

Quality of fixed prosthodontics after twenty-two years

Per-Olof J. Glantz, Krister Nilner, Malcolm D. Jendresen and Hans Sundberg

Department of Prosthetic Dentistry, Faculty of Odontology, Malmö University, Malmö, Sweden;
Department of Restorative Dentistry, University of California, San Francisco, USA; The National
Board of Health and Welfare, Stockholm, Sweden

Glantz POJ, Nilner K, Jendresen MD, Sundberg H. Quality of fixed prosthodontics after twenty-two years. *Acta Odontol Scand* 2002;60:213–218. Oslo. ISSN 0001-6357.

After an observation period of 22 years, this study was conducted to clinically examine and interview patients who in 1984 and 1989 had participated in similar investigations regarding the quality, over time, of treatments with fixed partial dentures. The patients were examined by two standardized and experienced clinicians using the California Dental Association quality rating system, their results indicating that after 22 years the overall survival rates were 46.5% and 41.1% for the originally placed crowns and pontics, respectively. However, a continuing decrease of the crown quality rating was noted during the more than 20-year-long observation period. Restorative treatments with common types of fixed partial dentures can therefore be regarded as both safe and reliable over long periods of time. □ *Denture; fixed; follow-up studies; longevity; partial*

Per-Olof Glantz, Department of Prosthetic Dentistry, Faculty of Odontology, Malmö University, SE-21421 Malmö, Sweden. Tel: +46 40 66 58497, fax: +46 40 66 58503, e-mail: per-olof.glantz@od.mah.se

The time, complexity, and expense of fixed prosthetic treatment can be justified only if the restorations last for a long time. The majority of investigators studying the long-term quality of fixed dental restorations (1–10) indicate that some fixed prosthetic treatments may have long survival times, often of up to 20 years (7, 9).

The majority of reports on the long-term results of treatments with fixed partial dentures indicate clear methodological disadvantages. For example, many of the studies have been of non-randomized groups of patients treated in dental schools or in special dental clinics. Although these studies *per se* are interesting and informative, particularly in relation to the outcome of specific treatment modalities (7), they cannot be regarded as reflecting the situation existing in general dental practice.

Investigators who have been studying randomized patient populations have based their findings on second-hand information material, such as existing radiographs and/or questionnaires (3). For methodological reasons, these studies too are often of limited relevance. In some long-term studies, other problems relate to a tendency towards a lack of proper patient control during the extensive course of the study, and consequently unacceptably high, unaccounted for, drop-out levels are experienced.

The aforementioned conditions or limitations make it difficult to draw general conclusions from the literature about the prognosis of restorative treatments with fixed partial dentures in general dental practice. In the mid-1970s, our group therefore decided to perform a series of clinical examinations of randomly selected groups of patients who were receiving such restorative treatments from general dental practitioners.

As a result of the regulations in the Swedish National Dental Insurance program, all fixed partial dentures had

to be produced using materials with established, good long-term biomaterial properties, mainly noble metal alloys mostly with acrylic and/or ceramic facings/veneers. As mentioned above, treatments with such restorations have frequently been reported to have an average service life of well over 10 years. As such restorations are often also believed to have technical qualities related to the skill and professional engagement of the individual operator/clinician (11), it was believed of essence: A) to select patients for the study after their new fixed partial denture had been permanently cemented, and B) to establish clinical quality baselines for the selected restorations after a sufficient clinical adaptation period. In 1979, baseline examinations were therefore performed of restorations which at that point in time were about 5 years old.

The patient selection process and methods used at the clinical examinations have been reported in detail by Glantz et al. (12). Briefly, from a total of over 3000 patients undergoing extensive restorative dental care by local general dental practitioners in 1974, a group of 150 patients were selected at random. The criteria for selection included a minimum cost of 2000 Swedish crowns (approximately US\$ 400) for total dental care in that year (1974). The selection system used was further designed so that no single dental practitioner had treated more than one of the selected patients. A detailed description of the selected patients and the type of restorative treatments performed in 1974 has also been given by Glantz et al. (12).

