect in the clinic (5). Its effect is even more reduced if the restoration is finished immediately after curing, as is usually the case. At this time, the hygroscopic expansion of the resin will not have compensated for the initial polymerization contraction of the material. So, in the few comparative clinical studies of resin restorations placed in etched and non-etched cavities, only minor differences have been found in the quality and durability of the restorations (6–11). However, there is no doubt that gap formation along resin restorations can be reduced significantly by using various modifications of the conventional acid-etch technique, and the gap-preventive effect of some modifications, moreover, seems independent of the time of finishing (5, 12).

The aim of this study was to compare the clinical quality and durability of class-III resin restorations completed with two modifications of the conventional acid-etch restorative procedure, which both allowed for an initial finishing of the restoration. The two modifications were A) beveling of the margins of the cavity preparations, and B) treatment of the etched butt-joint cavities

before filling with the dentin-adhesive NPG-GMA/ethanol together with re-etching and surface coating of the finished restorations with low viscous resin. The results obtained at base line and after 2, 4, and 6 years have been reported previously (13–15). These results will therefore only be summarized in the present paper, which focuses on the findings at the 11-year recall of the patients.

Materials and methods

A total of 52 pairs of class-III composite resin restorations were performed by one of the authors (C. Strøm) in 17 women and 18 men 24–65 years old ($\bar{x} = 41$ years). Each patient required at least one pair of class-III restorations of approximately the same size and location. Forty-seven pairs were made in maxillary incisors and canines and five pairs in mandibular incisors. The following modifications of the conventional acid-etch restorative procedure were used: A) beveling of the margins of the preparations, and B) treatment of the etched cavities before filling with the dentin-adhesive NPG-GMA/ethanol together with re-etching and surface coating of the finished restorations with low viscous resin.

Cavity preparation and lining

After pumicing of the teeth, classical class-III cavities were prepared and lined with a calcium hydroxide base material (Dycal Improved, batch 100980, L.D. Caulk Co., Milford, Del., USA). After randomization, a ½- to 1-mm bevel was prepared along the enamel margin of the type-A cavity in each pair (Fig. 1). After preparation, the shortest distance from the cervical margin of the cavities to the cementoenamel junction was measured.

Cavity treatment

The cavities were sprayed with water and air-dried before and after a 60-sec etching with 37% phosphoric acid of the cavity walls and 1–2 mm of the adjacent enamel surface (Concise Etching Liquid, batch 91451, 3M Co., Minneapolis, Minn., USA). In the type-B cavities (Fig. 1) a 2% w/w ethanol solution of *N*-phenylglycine-glycidyl methacrylate NPG-GMA was sprayed twice over the etched area (Cosmic Bond, De Trey Division, Dentsply Ltd., Wybridge, England). After each application of the dentin adhesive the cavities were briefly re-dried.

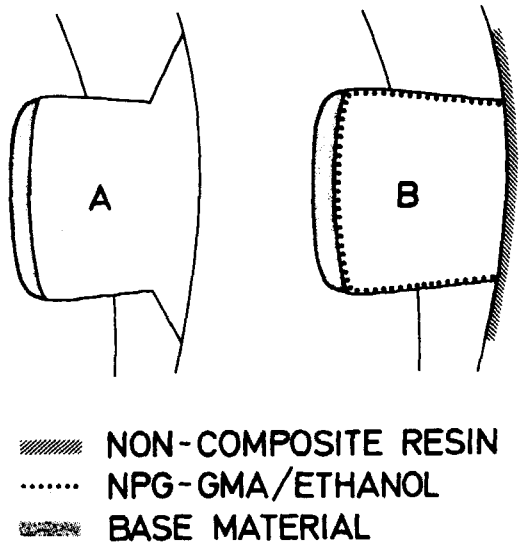

Fig. 1. Schematic illustration of the restorative procedures used for type-A and type-B restorations.

Filling procedure

The chemically cured, microfilled resin (Silar, batch 0K2, 0G1, 3M Co.) was inserted into all cavities with an excessive layer on the surrounding etched tooth surface. During polymerization the restorative material was pressed firmly into the cavity with a polyester strip.

