# Adaptation of resin facings to cast gold alloy restorations in the mouth

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The occurrence of marginal spaces between the resin facing and gold alloy framework in 176 crowns and bridge retainers was studied. The restorations were made for canine teeth. The assessment of spaces at the cervical alloy–resin junction was carried out by examining slides of the buccal surfaces taken after application of disclosing agent. Spaces at the incisal alloy–resin junction were assessed by examining resin models under the stereomicroscope. Randomly selected restorations were grouped and examined with reference to length of clinical service (1, 3, 6, and 9 years). The methods were tested for reliability and consistency. The results showed that the frequency of cervical spaces tended to increase with length of clinical service, whereas the frequency of the incisal spaces seemed to remain unchanged. The most severely worn facings had the highest frequency of cervical spaces. In contrast, the least worn facings seemed to have the highest frequency of incisal spaces. For both the cervical and the incisal spaces the highest frequencies were found for relatively long resin facings. □ *Resin facing adaptation; resin-veneered cast restorations*

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The properties that are considered critical to the manner in which resins act in the mouth when used as facing material in full crowns and pontics comprise wear resistance, water sorption, linear coefficient of thermal expansion, hardness, compressive and tensile strength, and color stability (1). It has been shown that minute spaces between the resin facing and the gold alloy in full crowns and pontics form pathways of seepage (2–4). The presence and dimensional changes of the spaces between the metal and the resin material have been associated with the curing shrinkage, absorption of water, lack of adhesion, and other factors such as stress release in function, modulus of elasticity, design of the metal framework, and the retention of the resin facing (see, for example, 1, 5–7). The laboratory properties have been and are useful in understanding the usage and limitations of resins when selecting material for facings in prosthodontic work for a patient. Although resins as a veneer have been applied for years, the correlations between the results of the laboratory studies and their clinical behavior have not been firmly established.

The present study was undertaken to study in the mouth some factors influencing the prevalence and the pattern of occurrence of spaces at the alloy–resin junction in full crowns with resin facings used as single crowns and retainers in bridge constructions.

## Materials and methods

The material consisted of 176 gold alloy–resin crowns made for 176 patients. The restorations included both single crowns and bridge retainers made for canine teeth (8). The patient population and selection and the materials used in the fabrication of the restorations have been described previously (Table 1) (9).

The spaces at the alloy–resin junction were studied by evaluating slides of the labial/incisal surfaces of the restored teeth. Before the photographs were taken, the surfaces were rinsed with water, dried with air, and

Table 1. Distribution and number of individuals within the test groups

| | Tooth no. | | | |
|---|---|---|---|---|
| | 13 | 23 | 33 | 43 |
| Group I (1 year), *n* | 10 | 11 | 11 | 10 |
| Group II (3 years), *n* | 10 | 12 | 10 | 10 |
| Group III (6 years), *n* | 11 | 11 | 12 | 10 |
| Group IV (9 years), *n* | 12 | 12 | 12 | 12 |

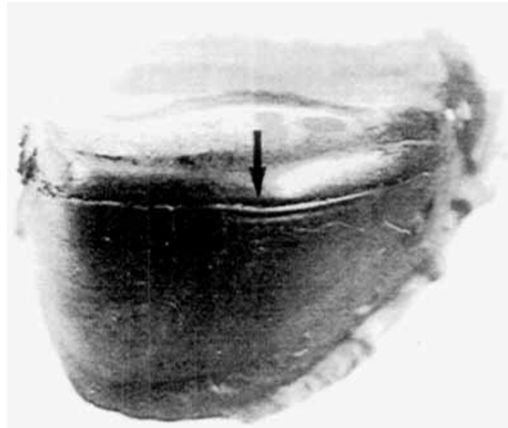

Fig. 2. Photograph taken through a stereomicroscope showing a space between the resin facing and the incisal gold protection (arrow) in a gold-coated resin model.

stained with a plaque-disclosing agent (Erythrocin E-127). The stain was applied with wafers containing the disclosing solution (Rondell Rød, LIC Dental, Sweden). Thereafter, the surfaces were rinsed with water and dried. A Nikon camera and a Medical Nikkor lens 120 mm, F4 (Nikon, Japan), together with a Kodak Ektachrome 100 slide film (Kodak, U.K.) were used to take photographs of the crowns. Conditions of illumination, exposure, and magnification (×2) were standardized.

