# Clinical complications in fixed prosthodontics

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**The purpose of this article is to identify the incidence of complications and the most common complications associated with single crowns, fixed partial dentures, all-ceramic crowns, resin-bonded prostheses, and posts and cores. A Medline and an extensive hand search were performed on English-language publications covering the last 50 years. The searches focused on publications that contained clinical data regarding success/failure/complications. Within each type of prosthesis, raw data were combined from multiple studies and mean values calculated to determine what trends were noted in the studies. The lowest incidence of clinical complications was associated with all-ceramic crowns (8%). Posts and cores (10%) and conventional single crowns (11%) had comparable clinical complications incidences. Resin-bonded prostheses (26%) and conventional fixed partial dentures (27%) were found to have comparable clinical complications incidences. The 3 most common complications encountered with all-ceramic crowns were crown fracture (7%), loss of retention (2%), and need for endodontic treatment (1%). The 3 most common complications associated with posts and cores were post loosening (5%), root fracture (3%), and caries (2%). With single crowns, the 3 most common complications were need for endodontic treatment (3%), porcelain veneer fracture (3%), and loss of retention (2%). When fixed partial denture studies were reviewed, the 3 most commonly reported complications were caries (18% of abutments), need for endodontic treatment (11% of abutments), and loss of retention (7% of prostheses). The 3 most common complications associated with resin-bonded prostheses were prosthesis debonding (21%), tooth discoloration (18%), and caries (7%).** (J Prosthet Dent 2003;90:31-41.)

A complication has been defined[1] as "a secondary disease or condition developing in the course of a primary disease or condition." Although complications may be an indication that clinical failure has occurred, this is not typically the case. It is also possible that complications may reflect substandard care. But once again, this is usually not true. Most of the time, complications are conditions that occur during or after appropriately performed fixed prosthodontic treatment procedures.

Knowledge regarding the clinical complications that can occur in fixed prosthodontics enhances the clinician's ability to complete a thorough diagnosis, develop the most appropriate treatment plan, communicate realistic expectations to patients, and plan the time intervals needed for post-treatment care. Although a plethora of articles present clinical complications data, none provide a comprehensive comparison of the complications associated with the most commonly used restorations/prostheses.

One of the purposes of this article is to present data regarding the incidence of clinical complications associated with the following restorations/prostheses: single crowns (all-metal, metal ceramic, resin veneered metal); fixed partial dentures (all-metal, metal ceramic, resin-veneered metal); all-ceramic crowns; resin-bonded prostheses; and posts and cores. A second purpose is to identify the most common complications associated with each of these restorations/prostheses. A third purpose is to compare the restorations/prostheses on the basis of the incidence of complications encountered.

## METHODOLOGY

A Medline search was initiated related to success, failure, complications, and clinical studies associated with single crowns, fixed partial dentures, all-ceramic crowns, resin bonded prostheses, and posts and cores. Reviewing the list of articles identified through the Medline search revealed additional publications, as did extensive hand searching. The literature search covered the last 50 years and focused on publications that contained clinical data regarding success, failure, and complications.[2-163] To be included in the calculated mean data of this report, publications must have presented clinical data that identified the number of restorations/prostheses being evaluated, how long they had been in place, and how many were affected by complications. Publications were grouped according to each type of restoration/prosthesis. The raw data from all the studies of a particular restoration/prosthesis were combined and a mean complications

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incidence was calculated for each type of restoration/prosthesis. The mean values were compared for the purpose of identifying which restorations/prostheses were associated with the greatest number of complications.

The most common complications associated with each type of restoration/prosthesis were identified, and a mean incidence was also calculated for each type of complication. For a specific complication to be included in this article, 3 or more studies must have reported data related to the incidence of that particular complication. Certain complications were reported in a large number of studies whereas others may have only been presented in 3 studies. Therefore the mean percentages present in this article suggest trends rather than absolute incidence values.