Finishing procedure

About 10 min after insertion of the filling material the restorations were finished under water spray. The surface of the type-B fillings and of 1–2 mm of the surrounding tooth was then re-etched with the phosphoric acid for 60 sec. After being water-sprayed and air-dried the etched surface was covered with a layer of low viscous, non-composite resin

Table 1. Criteria used in the assessment of the restorations and the recording of the habits of the patients. Score 0 was used for 'optimal' restorations, score 1 for 'acceptable' restorations, and score 2 for 'unacceptable' restorations with need for repair or replacement

Characteristic/habit	Criterion	Assessment
Vitality	Pulpal reaction at electrometric vitality testing of tooth	No/yes
Plaque	Plaque deposits on restoration removable with probe	No/yes
Surface discoloration	Extrinsic staining of restoration removable with pumice	0/1/2
Corpus discoloration	Difference in color between corpus of restoration and tooth beyond the normal range	0/1/2
Shade matching	Difference in shade value between corpus of restoration and tooth after comparison of both structures with a Biodent shade guide	Lighter/ optimal/ darker
Marginal discoloration	Staining visible at the cavosurface margin of restoration	0/1/2; mm; location
Marginal discrepancies	Ditching or catch at the cavosurface margin of restoration detectable with probe	0/1/2; mm; location
Secondary caries	New caries associated with restoration	0/1/2; location
Surface wear	Evidence of material loss due to abrasion, attrition or degradation	0/1/2; location
Fracture of filling/tooth	Fragment or bulk of filling/tooth mobile or lost	0/1/2; location
Occlusion/articulation	Contact between restoration and antagonist during occlusion or articulation	No/yes
Smoking habits	Daily smoking of cigarettes, etc.	No/yes
Consumption habits	Daily consumption of coffee, tea, and alcoholic beverages	No/yes

(Concise Enamel Bond System, batch 0036X1, 0081Z1, 3M Co.) (Fig. 1).

Clinical evaluation

The clinical quality of the restorations was evaluated by both authors together about 10 min after completion and at the following 2-, 4-, 6-, and 11-year recalls of the patients. The criteria used at the evaluations are summarized in Table 1. For eight characteristics the assessment of the restorations included a scoring. Score 0 was used to indicate absence of the respective type of defect. Score 1 indicated minor defects without significance for the function of the restorations. Score 2 was used to classify defects of such a magnitude that repair or replacement was needed. On the basis of the highest score value obtained, an overall assessment of the clinical quality of each restoration was finally given in terms of 0 = optimal, 1 = acceptable, and 2 = unacceptable. To examine possible connections between daily habits and the clinical quality of the restorations, the patients were interviewed about their respective smoking habits and daily consumption of coffee, tea, and alcoholic beverages at the recalls (Table 1).

Statistical analysis

For each of the clinical characteristics the difference in the assessments of paired type-A and type-B restorations was tested for significance with the Sign test. Correlations between the clinical characteristics and between these and the daily habits of the patients were tested for significance with the chi-square test. The cumulative survival rates of the restorations were calculated by means of the life table method (16, 17).

Results

Overall assessment

The overall assessments of the restorations at base line and after 2, 4, 6, and 11 years of function are given in Table 2. At the final recall 14 restorations could not be evaluated as 2 patients with 6 restorations had moved, and 3 patients had died during the observation period.

Owing to immediate repair of five restorations (3A, 2B) with marginal discrepancies, all restorations were classified as optimal at base line. A gradual deterioration of their clinical quality was recorded during the follow-up period (Fig. 2). Approximately half of the type-A and -B restorations were still optimal after 4 and 6 years, respectively, but at the 11-year recall only 17% (15 of 90) were recorded as being faultless (Fig. 3). The difference in the overall quality of the type-A and -B restorations was significant at the 6-year control ($P = 0.02$).

At the 11-year examination all teeth responded positively to electrometric vitality testing except two (1A, 1B), which had been endodontically treated. Moreover, three restorations (2A, 1B) were classified as unacceptable owing to fracture of the incisal part of the tooth or secondary caries. The same types of failure had already resulted in replacement of eight restorations, and seven further restorations had been replaced for other reasons (Fig. 4). The cumulative survival rates for the type-A and -B restorations were almost congruent during the whole observation period. For the total material of 104 restorations, the estimated 10-year probability of survival was 89%, with a 95% confidence interval at 96–83%, and the corresponding 11-year estimates were 84% (91–76%).

Detailed assessment

The occurrence of acceptable and unacceptable failures of the controlled restorations is listed in Table 3 for each of the examinations.

