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Longevity of cast gold inlays and partial crowns – a retrospective study at a dental school clinic

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Abstract From 1963 to 1993, 890 patients were treated with 3518 cast gold restorations by students and postgraduate dentists. The longevity of these restorations was studied retrospectively using the patient files. Longevity was calculated using the method described by Kaplan and Meier. After the observation period, 111 (3.2%) of the examined restorations were not in place anymore. The most frequent reasons for failure were caries (33.7%), lack of retention (32.7%), endodontic treatment (29.6%), insufficient marginal adaptation (3.1%) and extraction (1%). The cumulative survival rate and a 95% interval of confidence was calculated for all restorations and for each of the locations and surfaces included in the trial. The 10-year survival rate for occlusal inlays was, 76.1% (12.1) for MO inlays 88.3% (4.2), for DO inlays 83.4% (4.6), for MOD inlays 87.5% (2.4), for partial crowns 86.1% (3.3) and 85.7% (1.7) for all restorations. Based on the statistical method used, the cast gold restorations demonstrated satisfactory longevity results.

Key words Inlay · Partial crown · Long-term results · Survival rate

Introduction

Cast inlay and partial crown restorations are considered clinically to be effective and long lasting. They remain the standard treatment for a durable restoration of posterior teeth [3]. Surveys of the extent of their durability are rare in the literature. Bentley and Drake [1] calculated the longevity of 173 inlays and 295 crowns made by students in a dental school clinic. They used a life table method and calculated the percentage of restorations surviving 10 years or more. A 10-year survival rate of 89% for crowns and 95% for inlays and onlays was found. Leempoel et al. [13] used the method of Kaplan and Meier [12] to calculate the longevity of 895 crowns and 785 partial crowns. They found a survival rate of 99% for crowns and 96% for partial crowns after 5 years, and 97% for crowns and 91% for partial crowns after 11 years. Westermann et al. [25] examined 222 crowns and partial crowns made in a private dental office using the method described by Kaplan and Meier. After 8 years, 88% of these restorations were still in service. Fritz et al. [10] used the method of Kaplan and Meier to calculate survival rates of inlays and partial crowns made in the dental school of Cologne. For 2717 restorations they calculated a 10-year survival rate of 65% for one surface inlays, 60% for two surface inlays and 68% for three surface inlays. Partial crowns and onlays had a survival rate of 70%. Schlösser et al. [22] calculated survival rates for 390 crowns and 725 partial crowns made in two general practices. They used the statistical method of Cutler and Ederer [5] to calculate a 9-year survival rate of 92.1% for full crowns and 87.3% for partial crowns.

The aim of our study was to evaluate the durability of different cast gold restorations made by students and dentists of the Department for Operative Dentistry at the dental school of the Philipps-University in Marburg, Germany.

Materials and methods

This retrospective study was based on patient records of the Department of Operative Dentistry in the dental school of the Philipps-University in Marburg, Germany. The dental records of all patients with gold restorations made by students or dentists from 1963 to 1993 were included in the study.

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During this time, 890 patients were treated with 3518 cast gold restorations. These restorations were divided into 171 occlusal inlays, 294 MO-inlays, 427 DO-inlays, 862 MOD-inlays, 1679 partial crowns and 85 inlays with more than three surfaces. Some 1593 restorations were located in the mandibular area, 1925 were located maxillary, 1409 restorations were located in premolars, and 2109 were in the molar region.

Of the patient group, 52.3% were male and 47.7% were female patients, with an average age of 32.4 years calculated at the time of the restoration's placement. All restorations were cemented using conventional zinc phosphate cement.

The cumulative survival rate for the restorations was analyzed by the method described by Kaplan and Meier [12]. A restoration was defined as intact from the date of placement (starting event) to the date of the last known examination recorded in the patient file if there was no further notice that the restored tooth was extracted or the restoration was replaced. A restoration was considered a failure (terminal event) when the tooth was lost by extraction or when it had to be replaced due to insufficient retention, insufficient marginal adaptation, primary caries at different surfaces, recurrent caries or endodontic treatment. Recemented restorations or restorations with repairs in the marginal area were not considered to have failed.

