Cavity design and marginal degradation of the occlusal part of class-II amalgam restorations

Asbjörn Jokstad and Ivar A. Mjör
Department of Anatomy, School of Dentistry, University of Oslo, Oslo, and NIOM, Scandinavian Institute of Dental Materials, Haslum, Norway

Jokstad A, Mjör IA. Cavity design and marginal degradation of the occlusal part of class-II amalgam restorations. Acta Odontol Scand 1990;48:389–397. Oslo. ISSN 0001-6357.

The effect of variations in the design of class-II cavity preparations on the marginal degradation of amalgam restorations was included as a study aim in a clinical trial. Four hundred and sixty-eight restorations were placed in 210 patients by 7 Scandinavian dentists using 5 different alloys. The marginal degradation was scored on impressions of the restored teeth by means of a six-point ordinal rating scale. The scores were then compared with defined characteristics of the occlusal parts of the initial cavity preparations. Characteristics of the cavity that could be related to the marginal degradation were diverging occlusal cavity walls, occlusal cavity depth, fissures perpendicular to the cavosurface angle, and rough or variable occlusal cavosurface angles. Cavity preparation features not influencing the rate of degradation were the occlusal width, the location of the cavosurface angle on the cusp slope, occlusal cavosurface angles with sectors smaller than 90 degrees, and less than 1 mm enamel remaining between the cavity preparation and another restoration. The association between the different cavity design features and the marginal degradation varied with the different alloys. Superior marginal performance is probably the result of optimal condensation or surface treatment, rather than features of the cavity preparation. □ *Clinical study; dental materials; iatrogenic effects; marginal fractures; operative dentistry*

Asbjörn Jokstad, Department of Anatomy, Dental Faculty, P.O. Box 1052 Blindern, University of Oslo, N-0316 Oslo 3, Norway

It is difficult in clinical trials to standardize cavity preparations, since the size and the design of the cavity are primarily governed by the extent of the caries or of the restoration needing replacement. It is also recognized that the cavity preparation may vary among operators participating in clinical trials. However, few clinical studies have been conducted in which the long-term performance of amalgam restorations has been correlated to the design or quality of the prepared cavities (1). These studies have focused on selective features of the cavity design, such as the width of the cavity (2–9), proximal retention grooves (10, 11), or the angle or quality of the cavosurface angles (12–17). The aim of this study was to assess whether and how variations in the occlusal parts of the prepared cavities could influence the marginal degradation of the amalgam restorations.

In a previous report it was shown that the clinical performance of amalgam restorations could be significantly influenced by the operator (18). It has also been shown that the design and the average size of the cavity preparations differed among the operators (19), in addition to the prevalence of discrepancies (20). A further aim of this study was to assess whether the variations in the quality and the dimensions of the cavity preparations could explain the differences in clinical behavior of the restorations. In addition, it was of interest to establish whether the dependence on the cavity design varied with the amalgam alloys.

Materials and methods

A detailed description of the materials and methods has been given (18). Seven Scandinavian general practitioners placed 468 class II amalgam restorations in 210 patients. No

Table 1. The cavity design variables that were estimated possibly to influence the marginal degradation of the amalgam restorations. All measurements were done with a periodontal probe or a flexible Mylar strip with 1-mm markings. The measures were also related to the intercuspal distance and the distance of the relevant proximal circumference

Occlusal outline of the cavity, measured in millimeters

1. Width of the preparation over the axial wall
2. The maximum width
3. The distance between the maximum width and the axial wall
4. The minimum width
5. The distance between the minimum width and the axial wall
6. The mesiodistal extension relative to the axial wall

Assessed and described by location

7. Cavosurface angle located >2/3 of the cusp surfaces
8. Parts of enamel remaining < 1 mm next to previous restorations
9. Deep fissures extending from the cavosurface angle
10. Areas with cavosurface angle smaller or larger than 90°
11. Areas with changing cavosurface angles (facets)
12. Areas with diffuse or rough cavosurface angles
13. Areas with change of continuity—that is, all points within a 1-mm^2 wall or a 1-mm cavosurface angle not part of the same spatial plane or line

Proximal outline of the cavity, measured in millimeters

14. Width at the marginal ridge
15. Distance from marginal ridge to the gingival margin

Occlusal depth of the cavity, measured in millimeters

16. From the central groove of the occlusal surface to the pulpal wall
17. Same as above but over the pulpoaxial angle

Retention

18. Degree of occlusal discernible walls. Tooth inspected directly occlusally for parallel, converging, or diverging walls
19. Same as above but for the proximal part of the cavity

instructions on preparation design were issued; that is, no information on ideal, adequate, or minimum quality of the cavities was presented to the operators. While it was clear to the clinicians that the cavities were to be examined, they were not aware of what was to be checked and rated. The cavity preparations are therefore considered to reflect the clinical situation in everyday dental practices. All cavities were prepared and restored without the use of rubber dam.

