Success and Failure of Different Types of Crowns and Fixed Dental Prostheses*

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*** Footnote:** This article is a revised and updated version of a presentation given by the author at the 10th International & 30th National Dental Congress of the Pakistan Dental Association 23–25 March 2012 in Karachi, Pakistan.

Abstract
The article presents a review of recent studies related to success and survival of various fixed prosthodontic treatment methods. In decision-making for treatment of missing teeth not only prosthodontic options are available but orthodontics and autotransplantation might be considered as well as the option to leave the space untreated. Single crowns and small fixed dental prostheses (FDPs) are the most common fixed restorations performed in general dental practice. For a long period metal-ceramics using high gold alloys was considered the material of choice in fixed prosthodontics. Today in Sweden all-ceramic materials dominate for both single implant and tooth-supported crowns anteriorly as well as posteriorly. For tooth-supported FDPs cobalt-chromium-porcelain is by far the most common material combination both in short-and long-span bridges. Based on the reviewed publications the following conclusions can be drawn: Both tooth- and implant-supported crowns and fixed dental prostheses are safe and predictable treatment methods with high survival rates up to and over 10 years. Metal-ceramic restorations provide higher survival rate and fewer complications than all-ceramic restorations. Biological and technical complications are frequent in all types of fixed prostheses, more so in implant-supported than in tooth-supported restorations. Cantilevers function well on implant-supported restorations but are associated with increased risk of failure and complication when used on tooth-supported restorations. Modern principles of construction have raised the resin-bonded restorations to a viable treatment option, especially for replacement of a single missing tooth.

Key words: All-ceramic, Crowns, Fixed dental prosthesis, Implant-supported prosthesis, Metal-ceramic, Resin-bonded restoration.

How to cite this article: Carlsson GE. Success and failure of different types of crowns and fixed dental prostheses. J Pak Prosthodont Assoc 2014; 02(01): 24-32

.Introduction

Most textbooks on prosthodontics and dental occlusion have stated that tooth loss must always be replaced because the masticatory system needs a complete dentition. Many studies have refuted this statement, and the successful application of the Shortened Dental Arch concept has indicated that tooth loss and its sequelae have been over-dramatized in the past.[1-3] However, most patients who have lost teeth, especially in the anterior part of the mouth, wish to have them replaced. Dentistry can offer a number of treatment options for tooth replacement (Table 1). This article will focus on prosthodontic treatment but other alternatives such as orthodontics and autotransplantation for treatment of a gap in the dental arch should not be forgotten, neither the option to leave the gap untreated.

Table 1: Treatment options for tooth replacement.

S. No	Type of Treatment
1	Implant-supported fixed prostheses.
2	Implant-tooth-supported fixed prostheses.
3	Resin-bonded bridges.
4	Conventional fixed dental prostheses (FDPs).
5	Removable partial dentures (RPDs).
6	Orthodontic treatment.
7	Autotransplantation.
8	No replacement.

Non-prosthetic options for managing missing teeth

An interesting study on orthodontic treatment of missing maxillary lateral incisor found that in general, subjects treated with orthodontic space closure were more satisfied with the appearance of their teeth than those who had a prosthodontic restoration. The authors concluded that orthodontic space closure produces results that are well accepted by patients, does not impair TMJ function, and encourages periodontal health in comparison with prosthetic replacements.[4]

A recent study on the cost-effectiveness of five treatment alternatives replacing a missing maxillary lateral incisor found that autotransplantation was most cost-effective. Among the other alternatives (single implant-supported crown, resin-bonded fixed dental prosthesis (FDP), cantilever FDP, and conventional full-coverage FDP; removable partial dentures were not included) the conventional FDP was least cost-effective.[5]

Another option to be considered is no treatment. Adaptation to a loss of one or two teeth is common, and can comprise both patient acceptance and occlusal stability (Figure 1). However, since adaptation processes take time, and all patients do not have the same capacity to adapt, a strategy of observation is recommended as a first choice after loss of one or a few teeth.[6]

Figure 1: Successful adaptation 10 years after loss of teeth 36 & 35 without treatment (Ref 6 with permission).

