Title: Reasons for placement and replacement of crowns in general dental practice.

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Abstract

Objectives: The aim of this study was to investigate the reasons for placement and replacement of crowns in general dental practice.

Methods: Forty general dental practitioners recorded the principal reason for the provision of new (initial) and replacement crowns for a maximum of up to 20 patients over a 20-week period.

Results: A total of 664 patients received 783 crowns during the period of this study. Of these, 69% (n=542) were new (initial) placements and 31% (n=241) were replacements. Overall, tooth fracture (45%; n=241) was the most frequently reported reason for new/ initial crown placements. Aesthetics (21%; n=53) and secondary/recurrent caries (20%; n=47) were the most frequent reasons for crown replacement. Maxillary premolars (27%, n=145) and mandibular molars (25%, n=137) were the teeth that received most initial crown placements. In contrast, maxillary incisors (50%, n=115) were the most common teeth to receive a replacement crown. Dentists were more likely to replace a crown if they had not placed it the original crown: 74% of replacement crowns (n=178) were placed by a different dentist. In contrast, 32% (n=77) of replacement crowns were provided for patients attending the practice for 5 years or less. Most patients had only one crown placed or replaced per course of treatment (n=611; 90%).

Conclusions: The results of this study reveal the prescribing habits of dentists in relation to provision of initial and replacement crowns. The vast majority of patients had only one

crown provided per course of treatment, which is probably a reflection of funding schemes and changing patterns of oral health. This sample reported fewer replacement crowns than in other similar studies. In keeping with existing literature, crowns were more frequently replaced when the treating dentist had not placed the initial crown. However, against this, more replacements were provided for more long-standing (5+ years attendance) compared to those with shorter attendance history (<5 years). In an area where high quality evidence is lacking, further consensus on the need for placement and replacement crowns is needed. Such information would assist dentists to provide high-quality care and commissioners in developing an evidence based service.

Introduction

The provision of crowns remains an important part of the range of treatments provided by dentists. Amongst others, the provision of crowns is needed for the management of heavily/ extensively restored teeth, fractured teeth and endodontically treated teeth. To a lesser extent than in the past, crowns can be used to improve the aesthetics of teeth.

Within the United Kingdom, the most recent Adult Dental Health Survey (2009) reveals that 37% of adults with teeth have crowns. This survey reported that crowns are mainly provided for older patients: almost 59% of those aged 45-74 years have a crown. It is also estimated that of those adults with crowns, each of these adults have, on average, three per person, amounting to an estimated 47.6 million crowns. Given the increasing numbers of patients retaining teeth into later life, the need for subsequent maintenance and replacement of existing crowns is likely to increase in the coming years

However the provision of crowns is costly in terms of both time and financial outlay. The provision of crowns also carries a biological cost –almost 20% of teeth receiving crowns require a root canal treatment within 15 years (Cheung et al. 2005). Therefore the decision to provide a crown should not be entered into lightly. One of the largest databases on crown/ restoration survival within general dental practice comes from the UK Dental Practice Board, which recorded information on the provision of dental treatments within UK general dental practice and funded by the National Health Service. Analysis of this database

revealed that between 48% - 68% of crowns provided were replaced within 10 years (Burke & Lucarotti 2009). Furthermore this analysis reported that the following factors affected the success of crowns:

- type of crown (full metal crowns survived the longest, followed by metal ceramic, followed by all ceramic/ porcelain jacket crowns)
- patient age (crowns survived longest in patients in the 30-49 year age bracket)
- patient attendance pattern (crown survival time was mandibular in patients who attended more frequently)
- method of remuneration (crowns lasted longer in patients who paid for treatment compared to patients who were exempted payment)

As such, the potential for over-treatment and subjectivity on the part of operators is high. At present the reasons for placement and replacement of crowns is not well described. A previous study from the North West of England carried out in the 1990s revealed that the most common reasons for initial placement of a crown was tooth fracture (38%) and restoration failure (26%). The most common reason for replacement of crowns was crown failure (27%). However unacceptable crown margins or secondary caries accounted for 30% of crown replacements. This study also revealed that crown replacements accounted for 33% of crowns placed within the period of investigation. However, while having a good sample size, this study was carried out in a group of patients who were regular attenders under the auspices of a privately funded dental insurance scheme.