Each operator took an impression

Table 2. Variables of the cavity design and observed differences between the categorical subgroups of the variable at one or several observation stages. The statistical significance levels are 0 = not statistically significant; * = $p < 0.05$; ** = $p < 0.01$

Variable no.	Categories	At year	Significance
7. Location of cavosurface angle on cusp slope	2	1,2,3,4,5	0
9. Continuous fissure from margin	2	2,3	**
		4	*
10–13. Rough and variable cavosurface angle	2	1,2,4	**
		3,5	*
16. Occlusal cavity depth	3	1,2,3,4	0
18. Occlusal converging or diverging walls	2	3	**
		4,5	*

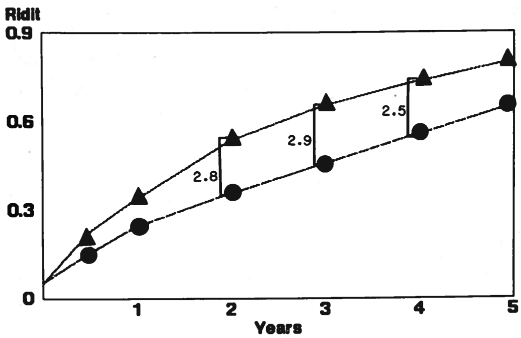

Fig. 1. The ridit means for the restorations placed in cavities with deep fissures perpendicular to the cavosurface angle (triangles, $n = 23$) and without deep fissures (circles, $n = 385$). The numbers at the brackets indicate the critical ratios between the mean ridits. Each paired comparison requires a critical normal curve value of 2.2 according to the Bonferroni criterion to be at a significant level of $\alpha = 0.05$, and 2.8 for $\alpha = 0.001$.

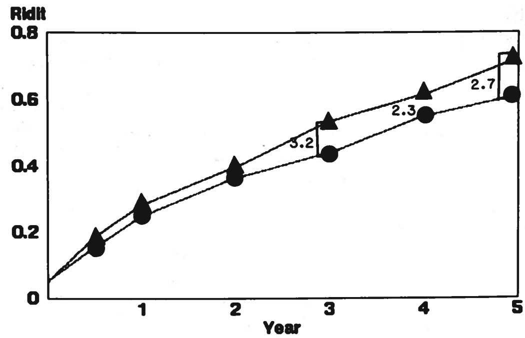

Fig. 3. The ridit means for the restorations placed in cavities with converging occlusal cavity walls (circles, $n = 261$) and with diverging occlusal cavity walls (triangles, $n = 177$). For further explanation, see Fig. 1.

(Optosil/Xantopren, Bayer) of the tooth immediately before the insertion of the amalgam. Epoxy plastic models were made from the impressions of the cavity preparations. The epoxy models were examined in a stereomicroscope (Spencer American Optical) at ×10 by one evaluator who lacked knowledge about the operators. A classification system applicable to models was used to categorize the various aspects of the cavities (21). The qualities and dimensions of the cavities as scored by this system have been described (19, 20). Nineteen variables of the cavity design that potentially influence the marginal degradation of the restorations were chosen from a list of 38 measured cavity design variables (Table 1). The number of categories for each cavity design variable varied from 2—that is, occlusal fissure connected to the cavosurface angle (Yes/No)—to 5—that is, cavity width (20%, 40%, 60%, 80%, 100% of the intercuspal distance). A crosscorrelation of the cavity design variables with calculations of the Pearson correlation coefficients showed interactions only between the different indexes for the buccolingual cavity widths ($p < 0.05$). The variables of the cavity designs were therefore treated as independent variables. The scores for each category were transformed to ridit values for all variables (22). Ridit analyses and paired comparison tests using the Bonferroni correction factor were used to determine differences between the various aspects of the cavities at the different observation periods (23).