Prosthodontic options for tooth replacement

Numerous procedures and materials for fixed prostheses have been presented in the literature over the years, many of them without good documentation but nevertheless used by dentists. This has often resulted in failures and withdrawal from the market of several of the novelties, unfortunately to the expense of patients and dentists. Even if it is clear that not all new technologies are better than the old ones, implementation of new undocumented methods and materials seems to prevail in dentistry. A way to rectify this predicament may be to better follow the principle of evidence-based practice.[7]

Regarding prosthodontic alternatives, single crowns and small fixed dental prostheses (FDPs) are the most common fixed restorations performed in general dental practice.[8] The prevalence of prosthodontic restorations varies much between countries and over time and is related among other things to differences in oral health and socio-economic situation. A study in a Swedish city[9] with four repeated investigations of people in various age groups over 30 years (Figure 2) showed that the 80-year-old subjects had a similar prevalence of crowned teeth (approximately 35 %) during the whole period whereas the 50-year-olds had a decreasing rate from 25 % in 1973 to 7 % in 2003. The improved dental health during the period in the younger part of the samples (≥ 50 years) has resulted in a decreasing need of prosthodontic treatment, whereas the rate of crowned teeth in the elderly people has stayed fairly stable because most of their crowns were made when they were younger.

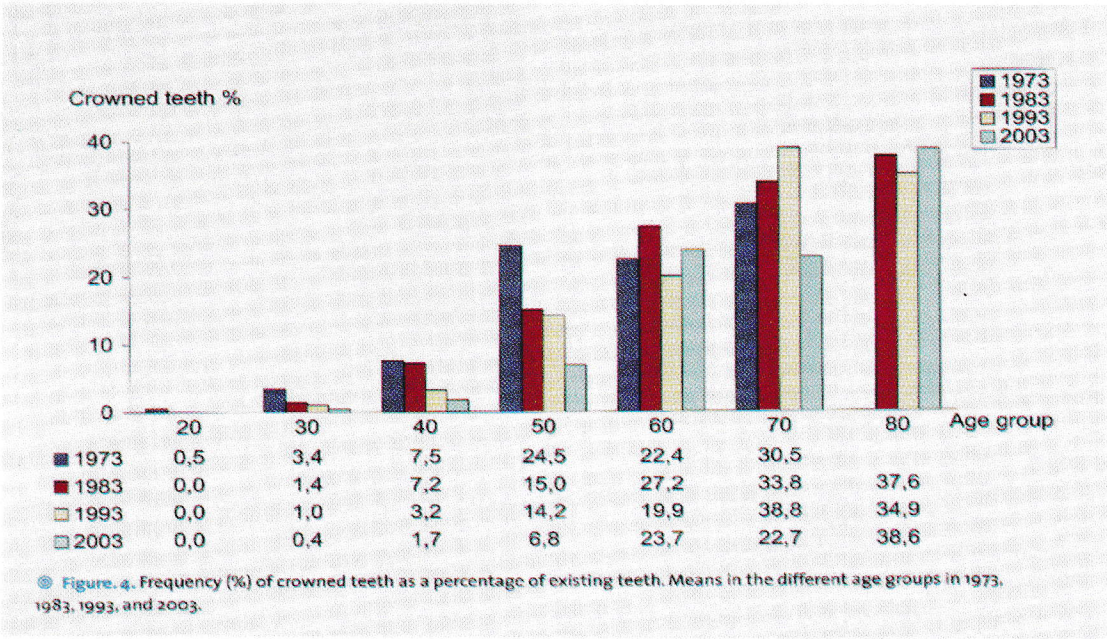

Figure 2: Prevalence of crowned teeth (% of all teeth) in various age groups in a Swedish city over 30 years (Ref 9 with permission).