Within UK primary dental care, treatments are funded in one of the three ways:

- funded by the National Health Service: the majority of patients pay a contribution for their treatment, and this is "topped up" by the government, while some patients are exempted payment and their charge is also paid by the government. The method of remuneration for dentists is complex and changed to a "Units of Dental Activity" basis, from a "fee-per-item" system over 10 years ago. Critically the number of crowns provided does not affect the fee paid – in practical terms this means that the dentist gains the same remuneration for one, two or many crowns provided to the same individual patient within the same course of treatment.

- Funded by private insurance schemes (such as a local scheme run by the individual practice) or widely-available commercial schemes such as 'Denplan'. Patients enter such schemes are being made "dentally fit" and are assigned to a category and associated premium based on their future risk of dental disease. Patients pay premiums each month, and if treatment such as crowns are required, pay the laboratory costs for these only.

- Funded on an individual basis by patients on a "fee-per-item" basis.

While some information exists (Wilson et al. 2003) on the prescribing habits and reasons for placement / replacement of crowns, this study was carried out 14 years ago and did not include the full range of funding in UK primary dental care. Since then, philosophies of

dental treatment, dental school teaching and materials have changed. Therefore the aim of this study was to establish contemporary reasons for placement and replacement of crowns in general dental practice and including all methods of remuneration currently available in UK general dental practice.

Materials and Methods

Ethical approval for this study was obtained from the UK North West Centre of Research Ethics Committees, REC reference no: 13/NW/0356. Dentists received a nominal fee, in recognition of their time involved in this study.

All dentists working in general dental practice in Wales were invited to take part in this study. Sixty volunteered to take part. Inclusion criteria for dentists were those working in general dental practice providing new or replacement crowns. To avoid any effects of organisational policies within multi-dentist practices, only one dentist per practice could enter the study.

Participating dentists were asked to invite patients to participate in this study. For each patient who required initial and/ or replacement crown(s), a pro-forma was completed. Information requested included the tooth being treated, the pre-existing 'restorative status' of the tooth, the rationale for why a new or replacement crown was being provided. The reasons included for new or replacement crowns are summarised in Figure1 & 2, respectively. These are based on those used in previous studies (Wilson et al 2003), which were, in turn, developed from the protocol of Mjor (1981). Reminders were sent to participating dentists via email and telephone.

Each practitioner was asked to collect data on up to a maximum of 20 patients over a 20-week period between July 2013 and January 2014. Data sheets were returned and entered onto an electronic database by the research team. Descriptive statistics are reported.

Results

Demographics of participating dentists

Of the 60 dentists who initially agreed to take part, 40 dentists provided data. Twenty dentists, withdrew for various reasons such as lack of time, other commitments, and changes in practice arrangements. Of the 40 dentists who took part in the study, 32 were male and 8 were female. Thirty-five had qualified in UK dental schools, one had qualified elsewhere in the European Union and four had qualified outside the European Union. The numbers of participating dentists located in the regions of Wales reflected the population density in those areas, with 20 in South East Wales, 8 in South West Wales, 7 in North Wales and 5 in Mid Wales. Their year of graduation ranged from 1976 to 2011. One dentist had qualified in the 1970s, 11 in the 1980s, 10 in the 1990s, 13 in the 2000s and 5 in the 2010s.

Details of patients and treatments received

A total of 664 patients received 783 crowns during this study. Of these crowns, 69% (n=542) were new / initial placements and 31% (n=241) were replacements. The number of new/ initial crowns placed in an individual patient during one course of treatment ranged from one to seven, while the corresponding number of replacement crowns ranged from one to five (Table 1). Most patients had only one crown placed (91% (n=433) of initial placements) or replaced (90% (n=178) of replacements).

More crowns were placed/ replaced in females than males (females: 61%, n=398; males: 37%, n=256; data missing: 10, 2%). The mean age of the patients was 53 years (with a range of 16 to 87 years). Almost one-half of the patients had been attending the practice for more than 10 years (47%, n=309), while 32% (n=77) of replacement crowns were provided for patients attending the practice for 5 years or less (Table 2).

Care for the majority of the patients was provided via the National Health Service (64%, n=415). A further 26% of patients (n=167) funded their own care on a private basis, and care for the remaining 10% (n=65) was based on insurance schemes (such as Denplan or the practices' own schemes).

The distribution of teeth treated is reported in Table 3. Maxillary pre-molars (28%, n=145) and mandibular molars (24%, n=137) were the teeth that received most initial crown placements. Maxillary incisors (49%, n=115) were the teeth which most commonly received replacement crowns (Table 3).