After checking the data for mistakes, the survival analysis was carried out using the Biomedical Package for Data Processing (BMDP) procedure P1L. The 10-year survival rates were calculated for all restorations together as well as for each restoration type individually. If possible, the 50% and 75% survival time was calculated. Group comparisons were done using the log rank test.and setting the level of significance as P=0.05..

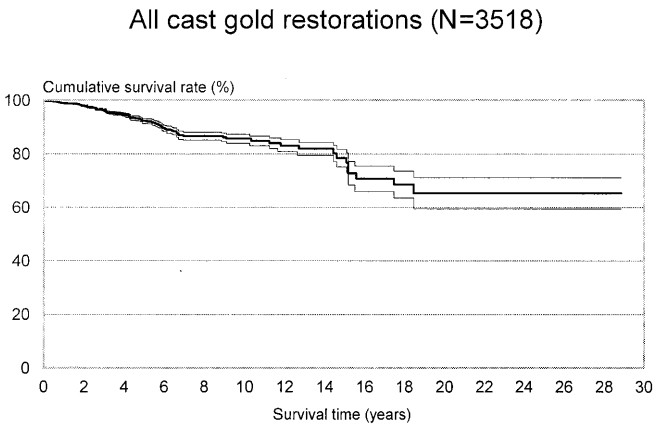

Fig. 1 Cumulative survival rate of all restorations in our study, calculated using the Kaplan and Meier method with a 95% interval of confidence

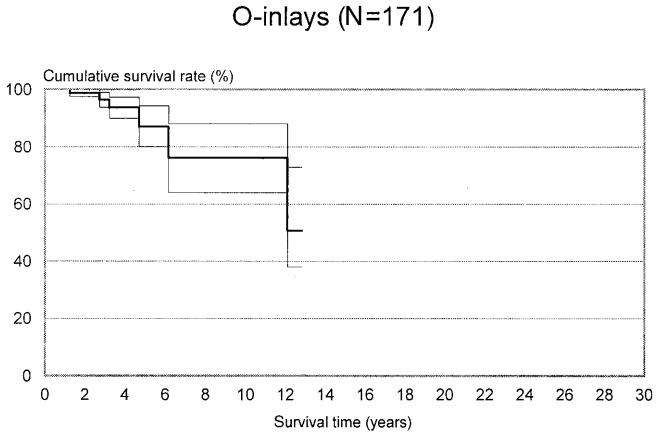

Fig. 2 Cumulative survival rate of occlusal restorations, calculated using the Kaplan and Meier method with a 95% interval of confidence

Results

The 10-year survival rate and the calculated 75% and 50% survival time for all groups are listed in Table 1. As 86.1% of the partial crowns were still in function after 22.6 years, it was not possible to calculate the 75% survival time. Except for the one-surface inlays it was not possible to calculate a 50% survival time. Figures 1–5 show the cumulative survival function (Kaplan-Meier) for all groups with a 95% interval of confidence.

There were 111 restorations that were lost or considered to have failed. The reasons for these were caries (n=38), insufficient retention (n=36), endodontic treatment (n=33), insufficient marginal adaptation (n=3) and extraction (n=1). The failed restorations were mostly MOD-inlays (n=36), partial crowns (n=35), DO-inlays (n=18), MO-inlays (n=11) and O-inlays (n=7).

A group comparison of MO-inlays and DO-inlays showed no significant (P<0.05) difference between the locations. A comparison of restorations in the molar and premolar region did not demonstrate a significant difference in either the lower jaws or the upper jaws.