In 1979, a letter and a questionnaire were sent to each patient, the letter explaining that the aim of the study was to determine the incidence of problems and complications associated with restorative treatment and the restorative dental materials used, particularly metallic material. The questionnaire requested information about oral hygiene

Table 1. Patients invited to clinical examinations in 1979, 1984, 1989, and 1995/96

Patient category	1979 <i>n</i>	1984 <i>n</i>	1989 <i>n</i>	1995/96 <i>n</i>
Deceased	1	10	20	26
Patients with data	136	76	77	77
Patients with clinical data	109	(≈40)*	63	77
Unable to locate/Declined to participate**	13	64	53	47

* A systematic data collection was started in 1984. The study was terminated prematurely, however, when it became evident that too many of the patients were unable to participate during the limited time period the standardized examiners were available.

** In 1979, five patients could not be located, while 8 declined to participate. In 1984 and 1989 the number of patients who could not be located was approximately doubled. As the study proceeded (1984 and 1989), the main reasons given for unwillingness to participate were high age, poor health, or too long a distance to travel to justify an examination. In addition, it is likely that in 1989 and 1995/96 some of the very old patients who could not be located had deceased.

habits and attitude towards dental care. Questions about recent dental care and subjective signs and symptoms, if any, during and after the dental care delivered in 1974 were also included.

All persons selected were offered free clinical examinations. These included examination of restorations placed in 1974 and other types of restorations in proximal contact with these. All examinations were conducted by two U.S. examiners, both of whom were previously standardized in use of the California Dental Association (CDA) quality evaluation system (13). The CDA system is based on application of clinical parameters. When applied by standardized examiners, it has frequently been demonstrated to be both precise and accurate in the evaluation of dental restorations and dental care (14).

The data collected at the baseline 5-year control showed that the survival rate was 98.2% for the fixed restorations placed in 1974. Of the remaining restorations, 90% were rated as Satisfactory according to the CDA system. Not acceptable ratings for crowns included 3.4% so-called T-ratings and 6.6% V-ratings. In most cases, T-ratings were indicative of noted over-contouring of the restorations, whereas V-ratings were given because of caries (12).

In 1984, our group decided to conduct a 10-year follow-up. A systematic data collection was started but was terminated prematurely, when it became evident that too many of the patients were unable to participate during the limited time period the U.S. examiners were available.

At the 15-year control, an extended time period was allocated for clinical data collection, together with an additional possibility for certain information to be gathered during telephone interviews. These were performed primarily with patients who were unable to attend clinical sessions because of problems and/or costs associated with travel to Malmö (15).

The results from the examinations at 15 years showed that 35% of the original restorations had been lost and another 8% partially lost. Thirty-five percent of the remaining restorations were rated as Satisfactory according to the CDA system, whereas the remaining ones had mixed clinical quality ratings. Failures and Not Acceptable quality ratings were caused mainly by fractures, loss of retention and/or dental caries (15).

Based on the results and observations made at 5, 10, and 15 years, the decision was taken in 1994 to carry out a final examination of the remaining restorations using the same protocol as in 1979.

Materials and methods

A series of exploratory contacts with the original patient group was made in 1994, i.e. 20 years after the original placement of the restorations. These contacts indicated that it would be meaningful to perform a final clinical examination of patients with remaining restorations. However, it also became clear that any clinical examination of the remaining restorations had to be preceded by careful, long-term planning. The actual clinical examinations were therefore conducted during the latter half of 1995 and the early part of 1996.

The original patient population consisted of 82 men and 68 women with a mean age in 1974 of 48.2 (SD 12.5) and 48.9 (SD 13.5) years, respectively. Table 1 gives the number of patients with available data at the 1979, 1984, 1989, and 1995/96 year follow-up sessions, as well as the number of patients who were known to be dead and those unable to participate or unwilling to do so. Based on the data given in Table 1, the percentages of surviving patients allowing clinical data collections were 73.2% in 1979, 48.5% in 1989, and 62.1% in 1995/96.