During the calibration sessions and at the clinical examination it became evident that incisal spaces, contrary to the cervical ones, were inconsistently, partly, or indefinitely stained by the disclosing agent and could not be assessed by means of the scale used. It was therefore decided to assess the presence or absence of spaces at the incisal alloy–resin junction in resin models, whereas the assessment of cervical spaces was based on the observations made after application of the disclosing agent.

Assessment of the adaptation of the cervical part of the facing to the metal structure was done in accordance with a dichotomous scale. The scores were recorded as observed in the slides. Absence of stainable matter at the alloy–resin junction was assigned a score of 1, and score 2 was assigned in the presence of a band of disclosed matter at the junction (Fig. 1). The slides were projected on a screen and examined in an adequately illuminated lecture room. Total magnification was about ×100.

The incisal fit of the facing to the framework was studied in resin models of the buccal/incisal surfaces. The models were produced from rubber impressions (President, light-body, Coltene, Switzerland) which were taken with custom-made self-curing acrylic trays (GC Ostron 100, GC Dental Industrial Corp., Japan). For the production of the models an epoxy resin was used (Epofix, Struers, Denmark), which was

Table 2. Percentage agreement (PA) and kappa statistic (K) for the intra- and inter-observer comparisons made in the study of the cervical and incisal adaptation

| | Intraobserver comparison | | |
|---|---|---|---|
| | Observer 1 (MB) | Observer 2 (JS) | Interobserver comparison |
| Cervical spaces | PA = 91.6% | PA = 96.6% | PA = 85% |
| | K = 0.86 | K = 0.93 | K = 0.65 |
| Incisal spaces | PA = 87.5% | PA = 91.6% | PA = 86.6% |
| | K = 0.75 | K = 0.84 | K = 0.73 |

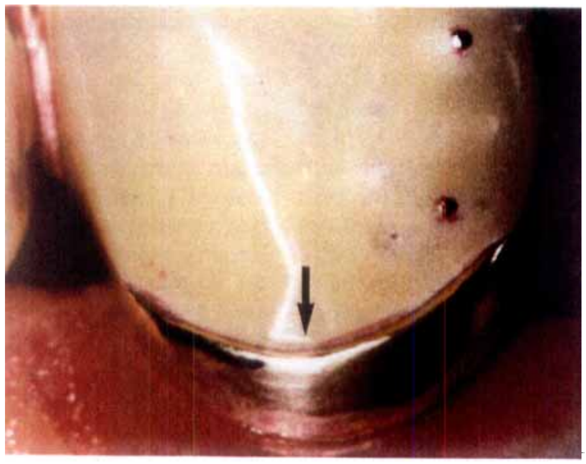

Fig. 1. Clinical photograph demonstrating space score 2 at the cervical alloy–resin junction (arrow) after application of the disclosing agent (Rondell Rød, LIC).

allowed to set for at least 48 h at room temperature before further handling. The surface of the model was coated with gold by sputtering for 2 min before examination in a stereomicroscope (Nikon SMZ-2 No. 106743, Nikon), using a fiberoptic light source (Fi L100, Fiberoptic-Heim AG, Switzerland) at a magnification ×10.

Assessment of the incisal spaces was based on observations in the stereomicroscope. Score 1 was assigned when a continuous surface at the alloy–resin junction was observed. Score 2 was recorded when a space was observed (Fig. 2). When the incisal alloy–resin junction showed both a score 1 and a score 2 along the mesiodistal extension, a score of 2 was recorded.

To assess the reliability of the two methods, the authors examined a 17% random sample ($n = 30$) of the units twice independently. The examination took place after several calibration sessions. The percentages of agreement for each observer and for interobserver comparisons were in compliance with the standard of 85–90% indicated by WHO (10) (Table 2). The kappa statistics (11) calculated for the assessment of the cervical adaptation were 'almost perfect' for each observer and in the range of 'substantial strength of agreement' for the interobserver comparison (Table 2) in accordance with the guidelines of Landis & Koch (11). The kappa values calculated for the assessment of the incisal adaptation demonstrated that one observer achieved a value within the range of 'almost perfect' and the other a value within the range of 'substantial strength of agreement' (Table 2). The same level appeared for the interobserver comparison (Table 2). Thus, the results of the test of the methods showed that the score assignments for each observer and between the observers were acceptably consistent. One of the authors (M. Berge) carried out the whole sample examination accordingly.