Marginal discoloration and marginal discrepancies proved to be the only clinical characteristics with significant differences between type-A and -B restorations after 2 and 6 years, respectively. However, the superior marginal quality of the B restorations during the first half of the observation period was not found at the 11-year control, at which approximately 45% of all restorations showed marginal failures (Fig. 5). A significant correlation was found between marginal discrepancies and their clinical sequelae in terms of marginal discolorations or secondary caries ($P < 0.001$). The extent of the failures varied between 1 and 5 mm ($\bar{x} = 2.2$ mm). They were often located in the cervical part of the restorations and were most frequently observed along restorations with less than 1 mm from the cervical part of the cavity preparation to the enamel–cement junction. However, this association was not significant, and the occurrence of marginal failures was not increased by either plaque or occlusion/articulation on the restorations. At the final

Table 2. Overall assessment of restorations at base line and the following recalls of the patients

	Base line		2 years		4 years		6 years*		11 years	
Type of restorations	A	B	A	B	A	B	A	B	A	B
No. of restorations	52	52	52	52	52	52	52	52	52	52
Optimal	52	52	31	33	24	31	14	25	7	8
Acceptable	—	—	18	16	22	16	30	19	28	29
Unacceptable	—	—	1	1	2	1	2	2	2	1
Replaced	—	—	1	1	2	2	2	2	8	7
Uncontrolled	—	—	1	1	2	2	4	4	7	7

* 6 years: A ≠ B; $P = 0.02$.

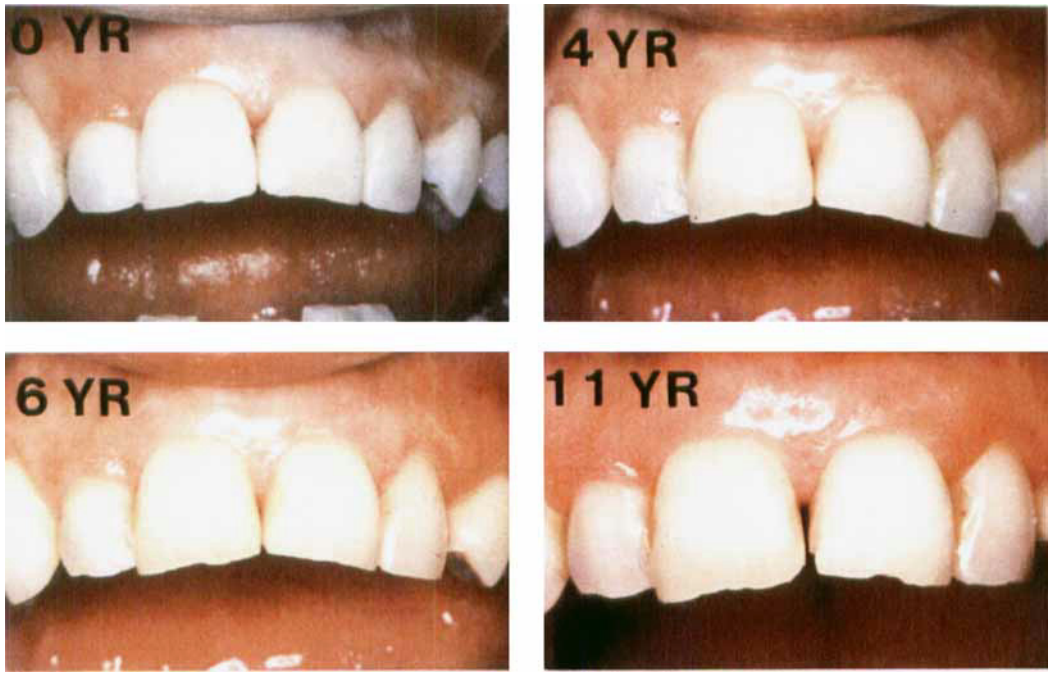

Fig. 2 Clinical photographs of six of the experimental restorations taken at base line and at the 4-year, 6-year, and 11-year controls. Type-A restorations: nos. 12-M, 11-D, and 21-D. Type-B restorations: nos. 11-M, 21-M, and 22-M. The 11-M restoration was replaced just before the final control for unknown reasons. At the 11-year examination corpus discoloration, marginal discoloration, surface wear, and fracture of tooth were recorded for one or more of the remaining restorations. However, they were all classified as being acceptable.