## SINGLE CROWNS

Eight studies[2-9] were included in the complications incidence data associated with single crowns. The types of crowns included all-metal, metal ceramic, and resin-veneered metal designs. One of the studies[2] identified the total number of complications that occurred but did not describe the nature of the complications, for example, caries and loss of retention. The other 7 studies[3-9] identified both the total number of complications and the type of complications. A total of 1476 crowns were evaluated in the 8 studies, and a total of 157 were associated with some type of complication, resulting in a mean complications incidence of 11%. The length of the studies ranged from 1 year to 23 years, with an average length of about 6 years. There were additional studies[10-18] containing complications data associated with single crowns. One of these studies[18] only provided data regarding 1 type of complication (need for endodontic treatment), and it was included in the calculations related to the need for endodontic treatment. The other studies[10-17] did not present the data in a manner that permitted the required types of calculations to be made. Therefore, they were not included in this publication.

Five of the 8 studies[2,4,6,8,9] included in the complications incidence calculations evaluated the crowns for time periods between 1 and 4 years, and a mean complications incidence of 16% was reported. Three other studies[3,5,7] reported data from observation times in excess of 5 years, and they reported a mean complications incidence of 7%.

Data regarding the following 5 types of complications were reported in 3 or more of the studies: need for endodontic treatment, porcelain fracture, loss of retention, periodontal disease, and caries (Table I). Two studies[4,7] provided data about all 5 of the complications, 1 study[6] evaluated 4 of the 5 complications, 3 studies[3,8,9] presented information about 3 of the 5 complications, and 1 study[18] provided incidence data related to only 1 complication. One other complication (tooth fracture) was evaluated, but incidence data were only reported in 2 studies, and therefore the inclusion criteria were not satisfied.

**Table I.** Most common single crown complications

| | Number crowns studied/affected | Mean incidence |
|---|---|---|
| Need for endodontic treatment | 823/27 | 3% |
| Porcelain fracture | 199/6 | 3% |
| Loss of retention | 1,061/19 | 2% |
| Periodontal disease | 986/6 | 0.6% |
| Caries | 1,105/4 | 0.4% |

### Need for endodontic treatment

Five studies[3,4,6,7,18] reported on the incidence of endodontic treatment needed in conjunction with single crowns. Of the 823 crowns studied, 27 needed endodontic treatment. There was a mean incidence of 3% and a range of 0% to 6%. The 6% incidence (3 of 51 crowns) was associated with pinledge crowns.[3] Two of the 3 teeth needing endodontic treatment occurred in conjunction with tooth preparation and 1 subsequent to restoration.[3]

### Porcelain fracture

Three studies[4,6,9] identified the incidence of porcelain fracture with a mean rate of 3% (6 of 199 crowns studied) and a range of 2.7% to 6%.

### Loss of retention

There were 5 studies[3,4,6-8] reporting loss of retention of single crowns, with 19 crowns loosening among the 1061 crowns studied. The mean loss of retention was 2%, with a range from 1% to 23%. The highest loss of retention (23%) was associated with pinledge restorations evaluated for a mean time of 98 months and an observation time range from 75 to 108 months. Twelve of the 51 pinledges loosened over this time period.

### Periodontal disease

Five studies[3,6-9] evaluated the periodontal health around single crowns, reporting a mean complication incidence of 0.6% (6 of 986 crowns affected). One study[3] reported only small differences in the periodontal results between restored teeth and controls. Only 1 crown produced a significant difference in the plaque index, gingival index, and pocket depth.[3] Another study[6] reported a lower percentage of gingivitis around the crowns after 2 years when compared to baseline conditions. Bergman et al[8] noted only minor periodontal changes after 2 years, and Nilson et al[9] found the periodontal health around single crowns to be comparable to the control teeth after 26 to 30 months.

**Table II.** Most common fixed partial denture complications

| Need for endodontic treatment | Number of prostheses or abutments studied/affected | Mean incidence |
|---|---|---|
| Caries | 3360/602 abutments | 18% of abutments |
| | 1354/113 prostheses | 8% of prostheses |
| Need for endodontic treatment | 2514/276 abutments | 11% of abutments |
| | 1357/88 prostheses | 7% of prostheses |
| Loss of retention | 1906/137 prostheses | 7% |
| Esthetics | 1024/58 prostheses | 6% |
| Periodontal disease | 1440/62 prostheses | 4% |
| Tooth fracture | 1602/44 prostheses | 3% |
| Prosthesis fracture | 1192/24 prostheses | 2% |
| Porcelain veneer fracture | 768/17 prostheses | 2% |

### Caries

Four of 1105 crowns evaluated in 6 studies[3,4,6-9] developed carious lesions, producing a mean incidence of 0.4% with a range from 0% to 2.7%.