Since the 1960s metal-ceramic restorations have been increasingly used and they have proven successful both from functional and aesthetic aspects (Figure 3). The metal component has varied from high gold alloys to low gold and palladium-based alloys and lately to base metal alloys such as cobalt-chromium and titanium alloys. For a long period metal-ceramics using high gold alloys was considered the material of choice in fixed prosthodontics but at present ceramic materials have become popular. In fact, in a recent questionnaire study among prosthodontists in Sweden[10] it was shown that the choice of materials in fixed prosthodontics has changed dramatically over the last decade. High noble metal-ceramic restorations are rarely used today and all-ceramic materials dominate for both single implant and tooth-supported crowns anteriorly as well as posteriorly. For tooth-supported FDPs cobalt-chromium-porcelain is by far the most common material combination both in short-and long-span bridges. For implant-supported FPDs in edentulous jaws titanium framework in combination with acrylic resin veneers is most common.[10] This development of alternative material combinations can mainly be explained by the huge increase in the gold price but to some part also by the wish of many patients today to avoid having metal in the mouth.The dominant combination titanium-acrylics for implant-supported FPDs in edentulous jaws is probably partly due to several still unsolved problems related to the fusing of ceramics to titanium. However, the belief based on early biomechanical considerations that acrylic resin would offer more favourable shock resistance to the implant-bone connection than ceramics[11], though later on questioned by experimental and clinical research, has probably also delayed the use of ceramic occlusal surfaces.

For a long time gold was considered the optimal occlusal material on tooth-borne FDPs. Currently ceramic is the first choice for the occlusal surface of fixed prostheses, from single crowns to full-mouth restorations (except for the implant-supported full-arch FDPs, at any rate in Sweden as mentioned above). The fear of ceramics being too brittle with risk of failures has proven largely unjustified, though

minor chipping of porcelain is a common but often easily amendable complication.

Figure 3: A 4-unit metal-ceramic FPD seen in a buccal & lingual view.

Success and survival

When reading studies on outcome of prosthodontic treatment it is important to know the difference between success and survival. Success means that the restoration has remained in function without any need of repair up to the follow-up. The definition of survival comprises restorations that are still in situ even if they were exposed to complications needing to be mended during the observation period or are in need of repair or remake at the follow-up. The distinction between success and survival is not always clear in the literature, which may make it difficult to compare outcomes of different treatments. Extensive discussions of this problem and proposals how to solve it have been presented recently.[12,13]

Metal-ceramic restorations have been in clinical use for several decades and were for long considered the gold standard in reconstructive dentistry, but only few long-term studies were published up to a decade ago according to systematic reviews.[14-16] In these reviews the survival of single metal-ceramic crowns was 95.6 % after at least 5 years. For FDPs the survival differed somewhat between different types of bridges after 5 years, but the differences increased substantially after 10 years, indicating that "long-term" studies should preferably be longer than 5 years (Table 2). Decreased survival after 10 years was especially evident for cantilever FDPs, implant-tooth restorations and resin-bonded FDPs.

Table 2: Survival of various types of FDPs according to Pjetursson & Lang 2008.

FDP Type	5-year (% Survival)	10-year (% Survival)
Conventional	93.8%	89.2
Cantilevered	91.4%	80.3
Implant-supported	95.2%	86.7
Implant-tooth combination	95.5%	77.8
Resin bonded.	87.7%	59.0

There are relatively great differences in outcomes between studies included in the reviews, among other things because of dissimilar success /survival definitions and limited reporting of clinical methodology, which may classify them "at best as outdated and at worst extensively misleading".[12] This provocative statement initiated a search of more recent studies on success and survival of fixed prosthodontic restorations, a few of which are presented below.

Single crowns: The survival of 2340 high-gold-based metal ceramic single crowns followed up to 25 years was 97 % after 10 years and 85 % after 25 years.[12] An extensive and interesting description and discussion of complications and failures are given in the paper. The survival rate was lower for crowns on non-vital teeth.