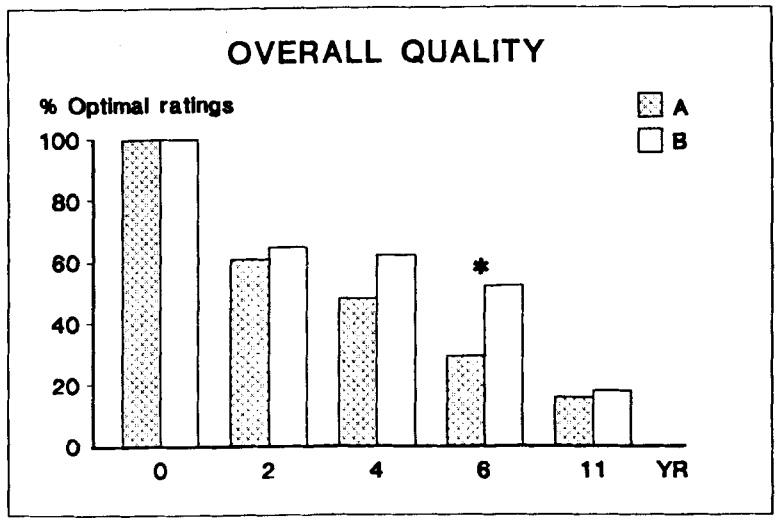

Fig. 3. Percentage of type-A and -B restorations assessed as being optimal with regard to all clinical characteristics (Table 1), at base line and at the following re-examinations. Significant difference in the overall quality of the two types of restorations was found after 6 years (B > A; $P = 0.02$).

examination plaque deposits were recorded on 37%, and 17% of the controlled restorations were in occlusion/articulation.

The esthetic quality of the restorations also deteriorated during the observation period. Almost all restorations appeared darker than the surrounding tooth at the 11-year recall (Fig. 6), and corpus and/or surface discolorations were recorded for approximately 75% of both types of restoration (Fig. 7). However, the discolorations were in all cases classified as acceptable, and only two restorations had been replaced because of esthetic shortcomings (Fig. 4). No relationship was found between surface and corpus discolorations, whereas both types of failures seemed to be associated with the daily habits of the patients.

The interview of the patients showed that

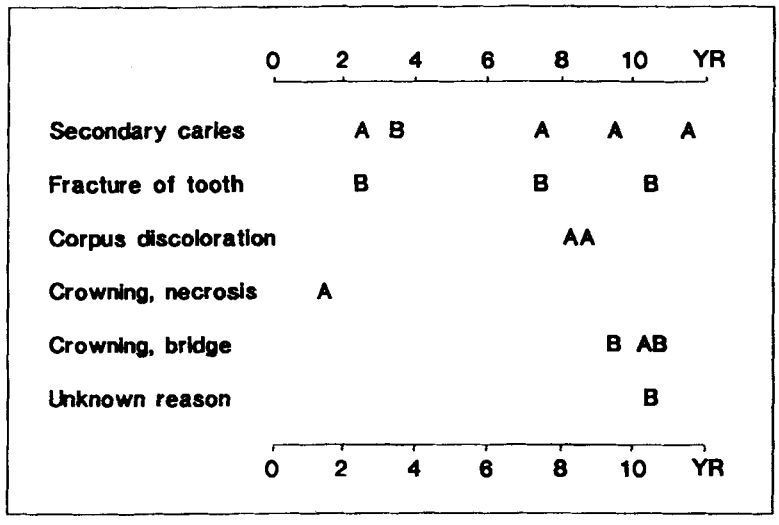

Fig. 4. Time and reason for replacement of type-A and type-B restorations during the 11-year observation period.

Table 3. Detailed assessment of restorations at base line and the following recalls of the patients

	Base line		2 years		4 years		6 years		11 years	
Type of restorations	A	B	A	B	A	B	A	B	A	B
No. of restorations	52	52	50	50	48	48	46	46	37	38
Surface discoloration	—	—	5	6	6	5	12	9	6	7
Corpus discoloration	—	—	3	5	1	1	7	7	22	25
Marginal discoloration*	—	—	9	3	4	1	6	4	7	10
Marginal discrepancies†	—	—	6	3	11	5	13	4	11	7
Secondary caries	—	—	—	—	—	1	1	1	1	1
Surface wear	—	—	1	2	9	11	9	3	8	3
Fracture of filling	—	—	—	—	1	—	1	—	—	—
Fracture of tooth	—	—	1	1	1	1	2	—	2	1

* 2 years A ≠ B; $P = 0.03$.
† 6 years A ≠ B; $P = 0.02$.