## FIXED PARTIAL DENTURES

The incidence of complications associated with fixed partial dentures was determined by evaluating data from 19 clinical studies.[2,5,13,19-34] The types of fixed partial dentures included all-metal, metal ceramic, and resin veneered metal prostheses but did not include resin bonded prostheses. A total of 3272 fixed partial dentures were evaluated in the 19 studies, and a total of 866 prostheses were associated with some type of complication, producing a mean complications incidence of 27%. The length of the 19 studies ranged from 1 year to 20 years, with an average length of about 8 years. There were other studies[16,17,36-44] containing data that were not included in this publication. One article[36] presented information about fixed partial dentures by calculating survival rates with the Kaplan-Meier method. Two other articles[37,38] performed meta-analyses of available studies and provided survival data. Additional publications[16,17,39-44] contained fixed partial denture clinical data, but they were not published in a form that permitted inclusion in this article.

Six of the included studies[2,13,19,20,27,28] evaluated the fixed partial dentures for periods between 1 and 4 years, reporting a mean complications incidence of 20% (148 of 737 prostheses affected). One study[13] did not provide a mean study length. The prostheses were evaluated over periods of 1 to 11 years, and a decision was made to include this study[13] in the 1- to 4-year group. Nine studies[21-26,29,30,32] evaluated the prostheses for periods between 5 and 14 years, and a mean incidence of 27% (555/2046 prostheses) was calculated for this group. One of the studies[22] in this group had a mean length of 4.9 years, and a decision was made to include the data in the 5- to 14-year group. In 4 studies,[5,31,33,34] the prostheses were examined after 15 to 20 years, and the mean complications incidence for this group was 27%.

Data regarding the following 8 complications were reported in multiple studies and therefore were included in this paper: caries, need for endodontic treatment, loss of retention, periodontal disease, esthetics, tooth fracture, prosthesis fracture, and esthetic veneer fracture (Table II). One study[33] evaluated all 8 complications. Three of the studies[23,25,31] evaluated 7 of the 8 complications, 4 studies[5,32,34,35] reported on 6 of the 8 complications, 3 studies[20,22,27] provided data on 5 of the 8 complications, 6 studies[26,28-30,45,46] limited their reporting to 2 to 3 complications, and 2 studies[18,47] only reported on 1 complication. Four of the studies[2,13,19,21] included in this article identified the number of prostheses that failed but did not provide data regarding the cause of the failure or information about complications.

There were other complications evaluated (in addition to the 8 reported in this article), but they were not reported in a sufficient number of publications to be included in this study. These factors included pain and sensitivity, mobility, edentulous ridge mucosa, root resorption, temporomandibular joint problems, possible reaction to metal, phonetic problems, and marginal fit.

### Caries

Fifteen studies evaluated the incidence of caries, but in 2 different ways. Some studies[22-24,26-28,35,45,46] presented the caries incidence in relation to the number of abutments affected and determined that 602 of 3360 abutments became carious for a mean incidence of 18% and a range from 0% to 27%.

Other studies[5,20,22,23,25-27,31-33] evaluated caries according to the number of prostheses affected and determined that 8% of the prostheses were affected (113 of 1354 prostheses). The caries incidence ranged from 0.7% to 26%. Four studies[22,23,26,27] presented the data as it related to both abutments and prostheses.

### Need for endodontic treatment

The endodontic incidence was also presented both according to the number of abutments and number of prostheses affected. Eleven studies[5,18,22,24,26,27,35,44-47] related the incidence of endodontic treatment to the number of abutment teeth, and the mean abutment incidence was 11% (276 of 2514 abutments affected). The range was from 3% to 38%.

Eight studies[22-25,27,33-34] related the incidence to the number of prostheses affected, thereby providing a prosthesis incidence. Of the 1357 prostheses evaluated, 88 required treatment for a mean incidence of 7% and a range of 0.7% to 21%.