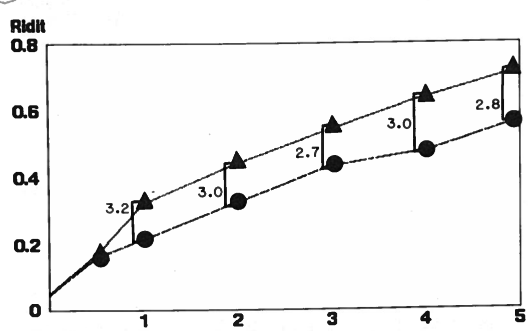

Fig. 2. The ridit means for the restorations placed in cavities with rough and variable cavosurface angles (triangles, $n = 112$) and with smooth cavosurface angles (circles, $n = 326$). For further explanation, see Fig. 1.

Results

The cavity design variables that influenced the average marginal degradation at one or more observation stages are shown in Table 2. The ridit scores of the restorations in the different categorical subgroups of these variables are shown in Figs. 1–3. The degree of marginal degradation seemed related to the occlusal depth of the preparation—that

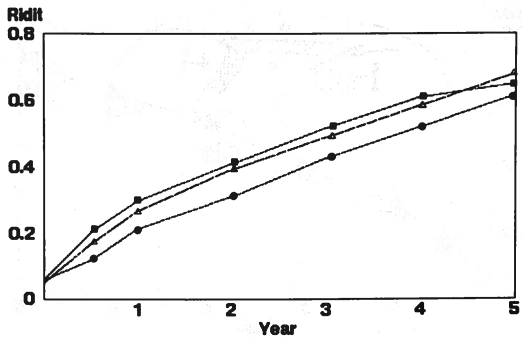

Fig. 4. The ridit means for the restorations placed in cavities with shallow occlusal depth (circles: less than 2 mm, $n = 91$), medium (triangles, $n = 294$) or in deep cavities (squares: more than 3 mm, $n = 56$). No paired comparisons reach the required critical normal curve value of 2.4 accroding to the Bonferroni criterion to be at a significance level of $\alpha = 0.05$.

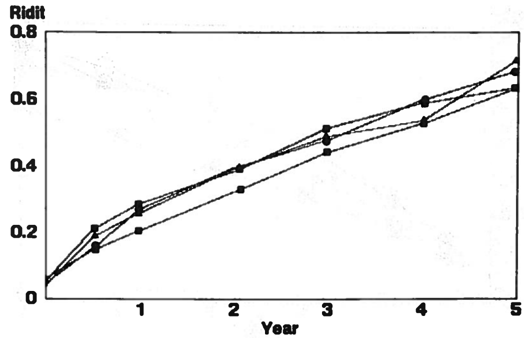

Fig. 6. The ridit means for the restorations placed in cavities of different widths. Circles: less than one-fourth of the intercuspal distance ($n = 206$); triangles: more than three-fourths of the intercuspal distance ($n = 44$); squares: one-fourth to half ($n = 81$) and half to three-fourths ($n = 106$) of the intercuspal distance. No paired comparisons reach the required critical normal curve value of 2.6 according to the Bonferroni criterion to be at a significance levels of $\alpha = 0.05$.

is, the bulk of the restoration. However, the differences between the subgroups of the cavity depth were not statistically significant ($p > 0.05$) (Fig. 4). A weak relationship of the marginal degradation to the location of the cavosurface angle on the cusp slope was noted (Fig. 5), but not to the occlusal buccolingual cavity width (Fig. 6). Cavosurface angles with sectors smaller than 90°, on the occlusal surface, could not be related to increased marginal degradation (Fig. 7). Nor could slices of less than 1 mm enamel remaining between the new preparation and former restorations be associated with the degree of degradation (Fig. 8).

The clinical performance of the amalgam restorations placed by one of the operators was significantly better than those placed by the other six operators (18). Further analyses were performed to relate this finding to any typical specific cavity design features. The operator prepared cavities that were enlarged compared with the average cavity size of the other operators (Fig. 9), but the

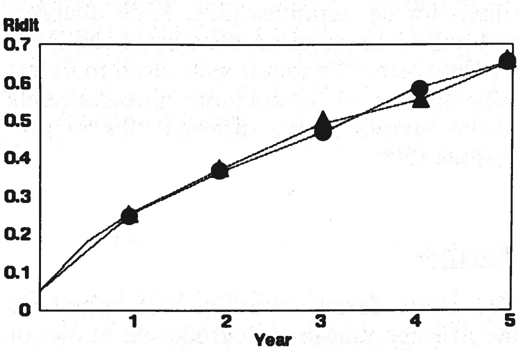

Fig. 5. The ridit means for the restorations placed in cavities with the cavosurface angle located occlusally to two-thirds of the cuspal incline (triangles, $n = 171$), and gingivally to two-thirds of the cuspal incline (circles, $n = 271$). No paired comparisons reach the required critical normal curve value of 2.2 according to the Bonferroni criterion to be at a significance level of $\alpha = 0.05$.