Here it should be noted that some of the patients who could not be located, especially in 1989 and 1995/96, were probably dead, as indicated by their high age and comments about poor health at previous contacts. It is thus likely that the true percentage of participating patients was a little higher than that given above.

Using the SPSS software (version 6.1), a statistical analysis was performed of age and gender of the surviving group of patients at the 5, 10, 15, and 21/22 year controls. It did not show any statistically significant gender or age differences between the patients participating and those not, i.e. those unable to be located or declining to participate. The *P*-values for differences (*t* tests) were thus found to be 0.28–0.86 for gender and 0.26–0.98 for age at all observations, indicating that there were no systematic

Table 2. Original (1974) extensions and abutment/pontic ratios for remaining ($n = 39$) and lost ($n = 38$) fixed partial dentures after 21/22 years

Reconstruction status in 1995/96	Extension (units)			Abutment/pontic ratio (% pontics)
	Range	Median	Mean	
Remaining ($n = 39$)	1–13	4	4.6	30.6
Lost ($n = 38$)	1–14	5	5.6	32.4

gender or age differences between the patients who participated and those who declined to do so for a variety of reasons.

The participants in the original group of patients examined in 1979 were wearing fixed partial dentures with a mean extension of 6.9 units and a mean pontic/abutment ratio of 0.47. At the 1995/96-year control, the corresponding values were 5.1 and 0.46. Based on these data and on the corresponding data from 1984 and 1989, a series of statistical analyses with the statistical methods given above was performed on the type and nature of the restorations done in 1974. These analyses were performed on data from patients who participated in the examinations and also on those who declined to do so, or who could not be located.

Here, for all examinations (1979, 1984, 1989, and 1995/96), very high statistically significant differences ($P < 0.0001$) were noted for extension of restorations, showing a higher willingness to participate among patients who were wearing more extensive restorations. At the 1995/96-year follow-up, for example, 2 out of 3 surviving patients with 8 or more unit-bridges participated (20 out of a total number of 30), while only 1 of 3 (17 out of a total of 55) with between 1 and 3 units did so.

It can therefore be concluded that even if only some 50% to 60% of the surviving patients actually participated in the clinical follow-ups at the 15 and 21/22-year follow-ups, higher percentages of the original restoration units were accounted for (between two-thirds and three-fourths).

The same protocol was used in 1995/96 as in 1979 and 1989. Only one of the original U.S. examiners, however, participated, as the other one was deceased. He was replaced by a substitute, also standardized and experienced in the use of the CDA quality rating system.

Results

Table 2 gives the number and original (1974) extensions and abutment/pontic ratios for remaining and lost fixed partial dentures after 21/22 years, the results showing that the median survival time for the recorded fixed partial dentures was about 22 years.

The baseline (1979) CDA ratings are given in Table 3 for restorations remaining in 1995/96 and those that had been lost up to this point in time. The data indicate that the overall survival rates after 21/22 years were 46.5% for crowns (125/269) and 41.1% for pontics (51/124). These data also demonstrate that there is no difference in long-term survival between crowns and pontics with baseline (5 year) ratings within the Satisfactory range. The data in fact demonstrate a slightly higher, although not statistically significantly different, survival rate for crowns with baseline Sierra ratings (52.9%, i.e. 94/178) than for those with Romeo ratings (45.9%, i.e. 28/61).

A highly statistically significant difference in long-term survival, however, was found between crowns with baseline quality ratings in the range of Satisfactory and those in the Not Acceptable range (51% and 10%, respectively).

It became difficult to determine the precise, individual reasons for loss of restorations during such a long time period as 1974–1995/96. At our clinical examinations, and during interviews of patients and some engaged dental practitioners, it became evident, however, that just as at the 5-year and 15-year controls, the common reasons for loss were fractures, loss of retention and caries. It was also interesting to note that during the 21/22-year observation period none of the selected fixed partial dentures were reported to have been removed because of the presence of material-related soft-tissue reactions.