The comparison of the results of the examination of the spaces at the alloy–resin junction showed that there was no statistical difference between the single crowns and the bridge retainers. This was true for both the incisal and the cervical junctions ($p > 0.05$).

Table 3. The criteria used for the evaluation of the wear of the resin facings

| | |
|---|---|
| Score 1 = | No visible evidence of wear |
| Score 2 = | A positive difference in surface levels between the surrounding gold alloy and the resin material |
| Score 3 = | The metal substructure shows through the facing material |
| Score 4 = | Exposure of metal either as isolated area(s) or spot(s) in the facing or as increased visible areas of the gold alloy along the periphery |

Therefore, the data for single crowns and bridge retainers were combined in the statistical analyses of the results of the observations. The examination showed also that 11 cervical units could not be evaluated because the alloy–resin junctions were within the gingival pockets. Six incisal junctions could not be assessed because of failures in the production of the epoxy resin models.

To study the relationship between the resin wear and the cervical adaptation of the facing, wear was assessed in slides taken before the application of the disclosing agent. The photographic techniques were as already described. Wear was assessed in accordance with a graded scale with criteria as shown in Table 3 (9). The associations between the wear and the cervical and the incisal adaptation scores were analyzed statistically.

The sample was divided into two subsamples on the basis of their history of previous periodontal treatment at the Department of Periodontology. The information about the treatment was collected from the patients' records and their own statements at the clinical examination. The adaptation scores of the patients who had received periodontal treatment including instruction in systematic methods for improving oral hygiene at the Department of Periodontology ($n = 122$) were compared statistically with the scores of the non-instructed individuals ($n = 52$).

The cervical–incisal length dimensions of the facings were measured mid-buccally parallel to the long axis of the crowns. The measurements were made twice with a cali-

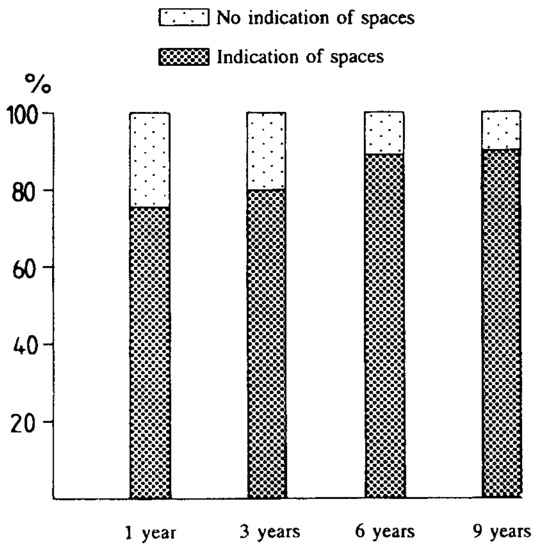


Fig. 3. Frequency distribution of percentage cervical spaces for group I, 1 year; group II, 3 years; group III, 6 years; and group IV, 9 years.

per to the nearest 1 mm, and the average of the two determinations was used in the statistical analyses. The reproducibility of the method was tested by calculating the correlation coefficient for the two series and by analyzing the differences between the first and the second measurements by the *t* test. The correlation coefficient was 0.96 ($p < 0.001$) and the *t* value 0.67 ($p = 0.50$). It may be concluded, therefore, that the reproducibility was satisfactory. The results of the facing length measurements showed that the average length in women was $9.5 \pm 2.0$ mm and in men $9.6 \pm 2.8$ mm. The difference was not statistically significant. The average length of the upper jaw facings was $10.2 \pm 1.7$ mm and that for the lower jaw facings $8.9 \pm 2.1$ mm. This difference was statistically significant ($t = 4.58$, $p < 0.001$). In the statistical analyses the lengths were categorized and related to the occurrence of spaces at the alloy–resin junction. The categories were category 1, $\leqslant 8$ mm; category 2, 8.1–10.0 mm; and category 3, $\geqslant 10.1$ mm. The results of the comparison of the distributions of the three categories among the four study groups showed that the differences were not statistically significant.

### *Statistical methods*

Chi-square tests were used to evaluate associations and differences for the comparisons made (12). The level of significance corresponded to a level of probability equal to or less than 5%.