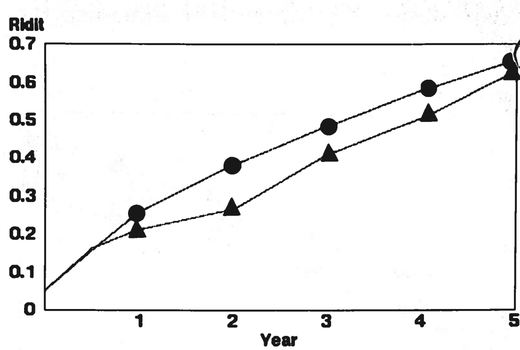

Fig. 7. The ridit means for the restorations placed in cavities with unsupported enamel occlusally (triangles, $n = 25$) and in cavities without supported enamel occlusally (circles, $n = 415$). No paired comparisons reach the required critical normal curve value of 2.2 according to the Bonferroni criterion to be at a significance level of $\alpha = 0.05$.

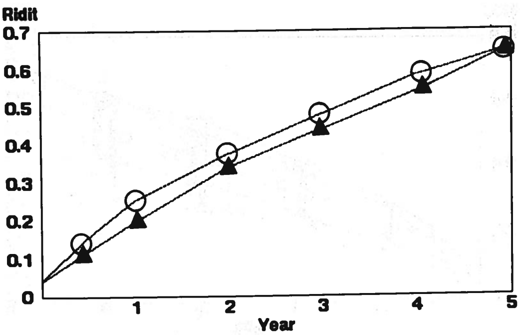

Fig. 8. The ridit means for the restorations placed in cavities with less than 1 mm enamel remaining between the new preparation and former restorations (triangles, $n = 65$) and in cavities without remaining enamel (circles, $n = 240$). No paired comparisons reach the required normal curve value of 2.2 according to the Bonferroni criterion to be at a significance level of $\alpha = 0.05$.

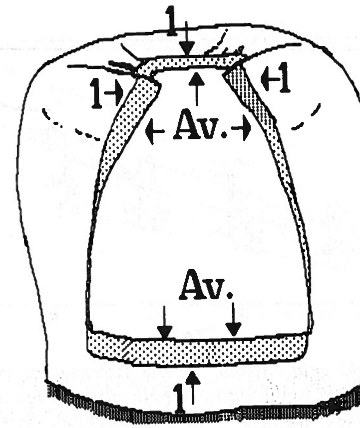

Fig. 9. The average external cavity outline of the preparations made by six of the participating operators (blank areas, marked with arrows and 'Av.', $n = 335$) and by the operator with the restorations with superior clinical performance (shaded areas, marked with arrows and '1', $n = 108$).

prevalence of preparation discrepancies did not differ from the other six operators, except by a lower frequency of preparations with diverging occlusal cavity walls (Table 3). The age and the oral health status of the operator's patients did not differ from those of the other patients.

The relationship between the cavity design features and the marginal degradation was in general similar for the restorations made by the operator with the superior restorations and the other six operators. The ridit scores for the different cavity design variables in the two subgroups showed the same patterns for the cavosurface angle qualities (Fig. 10), the cavity depth (Fig. 11), and the location of the cavosurface angle on the cusp slope (Fig. 12). A possible influence of the cavity width on marginal degradation could not be observed. The ridit scores for the restorations in the cavities with diverging and with converging occlusal cavity walls were more similar when the operator with the superior restorations was excluded from the sample (Fig. 13).