Table 1 The 10-year survival rate with 95% interval of confidence of all groups. If possible 50% and 75% survival quartiles were calculated. In most groups the failure rate was too low to calculate all survival quartiles

Survival rate	O	MO	DO	MOD	Partial crowns	All restorations
75%	11.2	15.3	15.2	26.1	–	15.2 years
50%	13.3	–	–	–	–	–
10 years	76.1%±12.1%	88.3%±4.2%	83.4%±4.6%	87.5%±2.4%	86.1%±3.3%	85.7%±1.7%

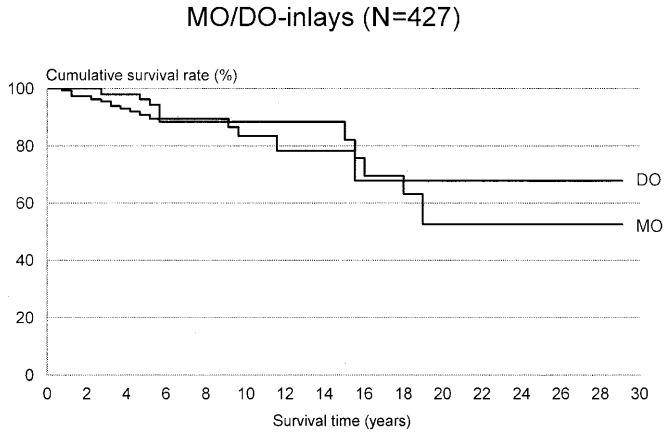

Fig. 3 Cumulative survival rate of two surface restorations, calculated using the Kaplan and Meier method. There was no significant ($P<0.05$) difference between the two groups

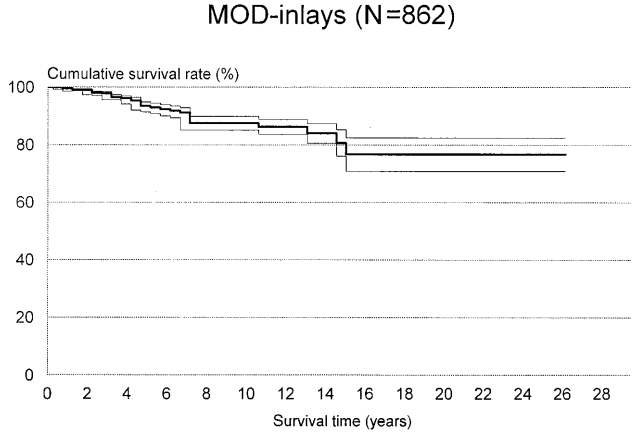

Fig. 4 Cumulative survival rate of three surface restorations, calculated using the Kaplan and Meier method with a 95% interval of confidence

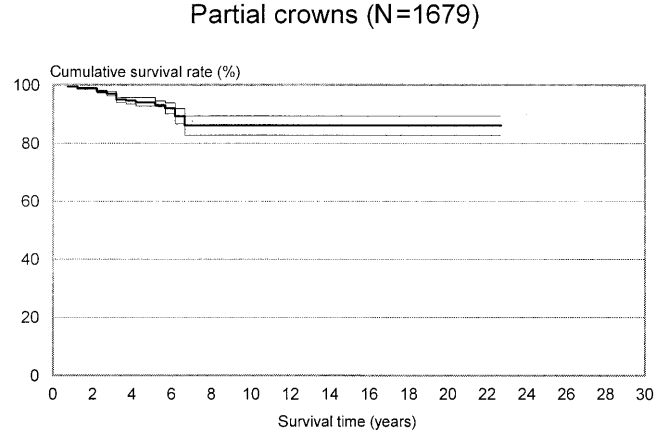

Fig. 5 Cumulative survival rate of partial crowns, calculated using the Kaplan and Meier method with a 95% interval of confidence

Discussion

Using statistical methods for survival analysis, the survival time is defined as time between a predefined starting event and a terminal event. This analysis can be achieved via the production of statistical values and survival functions. The most commonly quoted statistics are the median survival time, the survival rate after a certain number of years (often the 5-year or 10-year survival rate) and the cumulative survival rate (the proportion of all cases surviving until the end of each interval) as a function of time.