56% of the 75 remaining, controlled restorations were situated in habitual smokers, that 95% were exposed to coffee daily, and 44% to tea. Moreover, 14 patients with 45% of the restorations answered that their weekly consumption of wine, beer, and so forth corresponded to at least one drink a day. When these recordings were related to the clinical assessments of the restorations, positive correlations were found for habitual consumption of alcoholic beverages versus corpus discoloration ($P < 0.001$), surface discoloration ($P < 0.06$), and wear of restorations ($P < 0.05$). Moreover, surface discolorations were recorded nearly three times as frequently among smokers as among nonsmokers, but the association was not significant at the 11-year control ($P = 0.09$), as was the case at the previous controls.

Discussion

In summary, the present study demonstrated that it was possible to perform class-III restorations with an extended durability and continuously acceptable clinical quality by using the applied resin material and the two restorative procedures.

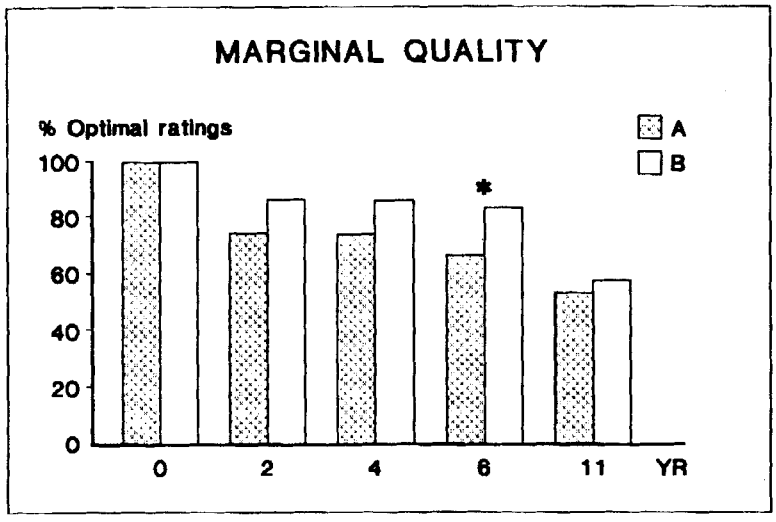

Fig. 5. Percentage of type-A and -B restorations assessed as being optimal with regard to marginal discolorations, marginal discrepancies, and secondary caries (Table 1), at base line and at the following re-examinations. Significant difference in the marginal quality of the two types of restorations was found after 6 years (B > A; $P < 0.05$).

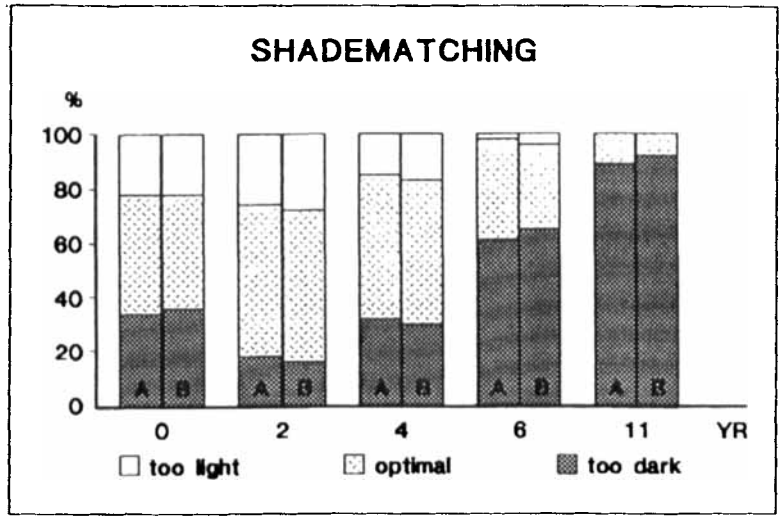

Fig. 6. Percentage of type-A and -B restorations with a shade matching the shade of the surrounding tooth tissue or assessed as being too light or too dark, at base line and at the following re-examinations, using the Biodent shade guide.

For the complete material, the cumulative survival rate was 89% at 10 years and 84% at 11 years. The replacement frequency was significantly lower than that seen in an earlier study from the School of Dentistry in Copenhagen, in which anterior silicate cement and composite resin restorations placed in unetched cavities by students were examined (18, 19). For the 317 class-III resin restorations the replacement rate after 2½ years corresponded to the 11-year rate in the present study, and only 56% of the restorations remained functional for more than 8 years. The difference in the achieved functional durability of the restorations is so pronounced that it cannot simply be attributed to operator variations or quality differences between the applied resin materials. The two gap-preventive restorative procedures used in the present study must have contributed significantly to the continuously high quality of the restorations. This conclusion is con-