The effect of the different cavity design variables on the marginal degradation varied also with the different alloys. An inverse relationship was observed between the buccolingual cavity width and the marginal degradation of the alloys Revalloy and Amalcap. The alloys Tytin, Indiloy, and Dispersalloy showed a gradual increase of the marginal degradation with the increased cavity widths (Fig. 14). This phenomenon was also present for two other cavity variables:

Table 3. The prevalence of external cavity discrepancies made by operator 1 and by the other operators

	Operator 1	Operators 2–7
Continuous fissures from cavosurface angle	3%	5%
Rough and variable cavosurface angles	45%	45%
Diverging occlusal cavity walls	5%	25%
Occlusal unsupported enamel	3%	5%
Cusp reduction > 2/3	60%	27%
Remaining parts of enamel < 1 mm	15%	20%

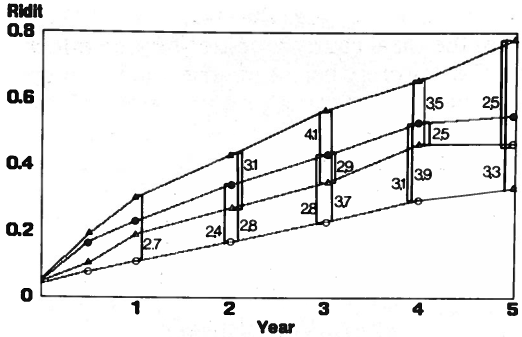

Fig. 10. The ridit means for the restorations placed in cavities with rough and variable cavosurface angles (triangles) and with smooth cavosurface angles (circles). The ridit scores are for the restorations made by operator 1 (open symbols, $n = 30$ and $n = 40$, respectively) and by the six other operators (closed symbols, $n = 82$ and $n = 287$, respectively). The numbers at the brackets indicate the critical ratios between the mean ridits. Each paired comparison requires a critical normal curve value of 2.4 according to the Bonferroni criterion to be at a significance level of $\alpha = 0.05$, and 3.1 for $\alpha = 0.01$. Compare with Fig. 2.

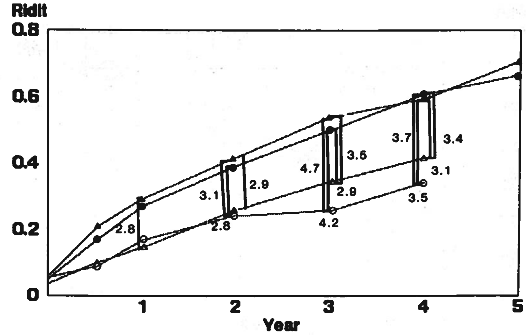

Fig. 12. The ridit means for the restorations placed in cavities with the cavosurface angles located occlusally (triangles) and gingivally (circles) to two-thirds of the cuspal incline; the ridit scores are for the restoration made by operator 1 (open symbols, $n = 37$ and $n = 33$, respectively) and by the six other operators (closed symbols, $n = 134$ and $n = 238$, respectively). The numbers at the brackets indicate the critical ratios between the mean ridits. Each paired comparison requires a critical normal curve value of 2.6 according to the Bonferroni criterion to be at a significance level of $\alpha = 0.05$, and 3.1 for $\alpha = 0.01$. Compare with Fig. 5.

the placement of the cavosurface angle on the cusp slope and the proximal cavity width at the marginal ridge. The effect of diverging versus converging occlusal cavity walls on the marginal degradation was also more pronounced for Tytin, Indiloy, Dispersalloy and Amalcap than for Revalloy (Fig. 15).

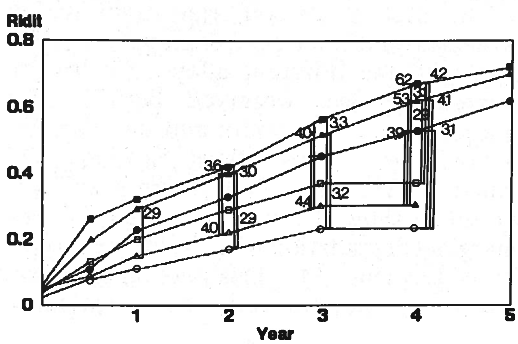

Fig. 11. The ridit means for the restorations placed in cavities with shallow occlusal depth (circles: less than 2 mm), medium depth (triangles), or in deep cavities (squares: more than 3 mm); the ridit scores are for the restorations made by operator 1 (open symbols, $n = 11$, $n = 45$, and $n = 14$, respectively) and by the six other operators (closed symbols, $n = 80$, $n = 250$, and $n = 42$, respectively). The numbers at the brackets indicate the critical ratios between the mean ridits. Each paired comparison requires a critical normal curve value of 2.9 according to the Bonferroni criterion to be at a significance level of $\alpha = 0.05$, and 3.4 for $\alpha = 0.01$. Compare with Fig. 4.