Metal ceramic/PFMs were the most common type of crown provided (70%, n=545). This was the case for both initial placement (68%, n=364) and replacement crowns (75%, n=178) (Table 4). Metal ceramics were used to replace existing crowns of the same material in 86% (n=132) of cases and were the most commonly used material to replace porcelain (48%, n=19) and full metal crowns (53%, n=17).

Reasons for initial placement of crowns and the replacement of crowns

Overall, tooth fracture 45% (n=241) was the most frequently reported reason for the initial placement of a crown, followed by failed restorations 22% (n=121) and endodontic reasons 19% (n=101). (Figure 3). Aesthetics (21%, n=53) and secondary/recurrent caries (20%, n=47) were the most frequent reasons for crown replacement, followed by lost crown (15%, n=36) and crown fracture (15%, n=36) (Figure 4).

The reasons for placing and replacing crowns were significantly different for different funding types (placement $p<0.001$ and replacement $p=0.005$, respectively). NHS (52%, n=168) and insured (45%, n=28) patients were more likely to receive an initial crown placement for a fractured tooth than private patients (25%, n=38). Private patients (33%, n=26) had more crowns replaced for aesthetic reasons than NHS (17%, n=24) and insured (12%, n=2) patients (Table 6). Dentists were more likely to replace a crown if they had not placed it in the first place (74% of replacements were placed by a different dentist (n=178) compared to 20% of replacement provided by the same dentist (n=49)).

Pre-treatment restorative condition of teeth – new crown placements

For initial crown placements, 91% (n=442) of teeth had a pre-existing filling. Of these, the average number of filled surfaces was 3.04. Two hundred and fifteen root filled teeth were included in this study, the majority of which received an initial crown placement within 3 years of completion of the root treatment (n= 117; 54%).

Replacement crowns – information on marginal status and repairability

Thirty-eight percent (n=92) of crown replacements were due to marginal gap or caries. The majority of these crowns had only one affected surface (61%, n=63) of which the buccal surface was most commonly affected (43%, n=33). Most commonly the defect size was greater than the diameter of a BPE probe tip (0.5mm) (37%, n=39). For 79% (n=190) of replacement crowns, the respondent dentist reported it would not have been possible to repair the existing crown. The most common reasons for not repairing the crown were due to the marginal defect being too large 26% (n=63) or the repair was unlikely to meet the needs/expectations of the patient 26% (n=63) (Table 5).

Longevity of crowns – reported time to replacement

Crowns had been in clinical service for periods between 1 month and 35 years, with a mean average of 12 years and median of 10 years, prior to replacement. This information was obtained from the patient or the clinical records.

Discussion

Primary dental care research has much to offer in terms of understanding the practice of clinical dentistry in the "real world" (i.e. away from the often-criticised sterile environment of dental school and specialist centre practice) (Gilbert et al. 2013; Heaven et al. 2013; Rindal et al. 2012; Gordan et al. 2012). There is merit in considering approaches to treatment in primary care settings as that is where dental care is delivered to the majority of the population. However, primary dental care research is often logistically difficult and time-consuming to undertake. Participant dentists are often geographically spread across a large area, standardisation is difficult and collection of data is dependent on the time requirements and enthusiasm of practitioners. In this study, while the participants were not a random sample, they included a range (age, gender) of primary care dentists working under a variety of funding conditions (e.g. NHS, privately funded, insured patients and mixed funding practices), as well as those in rural, suburban and urban locations. The data collection tool was based on those used in a previous study into the placement and replacement of crowns by Wilson et al (2003), which was, in turn, developed from the protocol of Mjor (1981). This may well have introduced some bias into the data collection, in that only the more motivated and enthusiastic dentists volunettered and subsequently collected data. Nevertheless the considerable volume of data fgathered allows some understanding of the decision-making process on the part of dentists in relation to the placement and replacement of crowns in a primary care setting.

The results of this study are quite revealing in relation to the decision-making process of dentists in relation to when to place initial and/ or replacement crowns. It is noted that replacement crowns accounted for 31% of all crowns placed. Across funding types, a greater proportion of replacements were seen in patients who were personally / privately funding their care (35%) compared to those whose treatment was funded by the NHS (29%) and those with insured care (22%). Within the previous comparable study by Wilson et al (2003), 33% of crowns included in the study were replacements – however this study considered insured patients only, which would suggest that within the current cohort, at least, the number of replacement crowns has reduced. A further similar study from a specialist clinic in Turkey of 842 crown placements found that 44% were replacements (Uzgur et al. 2017).