## Results

Since the methods of assessing the prevalence of cervical and incisal spaces at the alloy–resin junction were different, the results of the cervical and incisal observations are reported separately.

### *Cervical spaces versus variables*

Comparison of the distribution of the adaptation scores (1 and 2) for the two jaws and both sexes in the four age groups (groups I, II, III, and IV) showed that the percentage of score 2 was 75.6 in group I, 80 in group II, 88.9 in group III, and 90.3 in group IV (Fig. 3). There was thus an association between the length of clinical service and prevalence of cervical spaces between the resin material and the gold alloy metal framework. The results after combining groups I + II and groups III + IV showed that the association was significant at the 5% level (F + M: chi-square = 4.02, $p = 0.04$, d.f. = 1).

Analysis of the overall wear and the occurence of cervical spaces showed that the cases with spaces accounted for 91.1% of the 3 + 4 wear scores and 77.7% of the 1 + 2 scores. The difference in number of restorations with and without spaces was statistically significant (F + M: chi-square = 10.34, $p = < 0.02$, d.f. = 3). Examination of the relation between cervical spaces and wear in the upper jaw showed that restorations with spaces answered for 100% of the 3 + 4 scores and 77.7% of the 1 + 2 scores. Thus, the difference in wear for the upper jaw between restorations with and without spaces was statistically significant

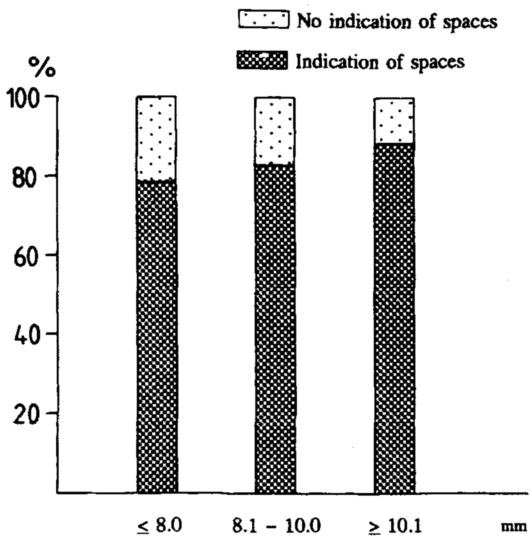


Fig. 4. Frequency distribution of percentage cervical spaces in restorations of different categories of facing lengths (category 1, ≤8.0 mm; category 2, 8.1–10.0 mm; category 3, ≥10.1 mm).

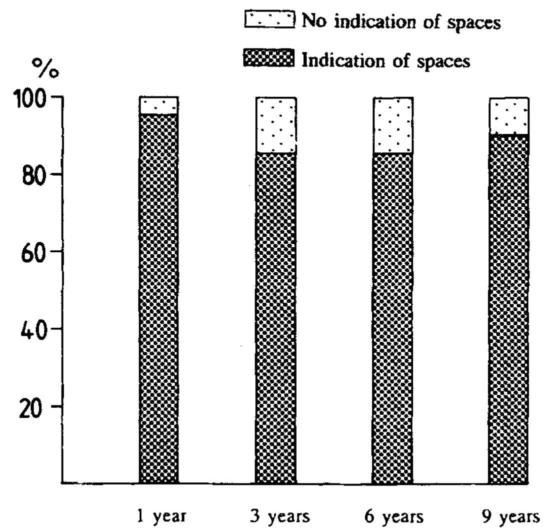


Fig. 5. Frequency distribution of percentage incisal spaces for group I, 1 year; group II, 3 years; group III, 6 years; and group IV, 9 years.

(F + M: chi-square = 8.51, $p < 0.04$, d.f. = 3). In the lower jaw the corresponding percentages were 85.7 and 77.7, respectively. The difference approached statistical significance at the 5% level. Thus, the most severely worn facings tended to have a higher frequency of cervical spaces.

Comparison of the prevalence of cervical spaces between those who had been instructed in oral hygiene measures at the Department of Periodontology and those who had not showed that 85.8% of the instructed subjects had cervical spaces, as against 77.7% of the non-instructed subjects ($p > 0.05$).