### Loss of retention

Fourteen studies[5,20,22-25,27-29,31-34,46] evaluated the loss of retention of fixed partial dentures. In the 14 studies, 137 of 1906 prostheses loosened for a mean incidence of 7% and a range from 0.0% to 13%.

### Esthetics

An unsatisfactory esthetic result was found in 58 of 1024 prostheses evaluated in 7 studies.[5,22,23,25,31,33,34] There was a mean esthetics complications incidence of 6% and a range from 2% to 12%.

### Periodontal disease

Thirteen studies[5,20,22,23,25,26,30-35,45] assessed the periodontal health around prostheses. Of the 1440 prostheses evaluated, 62 adversely affected periodontal health. There was a mean incidence of 4% and a range from 0% to 17%.

### Tooth fracture

The incidence of abutment tooth fracture was recorded in 14 studies.[5,20,22,23,25-34] The data were provided in relation to the number of prostheses in which fracture occurred. There was not a sufficient number of studies reporting the number of abutments that fractured to include the data in this article. The mean prosthesis incidence was 3% (44 of 1602 prostheses recorded abutment tooth fracture). The range was from 0.7% of prostheses to 25% of prostheses.

### Prosthesis fracture

Eight studies[5,20,23,25,32-35] assessed the incidence of framework fracture with 24 prostheses fracturing from a combined study group of 1192 prostheses. The mean incidence was 2%, with a range from 0.7% to 4%. The studies in which framework fractures occurred involved mostly long span prostheses, and many of the prostheses had cantilevered pontics (single and double cantilevers).

**Table III.** Most common all-ceramic crown complications

| | Number of crowns studied/affected | Mean incidence |
|---|---|---|
| Fracture | 4277/318 | 7% |
| Loss of retention | 545/11 | 2% |
| Pulpal health | 1088/15 | 1% |
| Caries | 1650/13 | 0.8% |
| Periodontal disease | 942/0 | 0.0% (no significant changes) |

### Porcelain veneer fracture

Five studies[25,27,31,33,35] provided data about veneer fractures, with 17 of 768 prostheses affected by fracture. The mean incidence was 2%, with a range from 0.6% to 4%.

## ALL-CERAMIC CROWNS

Complications encountered with all-ceramic crowns are presented in 22 clinical studies.[4,48-69] A total of 4277 crowns were evaluated, and 357 exhibited some type of complication, producing a mean complications incidence of 8%. In the 22 studies, the observation times were as short as 1 month and as long as 14 years. The average length was about 4 years. Other studies reported data about all-ceramic crowns but were not included in this publication for 2 reasons. Three studies[70-72] presented complications data that were subsequently published after longer time periods, and therefore these 3 studies were excluded in favor of the longer studies. Other publications[10,13,16,17] did not provide data in formats that permitted inclusion.

Eighteen of the included studies[4,49-61,63,65,68,69] evaluated the crowns for periods between 1 and 4 years and recorded a mean complications incidence of 7% (range of 0% to 18%). Four studies[48,62,64,66] were 5 or more years in length and reported a mean complications rate of 14% (range of 8% to 18%).

The 22 clinical studies provided data regarding the following 5 complications: crown fracture, loss of retention, need for endodontic treatment, caries, and periodontal disease (Table III). One study[64] provided data regarding all 5 of the reported complications. Five of the studies[55,57-59,63] presented data regarding 4 of the 5 complications, and 5 articles[53,60-62,68] provided information about 3 of the 5 complications. There were 5 studies[4,48,51,65,69] that identified data for 2 of the complications, and 6 publications[49,50,52,54,56,66] only reported data about 1 complication (crown fracture). Other factors were evaluated in the studies but not in the required number of studies, and therefore no data are included in this report. The factors included inadequate form/color,[63] marginal fit/smoothness,[63] marginal discoloration,[63] tooth sensitivity,[56,57] and occlusal evenness.[63]

### Crown fracture

All 22 clinical studies[4,48-69] provided data regarding crown fracture. A total of 318 of the 4277 crowns fractured for a mean incidence of 7% and a range from 0% to 16%. The fracture incidence varied with the length of the study. There were 18 studies[4,49-61,63,65,66,69] of 1 to 4 years in length, reporting a mean fracture incidence of 5% and a range of 0% to 16%. Four studies[48,62,64,66] evaluated the crowns after 5 years or more and reported a mean fracture incidence of 13% (192 of 1,520 crowns) and a range from 5% to 14%.