The vast majority of patients (>90%) had only one initial or replacement crown. This is of interest as it may reflect improved oral health within society, changing approaches to dental care, or the availability of alternate, predictable dental treatments (e.g. veneers, fillings). At a more subtle level, the NHS funding scheme in the UK authorises payment of the same fee regardless of the number of crowns placed (i.e. same payment for one or many crowns). In this study, 64% of crowns placed were provided under NHS funded care – the relatively low rate of replacement crowns, and the tendency towards single crown placement per treatment episode may reflect the pressures of the funding arrangements.

The maxillary pre-molars (27%, n=145) and mandibular molars (25%, n=137) were the teeth that received most initial crown placements. In contrast, maxillary incisors (50%, n=115) were the most common teeth to receive a replacement crown. These findings are similar to those of Wilson et al. (2003) who proposed that the reason for the greater number of crown replacements for maxillary incisors was due to a previous trend of placing crowns mainly on

maxillary anterior teeth (Fyffe 1992). These results suggest that the change in pattern of crown placement highlighted by Wilson et al. (2003) – i.e. more initial crowns placed on teeth other than maxillary incisors - is still present, and that the pattern of replacement reflects the numbers of maxillary incisors crowned previously. The reason for fewer initial crown placements in maxillary incisors may also be related to the availability of alternate predictable aesthetic treatment such as bleaching and resin composites.

Within this study, it was noted that middle aged patients (31-60 years old) and older patients (61-86 years old) were more likely to receive a new crown for mandibular molars (29%, n=94) and maxillary pre-molars (30%, n=54), respectively, than other tooth types. This is a reflection of the need for complex restorative intervention in the so-called 'heavy metal' generation (Steele 2009). These are a cohort of previously identified patients who have, in the past, received many and extensive mainly amalgam restorations, who, as they age, require expensive and complex treatments. This is again highlighted by the finding that initial crown placements were for so-called "damaged"/ already heavily restored teeth, such as tooth fracture (e.g. adjacent to a large restoration, 45%), failed (often extensive) restorations (22%) and subsequent to endodontic treatment (19%), rather than aesthetic reasons (5%).

In this study, the prescription pattern and decision-making in relation to replacing crowns are of interest. In keeping with existing literature (Burke & Lucarotti 2009), the likelihood of replacing a crown increases if a different dentist to the one who placed the initial crown is involved in the patient's care (74% of replacements were placed by a different dentist).

However, against the findings of Burke & Lucarotti (2009), only 32% of replacement crowns were provided for patients who had attended the practice for less than 5 years (i.e. replacement did not seem to be associated with those who changed dentist more frequently).

An area of subjectivity in terms of managing existing crowns relates to the degree to which dentists choose to replace rather than repair a defective crown, potentially exposingpatients to over-treatment. In only 2 of the 241 replacement crowns provided in this study, would the treating dentist have considered a repair as an alternative.

There is a lack of clinical evidence relating to the potential for repairing, rather than replacing, crowns with defective/ unsuitable margins. In a related approach, the notion of similarly repairing restorations (e.g. amalgam, resin composite) with unfavourable/ deteriorating margins has been proposed for many years – yet there is a similar lack of high-quality evidence in relation to the appropriateness of restoration versus repair. It is suggested as a priority that there is a need for high quality clinical evidence to demonstrate the need – or not – for marginal repair as a suitable treatment for the management of crowns which are clinically serviceable notwithstanding marginal deterioration/ caries.

Conclusion

This study, which has been carried out in a primary dental care setting, has highlighted primary dental care practitioner approaches to the provision of initial and replacement crowns. Replacement crowns accounted for almost one-in-three crowns provided. In particular, the highly subjective nature of the decision-making process, on the part of dentists, especially relating to replacement crowns, is evident. Further consensus and evidence is needed in this important clinical area to provide assistance to dentists when aiming to provide high-quality care for their patients.

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Tables

Table 1: Number of crowns placed per course of treatment.

Number of crowns	Placement n (%)	Replacement n (%)	Total n (%)
1	433 (91)	178 (90)	611 (90)
2	76 (8)	42 (10)	118 (9)
3	6 (0)	3 (0)	9 (0)
4	20 (1)	8 (0)	28 (1)
5	0(0)	10 (0)	10 (0)
6	0(0)	0(0)	0(0)
7	7 (0)	0(0)	7 (0)
Total	**542 (100)**	**241 (100)**	**783(100)**

Table 2: Years patient attending practice when placement/ replacement crowns provided.