The survival rate for single crowns on implants was lower than the impressive results reported in for tooth-borne crowns[12] according to a systematic review: 96 % after 5 years, 89 % after 10 years.[17] Another review concluded that implant-borne single crowns offer comparable clinical service to tooth-borne fixed dental prostheses. However, single-tooth implant restorations are associated with an increased incidence of biological and technical complications.[18]

All-ceramic crowns are being increasingly popular and are used also posteriorly (Figure 4).[10,19] A recent systematic review using life table analysis of 16 studies reported cumulative 5-year survival rates of 95.9% for tooth-supported and 97.1% for implant-

supported zirconia crowns.[20] The authors concluded that "the results suggest that the success rate of tooth-supported and implant-supported zirconia-based crowns is adequate, similar, and comparable to that of conventional porcelain-fused-to-metal crowns. These results are, however, based on a relatively small number of studies, many that are not controlled clinical trials. Well-designed studies with large patient groups and long follow-up times are needed before general recommendations for the use of zirconia-based restorations can be provided."

Figure 4: Two zirconia crowns on molars at 5-year follow-up (Ref 19 with permission).

Conventional tooth-supported FDPs: A re-examination of 56 patients with 95 metal-ceramic FDPs demonstrated a survival rate of 90.4 % after 10 years and 80.5 % after 15 years.[21] The probability to remain free from any complication / failure was 79.7% at 10 years and 34.6% at 15 years. The risk of FDPs being affected by a biologic complication or failure after 10 years was 14.9 %; the risk was 5.3 % for a technical complication or failure. After 15 years, the risks of a biologic or technical complication or failure were 45.7% and 19.7%, respectively. It was concluded that the survival rates of FDPs decreased gradually with time. Freedom from complications and failures was drastically decreased for FDPs that had been in function for longer than 10-years.[21]
An elegant and sophisticated review concluded that metal-ceramic FDPs had high survival, with a significantly greater 5-year survival rate (94.4%) than all-ceramic FDPs (88.6%). Differences in complications were unknown, but evidence indicated that the complication incidence of metal-ceramic FDPs was lower than that of all-ceramic FDPs.[22]
The so-called Ante's law from 1928 forbid construction of FDPs on patients with compromised periodontal status. Several studies, originally conducted by periodontists in Sweden, refuted the concept and a systematic review based on 6 studies, all from Sweden, concluded that masticatory function could be established and maintained in subjects receiving FDPs on abutment teeth with severely reduced but healthy periodontal support. Furthermore, the survival rate of such restorations compared favourably with that of FDPs in subjects with normal periodontal status.[23]

Cantilever FDP:. A similar result as the relatively poor survival rate after 10 years for cantilever tooth-supported FDPs presented in Table 2 was reported in a study of 175 tooth-, implant- and tooth-implant supported restorations. FDPs with end abutments had high survival rates and low risk for complications whereas all types of restorations with cantilevers had a much-increased risk for complication and lower survival rate.[24]
In contrast, a systematic review of implant-supported FDPs with cantilevers concluded that there was no increase in complication rate due to the presence of cantilevers and the survival after 5 years was high and similar for those with and without cantilever.[25]

Implant-supported FD: An updated systematic review from the Pjetursson group[26] reported improved survival both of implants and FDPs compared to the previous results in Table 2, when early types of implant surfaces and gold-acrylic FDPs were excluded. The survival rate of metal-ceramic implant-supported FDPs was 96.5 % after 5 years and 93.9 % after 10 years. However, only two out of three of the patients (66.4 %) were free of any complications after 5 years. Another systematic review showed even higher survival rates both for implant-supported FDPs on 4–6 implants in edentulous and on 2–4 implants in partially edentulous jaws, with similar results in the maxilla and the mandible.[27]

Resin-bonded FDP: The longevity of early types of resin-bonded FDPs was limited mainly due to

debonding (Table 2). However, new principles of resistance preparations and use of two-unit cantilevered FDPs rather than three-unit FDPs to replace a missing tooth have improved the longevity. Recent studies on relatively small samples have reported 5- and 6-year survival rates of 100 % for single retainer / 2-unit cantilevered resin-bonded FDPs.[28,29] A larger patient material analysing 211 two-unit cantilevered resin-bonded FDPs found after a mean service life of 9.4 years success, retention and survival rates of 84.4, 86.7 and 90.0 %, respectively.[30]

Discussion

The literature in prosthodontics as well as in other dental areas increases rapidly. A great number of new studies relevant for the topic of this article was found in a search to update the material in my presentation from 2012. The procedure used does not qualify as a systematic review but adds some more recent and hopefully interesting results to the data I presented in my lecture.