Table 3. Baseline CDA quality ratings (1979) for crowns and pontics known to remain or lost after an observation time of 21/22 years

CDA quality ratings in 1979	Reconstruction status in 1995/96		
	Remaining (crowns/pontics)	Lost (crowns/pontics)	All restorations (crowns/pontics)
Satisfactory			
Range of Excellence (Romeo)	51 (28/23)	62 (33/29)	113 (61/52)
Range of Acceptability (Sierra)	120 (94/26)	116 (84/32)	236 (178/58)
Not acceptable			
Replace or correct for Prevention (Tango)	3 (1/2)	24 (12/12)	27 (13/14)
Replace Statim (Victor)	2 (2/0)	15 (15/0)	17 (17/0)
Sum	176 (125/51)	217 (144/73)	393 (269/124)

Table 4. Baseline (1979) CDA oral hygiene ratings (%) for patients (*n* = 66) known to have remaining (*n* = 31) or missing (*n* = 35) fixed partial dentures after an observation period of 21/22 years

Baseline (1979) CD oral hygiene ratings	Patients (%) with remaining restorations (<i>n</i> = 31)	Patients (%) with missing restorations (<i>n</i> = 35)
Satisfactory		
Range of Excellence (Romeo)	3 (10%)	9 (26%)
Range of Acceptability (Sierra)	21 (68%)	16 (46%)
Not acceptable		
Correct for Prevention (Tango)	5 (16%)	10 (28%)
Replace Statim (Victor)	2 (6%)	0

The baseline (1979) CDA oral hygiene ratings are given in Table 4 for patients with remaining reconstructions and for those with missing reconstructions after 21/22 years. Some patients accounted for in Tables 1 and 3 are not included in Table 4, as only parts of their restorations remained in 1995/96.

The results given in Table 4 do not point to any strong correlation between patient oral hygiene and long-term survival of fixed partial dentures. Rather, the data show that a minority of patients (25%, i.e. 3/12) with Excellent baseline oral hygiene had remaining reconstructions, whereas those with only Acceptable baseline oral hygiene exhibited a higher survival rate (57%, i.e. 21/37). Furthermore, about 40% of patients with Not Acceptable baseline oral hygiene ratings turned out to be wearing their reconstructions after 21/22 years.

The CDA quality ratings of the crowns that remained in 1995/96 are given in Table 5, along with their baseline (1979) ratings. The data in the Table point to a continuing decrease in the crown quality ratings for remaining restorations during the over 20-year-long observation period. This table also demonstrates that a poor baseline crown quality rating is a strong predictor of reduced survival time.

The relation between survival rates and the use of distal cantilevers in the studied groups of fixed partial dentures is given in Table 6. This table demonstrates that the use of distal cantilevers is associated with increased risks for reduced survival times ($\chi^2=3.62$; *P* = 0.05).

Discussion

We believe that this study is a precise and accurate report of the long-term results of common types of fixed partial denture treatments by general practitioners. The methods used for selection and follow-up of patients are in line with those generally recommended and accepted in epidemiology. The percentage of surviving patients followed throughout this study (62.1%) is not only acceptable, but must be considered exceptionally good under the given circumstances.

The series of studies of the group of patients who did not participate failed to demonstrate the presence of any important statistically significant difference between this group and that participating. The only detectable, significant difference was related to the extension of the selected fixed partial dentures. Here the majority of patients who decided not to participate turned out to be wearing restorations of comparatively limited extension. Their lack of interest can therefore be explained on the basis of the comparatively limited financial and biological investments made by these patients.

The methods and techniques used at the clinical data collections are also well established and have proved to be of sufficient accuracy and precision for the types of examinations and evaluations carried out in this study (14).

The most important overall conclusion from this study is that restorative treatments with common types of fixed partial dentures are both safe and reliable over long

Table 5. Distribution (% of CDA Quality ratings (for 1995/96) of remaining crowns and baseline (1979) ratings for these crowns as well as for those lost since 1979 (*n* = 70 patients*)

	CDA Quality ratings							
	Satisfactory				Not Acceptable			
	Excellent		Acceptable		Replace/Correct		Replace Statim	
	–79	–95/96	–79	–95/96	–79	–95/96	–79	–95/96
Remaining restorations	21.6	5.7	76.0	58.6	0.8	24.2	1.6	11.5
Missing restorations	23.6	–	57.7	–	8.3	–	10.4	–
All restorations	22.7	5.7	66.2	58.6	4.8	24.2	6.3	11.5

* As baseline data are not available for 7 patients, this table accounts for only 70 out of the 77 patients participating in the 1995/96 control.