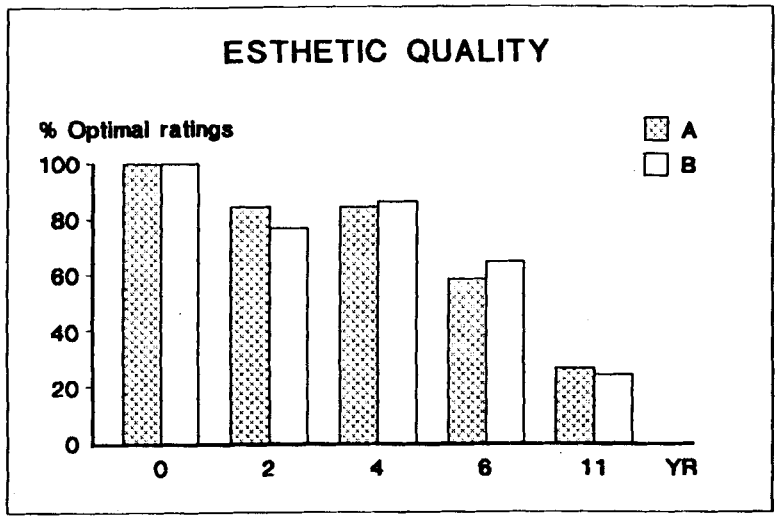

Fig. 7. Percentage of type-A and -B restorations assessed as being optimal with regard to surface discoloration and corpus discoloration (Table 1), at base line and at the following re-examinations.

firmed by a later, as yet unpublished study from Copenhagen of anterior resin restorations placed by students using the same restorative technique as used here for type-B restorations. After 2–3 years the clinical quality and durability of the class-III restorations were almost identical to those in the present study.

It is therefore remarkable that the 10- to 11-year survival rate in the present study corresponds to those found after a few years of observation in several other longitudinal studies of anterior resin restorations placed with various gap-preventive restorative procedures (8, 20–25). The results in the few comparable studies with longer observation times have also generally been poorer than ours (10, 11, 26, 27).

For example, van Dijken (27) found a survival rate of 68% after 6 years for anterior resin restorations completed with the same resin material and restorative procedure as used in the present study for type-A restorations. For the other resin materials in his study the percentage of restorations that remained functional for more than 6 years varied between 86% and 46%. After the same observation period Smales (10) found a 64% probability of survival for anterior resin restorations placed in unetched cavities, compared with only 59% for restorations placed with an acid-etch restorative procedure. However, the median or 50% survival rate for both types of class-III restorations was approximately 10 years. There was, however, a high fall-out rate in the study. The same problem is probably the reason Bayne (11), in his 10-year study of class-III resin restorations placed without acid-etching and using the conventional acid-etch technique, does not report replacement frequencies but only states that marginal discolorations in the first half of the observation period most often occurred in restorations placed in unetched cavities.

The great variation in results might be attributed to several factors that are related to the patient's age, oral hygiene, and caries activity, the skill of the operator, and the actual restoration, including the resin material utilized, the size and shape of the preparation, the cavity treatment, and the time of finishing. One cannot therefore on the basis of earlier studies determine the relative importance that acid-etch restorative techniques may have for the clinical quality and durability of resin restorations. The three Danish studies indicate, however, that the clinical effect of gap-preventive restorative procedures can be particularly good.

The two restorative procedures compared in this study both permit the initial finishing of the restorations but are, however, different in other ways.

The most frequently used modification of the conventional acid-etch restorative procedure seems to be beveling of the margins of the cavity preparations, the procedure used for the type-A restorations. The reasons are that a beveled margin exposes more enamel and cross-cut rather than longitudinally cut enamel for acid-etching. Consequently, it may produce a stronger retention of the resin and may reduce stress-induced fractures of unsupported enamel along the restorations. Compared with the conventional butt-joint cavity design, a beveled margin may also provide improved marginal seal and may result in improved esthetics due to a gradual transition from the tooth structure to the composite resin. The obvious disadvantages of the bevel design are the more destructive nature of the cavity preparation and the increased amount of composite resin exposed at the surface (28). Chipping along the margins of beveled restorations may also result in clinical problems because of the limited tensile strength of resin restoratives, especially of microfilled materials such as Silar (20).