Discussion

In most clinical trials emphasis is placed on

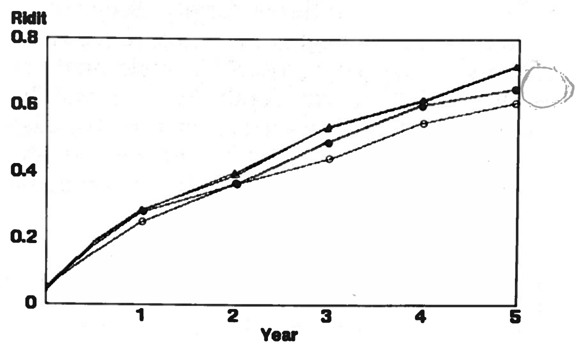

Fig. 13. The ridit means for the restorations placed in cavities with converging occlusal cavity walls (circles), and with diverging walls (triangles), not including the restorations made by operator 1 (closed symbols, $n = 173$ and $n = 191$) and superimposed on Fig. 3 (open symbols). No paired comparisons reach the required critical normal curve value of 2.6 according to the Bonferroni criterion to be at a significance level of $\alpha = 0.05$.

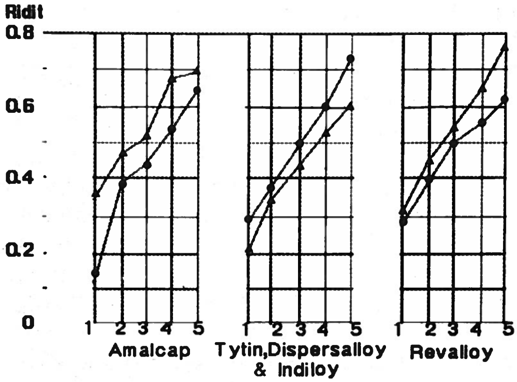

Fig. 14. The ridit means for the restorations over 5 years, made with different alloys and placed in cavities of different widths. The ridit scores are for the restorations made from Amalcap, from Tytin, Dispersalloy and Indiloy, and from Revalloy. Triangles, less than one-fourth of the intercuspal distance; circles, more than three-fourths of the intercuspal distance.

making optimal cavity preparations under standardized conditions. This aim differed from that in the present study. While maintaining the control of as many variables as possible, the design of the study was that the cavity preparations should represent the regular clinical work performed by the dental

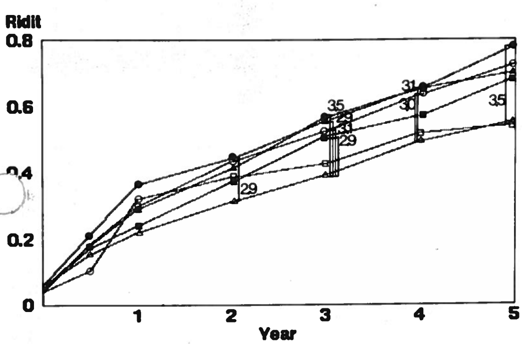

Fig. 15. The ridit means for the restorations placed in cavities with converging occlusal cavity walls (open symbols) and with diverging walls (closed symbols); the ridit scores are for the restorations made from Revalloy (circles, $n = 81$ and $n = 51$), Amalcap (triangles, $n = 43$ and $n = 38$), and Tytin, Indiloy, and Dispersalloy (squares, $n = 138$ and $n = 88$). The numbers at the brackets indicate the critical ratios between the mean ridits. Each paired comparison requires a critical normal curve value of 2.9 according to the Bonferroni criterion to be at a significance level of $\alpha = 0.05$, and 3.4 for $\alpha = 0.01$. Compare with Fig. 3.

practitioners. Since these often deviated from the ideal cavity preparation, the effects of the discrepancies of the cavity preparations on marginal degradation of the amalgam restoration could be assessed. Although the variables of the cavity design in the present study were considered independent variables, interaction effects should not be ignored. However, this could not be assessed because of the design of and the relatively low number of observations in the present study.