Table 6. Number of fixed partial dentures with or without cantilever units in remaining and lost extensive (3–14 units) fixed partial dentures after 21/22 years

Reconstruction Status in 1995/96	Design of reconstruction	
	With distal cantilever	Without distal cantilever
Remaining	3	22
Lost	12	24

periods of time. In overall terms, the results therefore concur with those presented for example by Karlsson (4) and Lindquist and Karlsson (9).

It should be remembered that no serious treatment-related side effects were noted in this study, despite an average service life of the studied restorations of about 20 years. Assuming that the performed treatments were needed, and as there were no indications that this was not the case for any patient, the absolute majority of financial and biological investments made by the patients must be considered well worthwhile. For the patients whose restorations lasted for 20 years, the sum written-off per day and abutment unit was in fact as low as 0.10 Swedish crowns, or $\approx$ 2 cents in US currency (1974 exchange rate).

During an extensive period beginning in 1973, Swedish general dental practitioners had good opportunities to carry out virtually all established types of restorative treatments within the Swedish National Dental Insurance Program. Published reports have verified very high frequencies for such treatments in Sweden. For a number of years this situation was probably leading to a comparatively high general, professional, clinical competence level among Swedish general practitioners in the field of restorative dentistry (15, 16). As this study was carried out on patients treated already in 1974, i.e. within the first full year of the new national dental insurance program, the training effects were probably limited. The results of this study should therefore be valid also for other societies where general dental practitioners have had undergraduate training based on modern principles in restorative dentistry.

When patient factors were correlated with survival, it became clear that neither patient age nor patient gender had any influence on the prognosis for the performed restorative treatments with fixed partial dentures. The same goes for extension of the restorations. Based on these findings, it can be stated that extensive fixed partial dentures are realistic restorative treatment alternatives in most groups of patients, i.e. also older ones.

A marked influence on survival was found for the design of the fixed partial dentures themselves. Cantilevered dentures for example exhibited reduced survival rates. This finding is well in line with some reports in the literature (18), but not with all (19, 20).

Good patient oral hygiene is generally considered to be one of the most important prognostic factors in restorative

therapy. Also this study indicates this to be a fact. Thus, of the patients with Satisfactory oral hygiene at baseline, 49% had surviving restorations after more than 20 years. The corresponding number for the Not Acceptable oral hygiene group was 41%.

At the same time as an influence from oral hygiene is indicated, it is interesting to note that those patients with Excellent oral hygiene ratings at baseline did not exhibit a better prognosis than those with merely Acceptable hygiene ratings. The latter group had in fact a better survival rate at 57% compared with 25% for the Excellent group. There is no reason to believe that the explanation to this somewhat contradictory finding should have anything to do with the executions of oral hygiene regimes as such. Rather it may be caused by unrealistic beliefs on the prognostic power of perfect patient oral hygiene among the dental practitioners. Thus, for patients with perfect oral hygiene, under the false assumption that such patients have a sort of improved overall prognosis for restorative treatments, practitioners may lure themselves into designing extreme restorations for example with one or more distal cantilever pontics.

The baseline technical quality of crowns and pontics was found to be of pronounced prognostic value. Thus, the survival rate for crowns with Satisfactory baseline ratings was 51% compared with only 10% for crowns with Not Acceptable baselines. At the same time, however, the prognosis for crowns with Excellent baseline technical quality was found not to be better than that for crowns with mere Acceptable technical baselines. Added patient values, if any, for crowns and pontics with excellent technical qualities must therefore be found, e.g. in improved aesthetics and comfort.