The restorative procedure used for the type-B restorations involves dentin-adhesive treatment of the etched, butt-joint cavities before filling and re-etching and surface coating of the finished restorations with low viscous resin. This modification has previously been found to result in the most superior marginal adaptation of resin restorations in the oral environment (12). The reasons seem to be that the dentin-adhesive NPG-GMA is dissolved in ethanol, which increases the interprismatic enamel resin penetration, and that marginal deficiencies along the finished

restorations and in the surrounding enamel may be sealed with the low viscous resin (5, 12). The surface coating may also provide improved wear resistance of stress-bearing restorations (29).

The present results generally confirmed the presumed effects of the two restorative procedures. Marginal discolorations, marginal discrepancies, and secondary caries were most frequently observed along the beveled type-A restorations, although the differences were only significant in the first 6 years of the observation period (Table 3; Figs. 4 and 5). The marginal failures were predominantly located at the cervical part of the restorations and were most frequently found at restorations in occlusion/articulation. But neither the amount of enamel cervical to the cavity preparations nor the functional stress on the restorations significantly influenced the occurrence of failures. The improved marginal quality of the butt-joint type-B restorations may, therefore, primarily be the cause of the superior microadaptation obtained with the dentin-adhesive/resealing restorative procedure, although chippings along the beveled type-A restorations undoubtedly have contributed to the differences.

The esthetic benefits of a beveled cavity design, which have been claimed by many authors, could not be confirmed in the present study. Already at the 2-year examination it was not possible to guess which restorative procedure had been used for the controlled restorations, and the occurrence of corpus discolorations, surface discolorations, and the shade of the restorations versus the surrounding teeth were almost identical for the two types of restorations during the whole observation period (Table 3; Figs. 6 and 7). However, it is well known that recordings of corpus discolorations do not always reflect the color stability of restorative materials (30). The most reliable information seemed to be obtained with the Biodent shade guide, although the assessments were encumbered with some uncertainty. The results obtained reflected that microfiller resins initially become lighter and then afterwards become darker (20, 22, 23). Furthermore, 94% of the restored teeth were evaluated as being darker at the 2-year examination than at base line after the acid-etching, and 72% showed increased darkening between the 2-year and the 11-year examination. The ideal, a restorative material that in time darkens like the natural tooth, has not been fulfilled with the resin material Silar. Indeed, it is likely that many of the present restorations will be replaced in the years to come because of unacceptable corpus discolorations, the clinical manifestation of the inferior color stability of the restorative material.

Both patients and dentists know that surface discoloration of resin restorations may be associated with daily habits such as smoking and tea-drinking. During the past few years there has, however, been an increased use of dentifrices that might counteract discolorations of teeth and restorations even among inveterate smokers. This is the most likely explanation for the reduced occurrence of surface discolorations after 11 years versus 6 years and may also be the reason why the association between smoking and surface discolorations was not significant at the final examination, as was the case previously. Indeed, the interviews with the patients showed that their daily habits with regard to smoking and consumption of coffee and tea were almost constant during the whole observation period, whereas twice as many patients told of a regular consumption of alcoholic beverages at the later recalls as after 2 years.

It is well known that organic acids and solvents such as alcohol may soften resin materials, but the previously found relationship between surface staining and plaque deposits on resin restorations could not be confirmed (31). However, the present investigation substantiated that continuous consumption of alcoholic beverages decreases the wear resistance and color stability of resin restorations and makes them more susceptible to surface staining.

During the past decade the chemically self-curing resin restoratives have almost been superseded by visible-light-curing materials with improved color stability. The restorative procedures have also been changed because of the more effective dentin

adhesives that have been marketed in the last few years. However, the improved clinical quality and durability of resin restorations placed with the latest materials and restorative procedures still have to be documented in longitudinal and cross-sectional studies.