Life table methods have the advantage that they use all survival information accumulated up to the closing date of the study [5]. Data with partial follow-up are referred to as censored data and fall into one of two categories: lost to follow-up before the end of the study or withdrawn “alive” at the end of the study.

Cutler and Ederer [5] state that the relative gain in utilizing survival information with censored cases will vary directly with the relative increase in the initial size of the sample, the relative completeness of the added survival information and the relative magnitude of the mortality rates during the first few follow-up intervals.

The method of life table analysis has found widespread use in medical studies, in particular cancer treatment studies. Unfortunately there are essential differences with data in medical studies and dental restoration studies [6]. In cancer studies, there is a high initial death rate and patients are highly motivated to keep follow-up appointments. In dental studies there is normally a low initial failure rate, so little is gained from the inclusion of a censored case with a short observation time. Consequently, a longer period of study is required in order to obtain a clear picture of the pattern of survival rate.

In dental restoration studies, normal dental appointments are commonly used for the collection of data. There can be wide gaps between these appointments and patient fluctuation is also common. Trying to overcome this by using regularly attending patients will possibly introduce bias [6]. Using the end date of the study as the date of censorship is not reliable unless it is known that the patient will reappear and has not sought treatment from an unrecorded source. This cannot be known with certainty but values for the likelihood of reappearance may be introduced [6].

The product-limit method proposed by Kaplan and Meier [12] is very closely related to the actuarial life table method. Using the life table, the period of time under study is subdivided into intervals and for each interval the probability of an event is calculated and combined to estimate cumulative probabilities [5]. The method of Kaplan and Meier does not use fixed intervals to calculate the probability of an event. Instead, the probability of an event is calculated each time an event is observed [12]. Leempoel et al. state that the Kaplan and Meier method gives more accurate estimates for the survival probabilities than the life table method [14].

Table 2 A comparison of sample size and survival rates of comparable studies. Survival rates are given as 10-year survival rate if not mentioned otherwise (*F1* one surface, *F2* two surfaces, *F3* three surfaces)

Author	*n*	Inlays	Partial crown	Crowns
Sobkowiak (1971)	3006	75% (6a)		
Leempoel et al. (1985)	1680		96% (5a), 91% (11a)	99% (5a), 97% (11a)
Bentley et al. (1986)	468	Inlays and onlays: 95%	89%	
Westermann (1990)	222		Partial crowns and crowns: 88% (8a)	
Fritz et al. (1992)	2717	F1: 65%, F2: 60%, F3: 68%	70%	
Schlösser (1993)	1115		87% (9a)	92% (9a)
Stoll et al., present study	3518	F1: 76%, F2: 88/83% (MO/DO), F3: 88%	86%	

In our study we had a retrospective 31-year study time (1962–1993). The number of cases (3518 restorations from 890 patients) is comparable to other studies. Fritz et al. [10] included 2717 cases from 548 patients, and Sobkowiak and Teseler [24] included 3006 cases from 974 patients in their studies. Nevertheless, we found a high percentage of short time censored data. The mean time of observation was calculated to be 2.1 years in our study. This is comparable to the results of Fritz et al. [10] who calculated a mean time of observation of 2.2 years. As stated above, a large amount of short time censored data is a problem of retrospective longitudinal studies. This produces a higher standard error of long-term survival probabilities and an underestimation of survival times [6] and variance of long-term survival probabilities [7]. Therefore, the calculated survival times from our study have to be discussed with this problem in mind.

The survival rates for partial crowns found in this study are comparable to other studies (Table 2). Schlösser et al. [22] found almost the same survival rate (87%) after 9 years; however, the results from Leempoel et al. [13] are slightly better. Fritz et al. [10] found a distinctly lower survival rate (70%) after 10 years.