Examination of the relationship between the cervical–incisal length of the facings and the occurrence of cervical spaces showed that on an average restorations with the relatively long facings (≥10.1 mm) had the highest frequency of cervical spaces (Fig. 4). The difference between category 1 (≤8.0 mm) and categories 2 and 3 combined (≥8.1 mm) were not statistically significant. In both jaws facings ≥10.1 mm had the highest frequency of cervical spaces. The results of the comparisons showed no statistical significance.

*Incisal spaces versus variables*

Comparison of the occurrence of incisal spaces (scores 1 and 2) for the two jaws and both genders in the four age groups (groups I–IV) showed that there was no statistically significant association between length of service and the occurrence of spaces (Fig. 5).

Examination of the relationship between the upper and lower jaws showed that the occurrence of incisal spaces was statistically different in the two jaws (F + M: chi-square = 6.75, $p < 0.01$, d.f. = 1) (Fig. 6). Incisal spaces seemed to be more frequent in the upper jaw than in the lower jaw.

Analysis of overall wear and the occurrence of incisal spaces showed that restorations with wear scores 3 + 4 had the least frequency of incisal spaces. Restorations with scores 1 + 2 had a percentage of spaces of 93.4, versus 84.0 for restorations with 3 + 4 scores. Statistically this difference was not significant.

Comparison of the occurrence of incisal spaces between those who had been instructed how to improve oral health at the Department of Periodontology and those who had not showed that in instructed

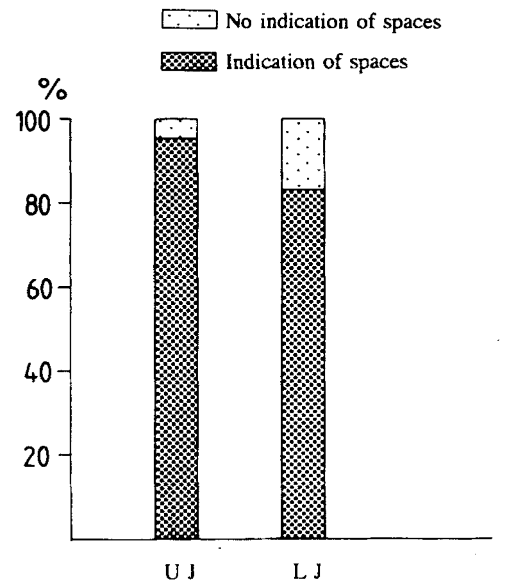


Fig. 6. Frequency distribution of percentage incisal spaces in upper jaw (UJ) and lower jaw restorations (LJ).

patients score 2 amounted to 91.5%, versus 84.6% in the non-instructed patients. The difference was not statistically significant.

Examination of the relationship between the incisal/cervical length of the resin facings and the occurrence of incisal spaces showed that the relatively short facings (≤8.0 mm) presented the lowest frequency of spaces. The chi-square test showed that the difference between category 1 (≤8.0 mm) and categories 2 and 3 combined (≥8.1 mm) was statistically significant (F + M: chi-square = 3.89, $p = 0.04$, d.f. = 1).

## Discussion

This study was planned and carried through to describe the manner in which resin facings act in single crowns and bridge retainers after having functioned in the mouth for various periods of time. It was hoped that the results of the present study could provide better insight into the clinical factors influencing the space formation over time at the alloy–resin junction in prosthodontic restorations. The data were collected by means of methods that are sufficiently similar to enable comparison of the cross-sectional data from 1987/88 (group I), 1985/86 (group II), 1982/83 (group III), and 1978/79 (group IV) (Table 1). Thus the inter-examiner and intra-examiner reproducibility, as already stated, seemed adequate for epidemiologic purposes.

These cross-sectional data from groups I–IV have confirmed clinical experience and experimental laboratory work that minute spaces may exist at the alloy–resin junction in resin-faced cast restorations (2–4, 7, 13, 14). The prevalence of cervical spaces varied between 75% in group I to about 90% in group IV (Fig. 3). The frequency of spaces was related to the length of service, with increasing frequencies with increasing time of service. This finding indicates that the prevalence of cervical spaces is progressive in nature, since the tendency to space formation and development does not seem to diminish as the facing ages. This observation corroborates the clinical experience that one of the important shortcomings of the resin facings in cast restorations is the lack of dimensional stability and its unfortunate sequelae (15–18).