Twenty-five restorations had been placed in cavities with sectors of the occlusal cavosurface angle that measured less than 90°. There were also 65 restorations placed in cavities in which less than 1 mm enamel was observed between the new preparation and former restorations. These restorations did not show any increased marginal degradation compared with the other restorations. The data thus suggest that sectors with cavosurface angles of less than 90° or thin enamel slices or areas occlusally do not fracture and contribute to the size of the margin ditch. It is acknowledged that this conclusion is only valid for the occlusal surface, since it is well established that unsupported enamel along the cavosurface angle on the proximal surface shows microcracking after use of the amalgam matrix (24, 25). Although previous investigators suggest that the amalgam margin angle (AMA) influences the margin degradation more than the cavosurface angle (CSA), their studies show that enamel along the cavosurface angles seldom fractures (13, 15, 17, 26). The origin of the high occlusal cavosurface angle is attributed to the original cavity designs of Black (27). However, the feature was a result of the principle that the axial walls should be perpendicular to the flat pulpal floor and not the result of the direction of the enamel prisms, since it was recognized that on the occlusal surface the angulation of the individual prisms showed considerable variation (28). Later investigators have confirmed these observations (29). On the other hand, a literature search for any clinical studies supporting the rationale for preparing occlusal cavosurface angles with at least 90° did not discover any references related to amalgam restorations.

Only one report suggested that unsupported enamel could be conserved with success when restoring teeth with resin-based materials (30). The reason the occlusal cavosurface angles smaller than 90° or thin enamel slices or areas could not be associated with the degree of the marginal degradation was presumably related to these variations in the enamel prism directions. The data thus indicate that cavosurface angles smaller than 90° or pieces of enamel remaining between the preparation and former restorations are not necessarily unsupported by sound dentin and should not be removed unless the enamel can be split off with a hand instrument.

The ridit scores for the 23 restorations placed in the cavities where a deep fissure was seen in continuation with the cavosurface angle were significantly higher than the score for the other restorations. In almost all cases these fissures became obliterated with amalgam after insertion of the restoration. The excess fractured after variable periods, and in some restorations the size of the fractured surface also gradually increased. No secondary caries was registered at these locations during the 5-year observation period. The relatively few observations in the present study preclude any generalized conclusions about the controversial opinions on the necessity of including the full fissure system in occlusal preparations (31, 32).

Although several different measures for the buccolingual widths were calculated, no correlations between any of these and the marginal degradation could be observed. The lack of correlation has also been observed in earlier studies (7–9), whereas other authors report a significant relationship (2–6). It is difficult to compare the results in these reports, as the methods for measuring the size and quality of the cavosurface angle are seldom described. A detail that may remain undetected in narrow preparations is the mutilated or large cavosurface angle on the contralateral surface, which frequently is present unless specially shaped burs are used (33). It is also uncertain to what extent the higher amalgam margin angles routinely carved in narrow cavities may influence the clinical behavior (13, 15). Finally, the lack of consistency in the previous reports may also be explained by a variable effect of the cavity width for different types of alloy (Fig. 14).

Amalgams made from different alloys behaved differently when placed by the different dentists. This difference in clinical behavior could partly have been related to the operators' variation in cavity preparation. However, the only cavity design factors that differed were the average cavity depths and the prevalence of cavities with converging occlusal cavity walls. It is therefore probable that the superior performance of amalgam restorations, as exemplified by those placed by one operator in the present study, is related to the condensation or surface treatment of the material, rather than the cavity preparation. Furthermore, although the morphology of the prepared cavity may influence the clinical performance of amalgam restorations, this influence varies slightly with alloy and with properly versus less optimally condensed restorations.

References

1. Thomas AE. Evaluation of principles of cavity preparation design. Ala J Med Sc 1970;20:379–82.
2. Nadal R, Phillips RW, Swartz ML. Clinical investigation on the relation of mercury to the amalgam restoration. 2. J Am Dent Assoc 1961;62:488–96.
3. Wilson CH, Ryge G. Clinical study of dental amalgam. J Am Dent Assoc 1963;66:763–71.
4. Osborne JW, Gale EN. Failure at the margin of amalgams as affected by cavity width, tooth position and alloys selection. J Dent Res 1981;60:681–5.
5. Berry TG, Laswell HK, Osborne JW, Gale EN. Width of isthmus and marginal failure or restorations of amalgam. Oper Dent 1981;6:55–8.
6. Weiland M, Nossek H, Schulz P. Zur klinischen bewertung der amalgamfüllungstheraphie der kavitätenklassen I & II. 1. Einfluss von lokalisation, grösse, alter & politur der füllung sowie patientalter und mundhygiene. Stomatol DDR 1988;38:801–5.
7. Birtcil RF Jr, Pelzner RB, Stark MM. A 30-month clinical evaluation of the influence of finishing and size of restoration on the margin performance of five amalgam alloys. J Dent Res 1981;60:1949–56.
8. Mjör IA, Espevik S. Assessment of variables in clinical studies of amalgam restorations. J Dent Res 1980;59:1511–5.
9. Mahler DB, Marantz RL. Marginal fracture of amalgam. Effect of type of tooth and restoration class and size. J Dent Res 1980;59:1497–1500.
10. Terkla LG, Mahler DB. Clinical evaluation of inter-