Our results for cast gold inlays are slightly higher than those of comparable studies. For two-surface and three-surface inlays we found survival rates around 86% (10 years), whereas Sobkowiak and Teseler [24] and Fritz et al. [10] reported lower survival rates. Crabb [4] reported a discouraging survival rate of 42% after 10 years. Nordbø and Lyngstadaas reported a median longevity of 34 years in a selected practice and 16.5 years for gold inlays inserted by clinicians with limited experience [18]. Mjör and Medina reported a median age of failed cast gold and compacted gold restorations of 18.5 years [17].

Our results show a significantly ($P<0.05$) lower survival rate for occlusal inlays than for two-surface or three-surface inlays. One reason for this could be the higher risk of approximal caries when the inlay simply covers the occlusal surface. Restorations with two surfaces normally cover the occlusal surface and either the mesial or distal surface. Comparing the longevity, we found no significant ($P<0.05$) differences between these possible locations.

The higher survival rates found in our study may be explained by the special selection of patients found in a dental school. Our patients, among them many students, are highly motivated and usually have an optimal oral hygiene. Most of these students leave the city soon after finishing their studies. This is the main reason we have fewer patients in long-term-recall or routine treatment. Consequently, only the patients who are originally from Marburg are available for long-term follow-up. These patients also have very good oral hygiene and receive regular oral hygiene instruction and control. Although we do not have a special recall program, the German social system motivates patients to have at least one oral examination per year. In this study we did not examine for differences between operators because our students use the same materials and methods as our postgraduate dentists and receive very intensive and frequent assistance and supervision from our instructors.

Gold inlays have higher survival rates compared to other restorations, especially fillings. Amalgam fillings are reported to have a median age of 5 years [8]; other studies reported a 50% survival time of 8 years [19, 20,25]. Jokstad et al. found a survival rate of 81% after 114 months [11].

Mjör et al. [15] reported a median age of failed amalgam restorations of 7–8 years following a review of a large number of cross-sectional retrospective surveys. They state that failed amalgam restorations are generally older than failed composite restorations. The median age of MOD composite restorations was reported to be about 4 years [15]. Friedl et al. found a median age of replaced composite restorations of 43.5 months [9]. Paterson reported a 50% survival time of 4.5 years [19]. After reviewing a large number of surveys, Roulet [21] concluded that the failure rate of posterior composite restorations is not inferior to that of amalgam.

Compared to other restorations for posterior teeth, cast gold restorations are considered to be long-lasting restorations at a high price. The cost of cast gold restorations exceeds that of similar amalgam restorations by a factor of 8:9; the price ratio between posterior composites and similar gold inlays is approximately 1:4 [2]. However, the long-term cost of restorative dentistry is not only dependent on the cost at the time of initial treatment, but also on the longevity of the restorations. The cost of dental treatment should be considered for the expected lifetime of the tooth, i.e., for a period of 50–70 years rather than for the immediate cost of a single restoration [15]. The median longevity of failed cast gold restorations exceeds that of failed amalgam restora-

tions by a factor of about 2 [17] and that of composite restorations by a factor of 4 (large restorations) and 2.5 (small restorations) [16].

Smales and Hawthorne [23] calculated the cost-effectiveness of amalgam restorations and cast gold crowns and found amalgam fillings to be 3.8 times more cost-effective than gold crowns. Mjör states that amalgam restorations now clearly represent the most cost-effective dental restoration material [16].

Based on an increasing irrational fear of amalgam and restrictions by German health authorities, the use of amalgam in Germany is rapidly decreasing. In economic terms this may place gold restorations in a more favorable position.

Conclusions

Cast gold restorations made in a dental school clinic have a good clinical performance and high longevity. One-surface restorations had a lower durability than those with two or three surfaces. The location of those surfaces (MO or DO) had no influence on the longevity.