The prevalence of cervical spaces seemed to be related to the wear of the resin facings. In general, the most severely worn facings had the highest frequency of cervical spaces. It is possible that stress release associated with wear has caused changes in the shape of the facings and thereby influenced the occurrence of cervical spaces, as discussed by Bergman et al. (19). The finding that females instructed in oral hygiene at the Department of Periodontology demonstrated a more pronounced wear (9) and at the same time showed an increased frequency of cervical spaces gives support to the belief that a relationship exists between the wear of facings and the occurrence of spaces at the cervical alloy–resin junction.

The results of the comparison of the patterns of prevalence and distribution of incisal and cervical spaces showed that they differed. First, the highest frequency of incisal spaces seemed to occur in the facings with the shortest time of service (group I). The other groups showed lower frequencies

(Fig. 5). These findings tend to show that the frequencies of incisal spaces may remain unchanged with length of service rather than increase, as seemed to be the case for the cervical spaces. Second, it appeared that the least worn facings had the highest frequency of incisal spaces, whereas the most severely worn facings showed the highest frequency of cervical spaces. The properties and the shortcomings of resins used as facing material in crowns and bridge retainers have recently been thoroughly reviewed (1, 7). It is established that the spaces between the facings and the metal framework are influenced by the difference in the thermal expansion between the resin and the gold and the lack of adhesion of resin to metal (2–4, 20). Sweeney (21) and Souder & Paffenbarger (22) showed that the absorption and loss of water are invariably associated with dimensional changes of resins. Braden (23) demonstrated that temperature has a decisive influence on the sorption and desorption of water and thereby on the dimensional changes of resin facings.

The gold alloy used in this study belongs to the type-IV alloys (Au + Pd + Pt > 75%, ISO 1562) (9, 24). According to the manufacturers (Delta, K.A.R., Hamar, Norway) this gold alloy has an elongation of 27%, which may be explained by the fine grain structure and the high gold content. The high value of elongation corresponds to high ductility and ease of burnishability (7, 13). On this background we have considered the possibility that the sliding movements between the jaws occurring on chewing, incision, and deglutition may be instrumental in a process of burnishing the gold of the incisal protection so as to flow or elongate against the resin facing with the result that an incisal reduction of the discrepancy at the alloy–resin junction may take place. Such an assumption would be useful in explaining the finding that the prevalence of incisal spaces seemed to remain unchanged rather than to increase with length of service. It may be reasonable to assume that the biting stress together with the elastic and thermal properties of gold could influence the size and the contents of the incisal spaces so that they should be looked upon as spaces with a continuous succession of changes. Clinical experience and experimental work in vivo (25) have shown that masticatory contacts between gold and opposing teeth may cause wear of the gold which may be progressive in nature.

In general, the processing shrinkage of resins is about 0.3% to 0.5%. Expansion through water sorption partially compensates for this shrinkage by about 0.1% to 0.2%. The net linear change can vary between 0.1% and 0.5% (7). The dimensional change in terms of percentage may serve as a contributory factor in the inaccuracy of the finished restoration facing. Thus, the results of the present study indicate that the fit of the resin facings is related to the lengths of the facings. In general, the shortest facings showed the least frequencies of cervical and incisal spaces. This observation proved to be in line with the finding that lower jaw facings, which were significantly shorter than those of the upper jaw, demonstrated a reduced prevalence of spaces at the alloy–resin junction. Facing lengths were ascertained by measuring mid-buccally the shortest distance between the incisal gold protection and the cervical metal collar. An attempt to analyze the possible effects of incisal–cervical convexity of the facings was not made. Such measurements should probably have been done before cementation of the restorations, when the incisal–cervical curvature of the facings was unimpaired. Bergman et al. (19) in the laboratory varied the shape of resin facings. They found that the shape of the facings, as modified in their experiment, did not seem to be an important factor for the rapidity of the influx of $^{22}Na$ ions into the spaces at the alloy–resin junction.

The adaptation and movement directions of the resin facings in cast restorations are related to the retention arrangement used for the resin facing. It has been shown in vitro that retentive gold beads may give a better fit of the resin to the metal surface than single wrought wires (19). The retention of the facings studied here was mechanical. Retentive beads, the remains of the casting sprues, beads and sprue remains together, undercuts, and combinations of these methods were used for retention. Data for the single case were not available, and the relationship between the retention of the facings and their fit could not be examined.