proximal retention grooves in class II amalgam cavity design. J Prosthet Dent 1967;17:596–602.
11. Grieve AR. Marginal adaption of amalgam in relation to the finish of cavity margins. Br Dent J 1971;130:239–42.
12. Elderton RJ. An in vivo morphological study of cavity and amalgam margins on the occlusal surfaces of human teeth [Thesis]. London: University of London, 1975.
13. Elderton RJ. The quality of amalgam restoration. In: Allred H, ed. Assessment of quality of dental care. London: Dorriston Ltd, 1977:45–81.
14. Akerboom HB, Borgmeyer PJ, Advokaat JG, Van Reenen GJ. The influence of the preparation on the marginal-breakdown of amalgam-restoration. Results after 3 years. IADR Program and abstracts of papers, No. 844, 1981.
15. Elderton RJ. Cavo-surface angles, amalgam margin angles and occlusal cavity preparations. Br Dent J 1984;156:319–24.
16. Swartz ML, Phillips RW. Evaluation of cavosurface design and microleakage. Gen Dent 1984;32:56–8.
17. Grajower R, Novickas D. The amalgam margin angle, marginal breakdown and adjacent caries in occlusal enamel, a pilot study on extracted teeth. J Oral Rehabil 1988;15:257–68.
18. Jokstad A, Mjör IA. Clinical variables affecting the marginal degradation of amalgam restorations. Acta Odontol Scand 1990;48:379–87.
19. Jokstad A. The dimensions of everyday class-II cavity preparations for amalgam. Acta Odontol Scand 1989;47:89–99.
20. Jokstad A, Mjör IA. The quality of routine class II cavity preparations for amalgam. Acta Odontol Scand 1989;47:53–64.
21. Jokstad A, Mjör IA. Cavity designs for class II amalgam restorations. A literature review and a suggested system for evaluation. Acta Odontol Scand 1987;45:257–73.
22. Bross ID. How to use ridit analysis. Biometrics 1958;14:18–37.
23. Fleiss JL, Chilton NV, Wallenstein S. Ridit analysis in dental clinical studies. J Dent Res 1979;58:2080–4.
24. Boyde A, Knight PJ. Scanning electron microscope studies of class II cavity margins. Matrix band application. Br Dent J 1972;133:323–5.
25. Krainau R. Verformungsmessung an kavitäten der klasse II unter matrizenbandeinwirkung [Thesis]. Göttingen: University of Göttingen, 1985.
26. Jørgensen Dreyer K, Wakumoto S. Occlusal amalgam fillings: marginal defects and secondary caries. Odontol Tidskr 1968;76:43–54.
27. Black GV. A work on operative dentistry. Vol. II. Technical procedures in filling teeth. 2nd ed. Woodstock: Medico-dental Publ. Co., 1914:154–206.
28. Black GV. A work on operative dentistry. Vol. II. Technical procedures in filling teeth. 2nd ed. Woodstock: Medico-dental Publ. Co., 1914:100–2.
29. Boyde A. Enamel structure and cavity margins. Oper Dent 1976;1:13–28.
30. Fusayama T. New concepts in operative dentistry. Chicago: Quintessence Publishing Co. Inc., 1980.
31. Bodecker CF. Eradication of enamel fissures. Dent Items Int 1929;51:859.
32. Sturdevant CM, Barton RE, Sockwell CL, Strickland WD. The art and science of operative dentistry. St Louis: The C.V. Mosby Co., 1985.
33. Kinzer RL, Morris C. Instruments and instrumentation to promote conservative operative dentistry. Dent Clin North Am 1976;20:241–58.

Received for publication 20 October 1989