Years patient attending practice	**Placements** n (%)	**Replacements** n (%)	**Total** n (%)
<1	58 (11)	31 (13)	89 (11)
1-3	66 (12)	29 (12)	95 (12)
4-5	64 (12)	17 (7)	81 (10)
6-10	93 (17)	43 (18)	136 (17)
>10	247 (45)	112 (46)	359 (47)
Data not reported	**14 (3)**	**9 (4)**	**23 (3)**
Total	**542 (100)**	**241 (100)**	**783 (100)**

Table 3: Distribution of the initial placement and replacement crowns according to teeth crowned

Teeth	Placements n (%)	Replacements n (%)	Total n (%)
Maxillary			
Incisors	75 (14)	119 (49)	194 (27)
Canines	17 (3)	14 (6)	31 (4)
Premolars	145 (28)	30 (13)	175 (22)
Molars	83 (15)	22 (9)	105 (13)
Subtotals	320 (60)	185 (77)	505 (66)
Mandibular			
Incisors	10 (2)	1 (0)	11 (1)
Canines	4 (1)	4 (2)	8 (1)
Premolars	68 (13)	22 (9)	90 (11)
Molars	137 (24)	28 (12)	165 (21)
Subtotals	219 (40)	55 (23)	274 (34)
Data not reported	3 (0)	1 (0)	4 (0)
Totals	**542 (100)**	**241 (100)**	**783 (100)**

Table 4: Distribution of the type of crown material used in the placement and replacement of crowns

Type of crown	**Placement** **n (%)**	**Replacement** **n (%)**	**Total** **n (%)**
Metal ceramic	367 (69)	178 (75)	545(70)
Porcelain	94 (17)	33 (14)	127 (15)
Metal	61 (11)	16 (7)	77 (10)
Zirconia	17 (3)	10 (4)	27 (4)
Composite	1 (0)	0 (0)	1 (0)
Data not reported	2 (0)	4(2)	6 (1)
Total	**542 (100)**	**241 (100)**	**783 (100)**

Table 5: Existing crowns affected by caries or marginal gap that received replacement crowns.

Number of surfaces affected by caries/marginal gap	Number (%)	**Distribution of surfaces affected by caries/marginal gap**	Number (%)	**Size of caries/marginal gap**	Number (%)	**Principal reason why repair would not have been possible**	Number (%)
1	63 (69)	**Buccal**	43 (33)	**Less than width of an explorer**	7 (8)	**Marginal defect too large**	63 (26)
2	21 (23)	**Distal**	26 (20)	**Width of an explorer**	18 (20)	**Repair unlikely to meet needs/expectations of the patient**	63 (26)
3	3 (3)	**Mesial**	23 (17)	**Width of a William's probe**	12 (13)	**Crown lost**	32 (13)
4	0 (0)	**Occlusal/Incisal**	22 (17)	**Width of a BPE probe tip**	10 (11)	**Shape/shade of crown flawed**	23 (10)
5	1 (1)	**Labial/Palatal**	3 (2)	**Greater than the width of a BPE probe tip**	39 (41)		
Data not reported	4 (4)	**Data not reported**	15 (11)	**Data not reported**	6 (7)	**Data not reported**	60 (24)
Total	**92 (100)**	**Total**	**134 (100)**	**Total**	**92 (100)**	**Total**	**241 (100)**

Figures

Figure 1: Reasons for placement of crowns

Failed restorations	Includes all reasons for the failure of restorations such as secondary (recurrent) caries, fractured restorations (bulk and marginal) resulting in the placement of crowns.
Tooth fracture	All forms of tooth fracture, including those that extend into a restoration and fracture due to trauma.
Aesthetics	Crowns placed to improve aesthetics for any reason (tetracycline discoloured teeth, large unsightly restorations).
Wear	Wear of tooth tissues by attrition, abrasion and erosion.
Endodontic reasons	Endodontic reasons for crown provision, e.g. crowning following root filling, or need for post and core to obtain adequate retention for a crown.
Occlusal problems	Occlusal reasons for crown placement.
Primary Caries	Is caries on a surface not directly associated with any existing restoration? If approximal caries is unrelated to an existing sound restoration, primary caries is recorded.
Other	Any other reasons for placement of a crown.