It is established that minute spaces at the alloy–resin junction must be expected in cast restorations with resin facings (for example, 1, 7). The space formation has mainly been attributed to the properties of the resin and metal and the disparity between them, as examined in the laboratory. The results of the present study of resin-faced restorations in the mouth have confirmed that spaces at the alloy–resin junction are frequent. The separate analyses have shown that it is reasonable to assume that length of service in the mouth after placement, the wear of the materials, and the incisal–cervical length of resin facings are influential determinants of space formation and development in resin-faced restorations. In evaluating the results, it should be borne in mind that the results may be restricted to the materials used and to the individuals treated in accordance with the guidelines of the Department of Prosthetic Dentistry.

## References

1. Malone WFP, Koth DL. Tylman's theory and practice of fixed prosthodontics. 8th ed. St. Louis: Ishiyaku EuroAmerica, 1989:385.
2. Lamstein A, Blechman H. Marginal seepage around acrylic resin veneers in gold crowns. J Prosthet Dent 1956;6:706–9.
3. Swartz ML, Phillips RW. A study of adaptation of veneers to cast gold crowns. J Prosthet Dent 1957;7:817–22.
4. Söremark R, Bergman B. Studies on the permeability of acrylic facing material in gold crowns. A laboratory investigation using $Na^{22}$. Acta Odontol Scand 1961;19:297–305.
5. Tylman SD. Theory and practice of crown and bridge prosthodontics. 5th ed. St. Louis: C.V. Mosby Co., 1965:1197–217.
6. Myers GE. Textbook of crown and bridge prosthodontics. St. Louis: C.V. Mosby Co., 1969:141.
7. Craig RG. Restorative dental materials. 8th ed. St. Louis: C.V. Mosby Co., 1989:509–59.
8. Berge M, Silness J. Fixed restorations produced for recipients of dental prosthodontic treatment. A comparison between general dental practice and a dental school. Acta Odontol Scand 1990;48:233–44.
9. Berge M, Silness J. The severity and pattern of wear of resin facings in metal–resin fixed prosthetic restorations in vivo. Int J Prosthodont 1992;5:269–76.
10. WHO. Oral health surveys. Basic methods. 3rd ed. Geneva: Macmillan/Ceuterick, 1987:15.
11. Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics 1977; 33:159–74.
12. Snedecor GW, Cochran WG. Statistical methods. 6th ed. Ames, Iowa: The Iowa State University Press, 1967:217.
13. Phillips RW. Skinner's science of dental materials. 8th ed. Philadelphia: W.B. Saunders Co., 1982: 245, 377.
14. Berge M, Gjerdet NR, Silness J. Marginal adaptation of resin veneers to gold castings. Acta Odontol Scand 1985;43:103–7.
15. Bäcklund N, Åkesson NÅ. Efterundersökning av kron- och broarbeten. Odontol Rev 1957;8:121–33.
16. Kandelman D, Nally JN, Meyer JM. Contrôles cliniques et radiographiques de 112 cas de prothèses conjointes. SSO 1974;84:1248–88.
17. Karlsson S. A clinical evaluation of fixed bridges, 10 years following insertion. J Oral Rehabil 1986;13:423–32.
18. Randow K, Glantz PO, Zöger B. Technical failures and some related clinical complications in extensive fixed prosthodontics. An epidemiological study of long-term clinical quality. Acta Odontol Scand 1986;44:241–55.
19. Bergman B, Hedegård B, Söremark R. Further studies on the leakage between resin material and gold alloy in resin faced gold cups. Acta Odontol Scand 1963;21:1–7.
20. Phillips RW, Swartz ML, Norman RD. Materials for the practicing dentist. St. Louis: C.V. Mosby Co., 1969:192.
21. Sweeney WT. Denture base material: acrylic resins. J Am Dent Assoc 1939;26:1863–73.
22. Souder W, Paffenbarger GC. Physical properties of dental materials. Washington: U.S. Department of Commerce, National Bureau of Standards, 1942: Circular C433:166.
23. Braden M. The absorption of water by acrylic resins and other materials. J Prosthet Dent 1964;14:307–16.
24. International Organization for Standardization. Dental casting gold alloys. ISO 1562, 2nd ed. 1984.
25. Ekfeldt A, Øilo G. Occlusal contact wear of prosthodontic materials. An in vivo study. Acta Odontol Scand 1988;46:159–69.

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