The continuing discussion about the use of amalgam as a restorative material, the need for an alternative material and the political situation of national health systems make it important to keep the economic aspects of dental treatment in mind. The results of this study prove a higher survival rate for cast gold restorations than for amalgam or composite restorations. The long-term cost of cast gold restorations competes favorably with amalgam and composite fillings. Cast gold restorations are a good treatment especially for large defects. Small cavities may be restored better by using adhesive techniques.

References

1. Bentley C, Drake CW (1986) Longevity of restorations in a dental school clinic. J Dent Education 50:594–600
2. Christensen GJ (1989) Alternatives for the restoration of posterior teeth. Int Dent J 39:155–161
3. Christensen GJ (1996) The coming demise of the cast gold restoration? J Am Dent Ass 127:1233–1236
4. Crabb HSM (1981) The survival of dental restorations in a teaching hospital. Br Dent J 150:315–318
5. Cutler SJ, Ederer F (1958) Maximum utilization of the life table method in analyzing survival. J Chron Dis 8:699–712
6. Davies JA (1987) Dental restoration longevity: a critique of the life table method of analysis. Community Dent Oral Epidemiol 15:202–204
7. Dixon WJ (1985) BMDP statistical software manual. University of California Press, Berkley
8. Friedl KH, Hiller KA, Schmalz G (1994) Placement and replacement of amalgam restorations in Germany. Oper Dent 19:228–232
9. Friedl KH, Hiller KA, Schmalz G (1995) Placement and replacement of composite restorations in Germany. Oper Dent 20:34–38
10. Fritz U, Fischbach H, Harke I (1992) Langzeitverweildauer von Goldgußfüllungen. Dtsch Zahnarztl Z 47:714–716
11. Jokstad A, Mjor IA (1991) Analyses of long-term clinical behavior of class-II amalgam restorations. Acta Odontol Scand 49:47–63
12. Kaplan EL, Meier P (1958) Nonparametric estimation from incomplete observations. J Am Stat Ass 53:457–481
13. Leempoel PJB, Eschen S, De Haan AF, van't Hof MA (1985) An evaluation of crowns and bridges in a general dental practice. J Oral Rehab 12:515–528
14. Leempoel PJB, van't Hof MA, De Haan AF (1989) Survival studies of dental restorations: criteria, methods and an analysis. J Oral Rehab 16:387–394
15. Mjör IA, Jokstad A, Qvist V (1990) Longevity of posterior restorations. Int Dent J 40:11–17
16. Mjör IA (1992) Long term cost of restorative therapy using different materials. Scand J Dent Res 100:60–65
17. Mjör IA, Medina JE (1993) Reasons for placement, replacement and age of gold restorations in selected practices. Oper Dent 18:82–87
18. Nordbø H, Lyngstadaas SP (1992) The clinical performance of two groups of functioning class-II cast gold inlays. Acta Odont Scand 50:189–192
19. Paterson N (1984) The longevity of restorations. A study of 200 regular attenders in a general dental practice. Br Dent J 157:23–25
20. Qvist J, Qvist V, Mjör IA (1990) Placement and longevity of amalgam restorations in Denmark. Acta Odontol Scand 48:297–303
21. Roulet JF (1997) Benefits and disadvantages of tooth-colored alternatives to amalgam. J Dent 25:459–473
22. Schlösser R, Kerschbaum Th, Ahrens FJ, Cramer M (1993) Überlebensrate von Teil- und Vollgußkronen. Dtsch Zahnarztl Z 48:696–698
23. Smales RJ, Hawthorne WS (1996) Long-term survival and cost-effectiveness of five dental restorative materials used in various classes of cavity preparations. Int Dent J 46:126–130
24. Sobkowiak EM, Teseler U (1971) Spätergebnisse bei Gußfüllungen im Seitenzahnbereich. Stomat (DDR) 21:305–308
25. Westermann W, Kerschbaum Th, Hain H (1990) Verweildauer von ausgedehnten Amalgamfüllungen. Dtsch Zahnarztl Z 45:743–747