Figure 2: Reasons for replacement of crowns

Secondary/ recurrent caries	Caries detected at the margins of an existing crown.
Unacceptable marginal adaptation	Degraded or poor margins but without secondary caries.
Lost crown	Cementation failure leading to the need for crown replacement.
Crown fracture	Fracture of any part of the crown that is the reason for replacement.
Tooth fracture	Any form of tooth fracture that does not involve the crown but is the reason for crown replacement.
Aesthetics	Aesthetic reason for the crown to be replaced. Includes gingival recession exposing the crown margin.
Wear	Wear by attrition, abrasion or erosion resulting in the need for crown replacement.
Endodontic reasons	Endodontic reasons that lead to the need for crown replacement.
Change of material	Replacement of a serviceable crown where the change of material was the reason for the replacement rather than failure of the crown.
Occlusal problems	Occlusal reasons for crown replacement.
Other	Other reasons for the replacement of a crown.

Figure 3: Reason for the initial placement of crowns

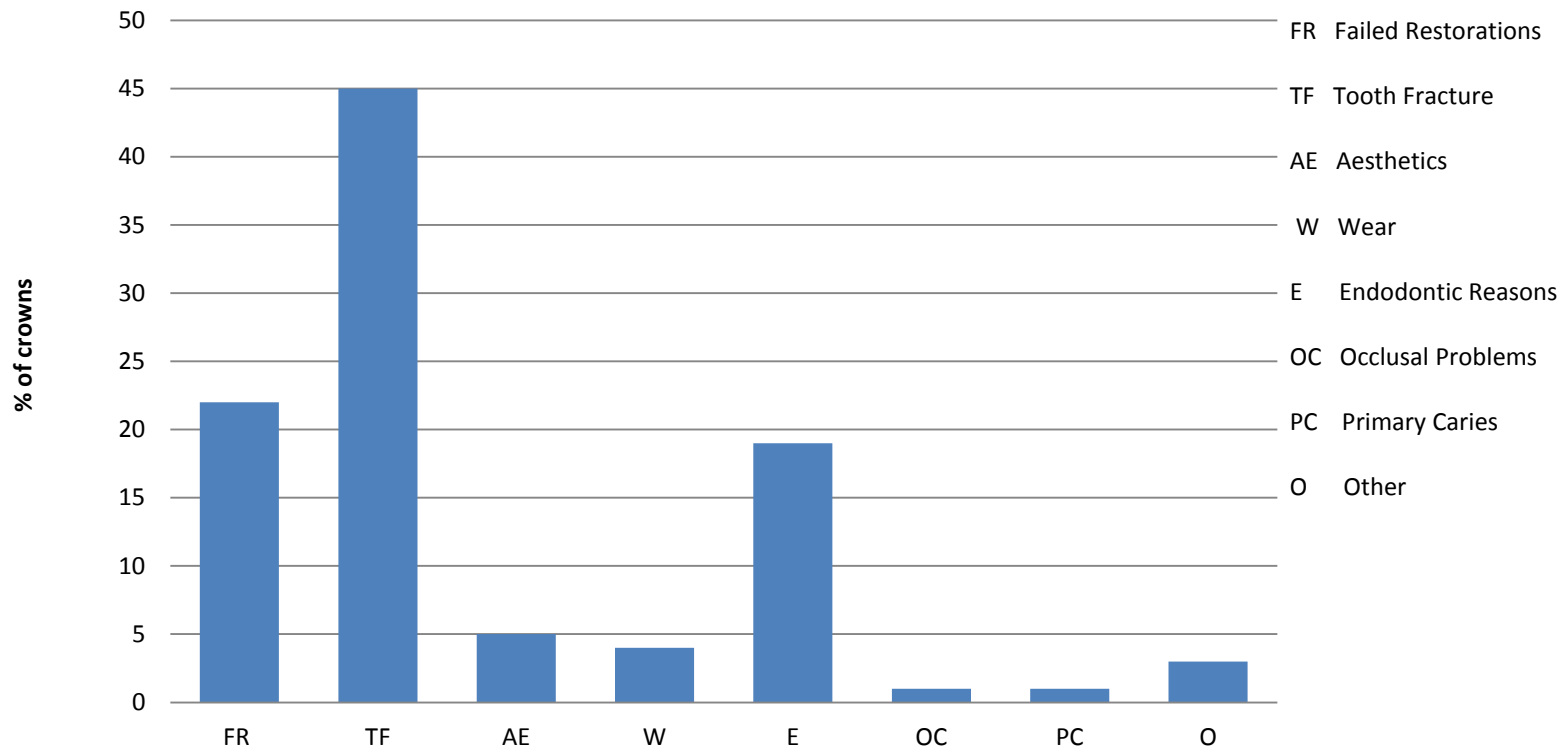

Figure 4: Reason for the replacement of crowns