As might be expected, the results of this analysis show that the two most important prognostic factors in fixed prosthodontics are the bridge design and the biological factors reflecting patient caries susceptibility. These two factors were found to be three times as powerful as the other two identified prognostic ones, i.e. crown technical quality and patient oral hygiene. Also of interest is that neither the bridge extension nor the material characteristics of the materials used were found to have a prognostic influence.

Acknowledgements.—The late Professor Gunnar Ryge is acknowledged for his generous help and advice and key contribution during the initial stages of this study. Mr Kjell Gunnarsson is also acknowledged for his valuable help with the statistical analyses

References

1. Nyman S, Lindhe J. A longitudinal study of combined periodontal and prosthetic treatment of patients with advanced periodontal disease. *J Periodontol* 1979;50:163–9.
2. Walton JN, Gardner FM, Agar JR. A survey of crown and fixed partial denture failures: length of service and reasons for replacement. *J Prosthet Dent* 1986;56:416–21.
3. Kerschbaum T, Gaa M. Longitudinale Analyse von festsitzen-

- dem Zahnersatz privatversicherter Patienten. Dtsch Zahnärztl Z 1987;42:345–51.
4. Karlsson S. Failures and length of service in fixed prosthodontics after long-term function. A longitudinal clinical study. Swed Dent J 1989;13:185–92.
 5. Valderhaug J. A 15-year clinical evaluation of fixed prosthodontics. Acta Odontol Scand 1991;49:35–40.
 6. Palmqvist S, Swartz B. Artificial crowns and fixed partial dentures 18 to 23 years after placement. Int J Prosthodont 1993;6:279–85.
 7. Creugers NHJ, Käyser AF, van't Hof MA. A meta-analysis of durability data on conventional fixed bridges. Community Dent Oral Epidemiol 1994;22:448–52.
 8. Valderhaug J, Jokstad A, Ambjørnsen E, Norheim PW. Assessment of the periapical and clinical status of crowned teeth over 25 years. J Dent 1997;25:97–105.
 9. Lindquist E, Karlsson S. Success rate and failures for fixed partial dentures after 20 years of service: Part I. Int J Prosthodont 1998;11:133–8.
 10. Scurria MS, Bader JD, Shugars DA. Meta-analysis of fixed partial denture survival: prostheses and abutments. J Prosthet Dent 1998;79:459–64.
 11. Glantz PO, Nyman S. Technical and biophysical aspects of fixed partial dentures for patients with reduced periodontal support. J Prosthet Dent 1982;47:47–51.
 12. Glantz PO, Ryge G, Jendresen MD, Nilner K. Quality of extensive fixed prosthodontics after five years. J Prosthet Dent 1984;52:475–9.
 13. Ryge G, Snyder M. Evaluating the clinical quality of restorations. J Am Dent Assoc 1973;87:369–77.
 14. Ryge G, Jendresen MD, Glantz PO, Mjør IA. Standardization of clinical investigators for studies of restorative materials. Swed Dent J 1981;5:235–9.
 15. Glantz P-OJ, Nilner K, Jendresen MD, Sundberg H. Quality of fixed prosthodontics after 15 years. Acta Odontol Scand 1993; 51:247–52.
 16. Hakestam U, Karlsson T, Söderfeldt B, Rydén O, Glantz PO. Does the quality of advanced prosthetic dentistry determine patient satisfaction? Acta Odontol Scand 1997;55:365–71.
 17. Kronström M. Prosthodontics and the general dentist. A study of practice profiles and prosthodontic decision making in Sweden [Thesis]. Swed Dent J 1999;137:1–62.
 18. Randow K, Glantz PO, Zöger B. Technical failures and some related clinical complications in extensive fixed prosthodontics. Acta Odontol Scand 1986;44:241–55.
 19. Lundgren D. Prosthetic reconstruction of dentitions seriously compromised by periodontal disease. J Clin Periodontol 1991;18:390–5.
 20. Lundgren D, Laurell L. Occlusal force pattern during chewing and biting in dentitions restored with fixed bridges of cross-arch extension. II. Unilateral posterior two-unit cantilevers. J Oral Rehabil 1986;13:191–203.

Received 15 November 2001

Accepted 28 March 2002