References

1. Qvist V, Thylstrup A, Mjör IA. Restorative treatment pattern and longevity of resin restorations in Denmark. Acta Odontol Scand 1986;44:351–6.
2. Allander L, Birkhed D, Bratthall D. Quality evaluation of anterior restorations in private practice. Swed Dent J 1989;13:141–50.
3. Qvist V, Qvist J, Mjör IA. Placement and longevity of tooth-colored restorations in Denmark. Acta Odontol Scand 1990;48:305–11.
4. Mjör IA, Toffenetti F. Placement and replacement of resin-based composite restorations in Italy. Oper Dent 1992;17:82–5.
5. Qvist V. Resin restorations: leakage–bacteria–pulp. Endod Dent Traumatol 1993;9. In press.
6. Bryant RW, Rees FT, Ross ID. Clinical evaluation of a restorative resin with inorganic filler. Preliminary report and discussion. Aust Dent J 1979;24: 402–7.
7. Bozell RR, Charbeneau GT. Clinical evaluation of unetched, etched and etched-bonded class 3 and 5 composite restorations [abstract]. J Dent Res 1979;58:333.
8. Hammer B, Hotz P. Nachkontrolle von 1-bis 5jährigen Amalgam-, Komposit- und Goldgussfüllungen. SSO 1979;89:301–14.
9. Oram V, Lyders B. Marginal defects of etched and unetched composite resin restorations. A 2 years clinical investigation [abstract]. J Dent Res 1981; 60:1246.
10. Smales RJ. Effects of enamel-bonding, type of restoration, patient age and operator on the longevity of an anterior composite resin. Am J Dent 1991;4: 130–3.
11. Bayne SC, Shugars DA, Heymann HO, Wilder AD, Taylor DF. 10-year clinical analysis of etched vs non-etched anterior composites [abstract]. J Dent Res 1992;71:559.
12. Qvist V. Marginal adaptation of composite restorations performed in vivo with different acid-etch restorative procedures. Scand J Dent Res 1985;93: 68–75.
13. Qvist V, Ström C, Thylstrup A. Two-year assessment of anterior resin restorations inserted with two acid-etch restorative procedures. Scand J Dent Res 1985;93:343–50.
14. Strøm C, Qvist V. Four-year assessment of anterior resin restorations performed with two restorative procedures [abstract]. J Dent Res 1986;65:828.
15. Qvist V, Strøm C. Six-year assessment of anterior resin restorations performed with two restorative procedures [abstract]. J Dent Res 1988;67:139.
16. Siegel S. Nonparametric statistics for the behavioral sciences. New York: McGraw Hill, 1956.
17. Armitage P. Statistical methods in medical research. 4th ed. Oxford: Blackwell Scientific Publications, 1971.
18. Qvist V, Johannessen L, Lambjerg-Hansen H. En klinisk sammenligning af fyldninger i silikatcement og komposit plast efter 4–5 års funktionstid. Tandlaegebladet 1980;84:529–35.
19. Qvist V, Johannessen L, Lambjerg-Hansen H, Thylstrup A. Replacement of class III and V composite resin and silicate cement restorations [abstract]. J Dent Res 1984;63:576.
20. Ameye C, Lambrechts P, Vanherle G. Conventional and microfilled composite resins. I. Color stability and marginal adaptation. J Prosthet Dent 1981;46:623–30.
21. Buth K von, Janik G, Janik G, Klinke G. Klinische Untersuchungen zur Beurteilung des Kompositfüllungsmaterials Evicrol nach einer Funktionsperiode von zwei bis drei Jahren. Stomatol DDR 1982;32:115–22.
22. Christensen RP, Christensen GJ. In vivo comparison of a microfilled and a composite resin: a three-year report. J Prosthet Dent 1982;48:657–63.
23. Loyes K, Lambrechts P, Vanherle G, Davidson GL. Material development and clinical performance of composite resins. J Prosthet Dent 1982;48:664–72.
24. Schlapbach T, Hotz P, Roulet JF. Ein klinischer Vergleich konventionell und mikrogefüllter Komposits für Klasse-III-Füllungen—Resultate nach zwei Jahren. SSO 1982;92:667–80.
25. Gängler P, Hoyer J, Krehan F, Niemella S, Weinert W. Biologic testing and clinical trial of a visible light-curing composite resin restorative material. Quintessence Int 1990;21:833–42.
26. Bentley C, Drake CW. Longevity of restorations in a dental school clinic. J Dent Educ 1986;50:594–600.
27. Dijken JWV van. A clinical evaluation of anterior conventional, microfiller and hybrid composite resin fillings. A 6-year follow-up study. Acta Odontol Scand 1986;44:357–67.
28. Noort R van. Controversial aspects of composite resin restorative materials. Br Dent J 1983;155:380–5.
29. Dickinson GL, Leinfelder KF, Mazer RB, Russell CM. Effect of surface penetrating sealant on wear rate of posterior composite resins. J Am Dent Assoc 1990;121:251–5.
30. Leinfelder KF. Criteria for clinical evaluation of composite resin restorations. In: Anusavice KJ, editor. Quality evaluation of dental restorations. Criteria for placement and replacement. Chicago: Quintessence Publishing Co, 1989:139–46.
31. Asmussen E, Hansen EK. Surface discoloration of restorative resins in relation to surface softening and oral hygiene. Scand J Dent Res 1986;94:174–7.

Received for publication 11 March 1993