The publications reviewed indicate that both tooth- and implant-supported FDPs are safe and predictable treatment methods with high survival rates up to 10 years. Studies covering longer periods are still rare and the results are inconclusive. One study demonstrated excellent results for tooth-supported single crowns up to 25 years[12], whereas another study indicated a drastic decrease of the survival after 10 years for conventional FDPs.[21] Such divergent outcomes are often found in the literature, which suggests that the results of an individual study must be interpreted with caution until they can be verified in further studies. If available, systematic reviews carried out according to the current strict guidelines are to be preferred. The controversial role of occlusion regarding survival of prosthodontic treatments has been discussed in a previous article.[31]

It must be noted that biological and technical complications are frequent in all types of fixed prostheses. Deserving even more attention is the fact that complications are more frequent in implant-supported than tooth-supported restorations.[26,32,33] Cantilevers are well accepted on implant-supported FDPs.[25,34] In contrast, several studies have reported increased incidence of failures and complications for tooth-supported FDPs with cantilevers.[16] However, such restorations can be a valuable treatment option if some basic guidelines are followed (Table 3; Figure 5).

Table 3: Some key points for long-term success of cantilever bridges.

1.	Establishment of good oral hygiene, which is always essential in fixed prosthodontics.
2.	Preparation of abutment teeth to get optimal retention (as parallel walls as possible, if necessary strengthened by grooves, boxes or pins).
3.	Avoid non-vital / root-filled distal abutment teeth.
4.	Avoid more than one extension unit.
5.	Proper dimensioning of the bridge components to get as rigid construction as possible.

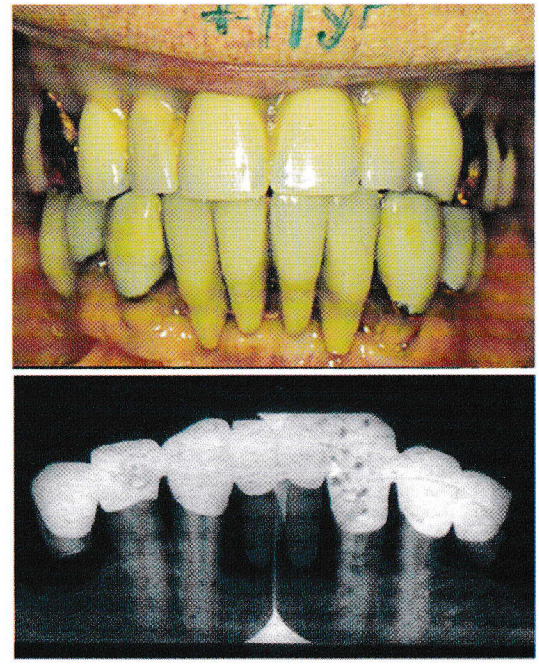

Figure 5: Clinical view and radiographs taken 11 years after insertion of the mandibular 10-unit FDP in a 70-year-old man, who still had the FDP when he died at age 84.

Resin-bonded FDPs have undeservedly held a bad repute mainly because the high incidence of de-

bonding among the early restorations (Table 2). Modern principles of construction have elevated the resin-bonded FDPs, especially the two-unit cantilevered type, to a durable and cost-effective treatment option offering good aesthetics and high patient satisfaction, a minimally invasive preparation and high biocompatibility.[28-30] Such a resin-bonded FDP deserves to be considered in decision-making for replacement of a missing tooth, not only as a provisional alternative but as a "permanent" restoration.

Conclusions

- Both tooth- and implant-supported crowns and fixed dental prostheses are safe and predictable treatment methods with high survival rates at least up to 10 years
- Metal-ceramic restorations provide higher survival rate and fewer complications than all-ceramic restorations
- Biological and technical complications are frequent in all types of fixed prostheses, more so in implant-supported than in tooth-supported restorations
- Cantilevers function well on implant-supported restorations but are associated with increased risk of failure and complication when used on tooth-supported restorations
- Modern principles of construction have raised the resin-bonded restorations to a viable treatment option, especially for replacement of a single missing tooth

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