Fracture was evaluated as it related to crown position in the arch and wear facets/occlusal habits. Data regarding these 2 factors were reported in a sufficient number of studies to be included. The effect of 5 other factors (age,[66] gender,[66,68] etching/type of cement,[66] finish line form,[67] and ceramic thickness[67]) on crown fracture was evaluated, but only in 1 or 2 studies. The data were therefore not included in this article.

The relationship between fracture and the location of the crown (anterior, premolar, molar) was evaluated in 10 studies.[56,59,62,67-70,72-74] The mean fracture rates for anterior (40 of 1255 crowns fractured), premolar (46 of 712 crowns fractured), and molar crowns (138 of 670 crowns fractured) were 3%, 7%, and 21%, respectively.

Four studies[49,56,59,68] assessed the effect of occlusal habits and the presence of wear facets in the mouth. Three of these studies[56,59,68] indicated these characteristics were not substantively correlated with crown fracture, whereas 1 study[50] indicated there was a critical relationship.

### Loss of retention

Four studies[58,59,64,65] indicated the number of crowns that came loose during the study. There was a mean loss of retention of 2% (11 of 545 crowns loosened), with a range from 0.3% to 5%.

### Need for endodontic treatment

Twelve studies[4,51,55,57-65] identified the number of restored teeth needing endodontic treatment. Of the 1088 all-ceramic crowns evaluated, 15 teeth needed treatment. A mean incidence of 1% was calculated, and there was a 0.0% to 5% range.

### Caries

Thirteen of 1650 teeth evaluated in 13 studies[53,55,57-65,68,69] developed carious lesions. There was a mean incidence of 0.8% and a range from 0.0% to 5%.

### Periodontal disease

Periodontal health was assessed in 8 studies.[48,53,55,57,63-65,68] Of the 942 crowns evaluated, any changes noted were either not significant or subjectively determined to be of no permanent detriment.

**Table IV.** Most common resin-bonded prosthesis complications

| | Number of prostheses studied/affected | Mean incidence |
|---|---|---|
| Debonding | 7029/1481 | 21% |
| Tooth discoloration | 343/62 | 18% |
| Caries | 3426/242 | 7% |
| Porcelain fracture | 1126/38 | 3% |
| Periodontal disease | 748/0 | 0.0% (no significant changes) |

## RESIN-BONDED PROSTHESES

Forty-eight studies[73-120] present complications data regarding resin-bonded prostheses. There were 56 published studies but only 48 different patient groups, because there were multiple publications reporting on the same patients at different time intervals. The studies with the longer follow-up times were included in this article, and those presenting earlier data[121-128] were excluded from the mean complications calculations but included in relation to specific complications. In the 48 studies, a total of 1823 complications were reported in conjunction with 7029 prostheses for a mean complications incidence of 26%. The length of the studies ranged from 1 month to 15 years, with an average study length of about 4 years. In addition to the 48 patient groups, there were 5 studies[129-133] that only evaluated the effect of resin bonded prostheses on the periodontium, 1 that assessed marginal fit,[134] a literature review[135] comparing the failure rates of resin-bonded prostheses with conventional fixed partial dentures and implant prostheses, and several articles[136-141] that assessed the survival of resin-bonded prostheses. In 1991, a meta-analysis[142] was performed on available clinical studies.

Thirty-seven studies[73-83,85-87,89-94,96-101,105,108,109,111-116,119,120] evaluated the prostheses for periods between 1 to 4 years and reported a mean complications incidence of 25% (1304 of 5204 prostheses affected). Eleven studies[84,88,95,102-104,106,107,110,117,118] provided data about prosthesis complications after 5+ years and reported a mean complications incidence of 28% (519 of 1825 prostheses affected).

The following 5 factors were evaluated in a sufficient number of studies to be included in this article: debonding, abutment tooth discoloration, abutment tooth caries, porcelain fracture, and periodontal disease (Table IV). Three studies[103,105,108] provided data related to all 5 complications, 4 articles[79,80,83,106] reported on 4 of the 5 complications, 4 studies[84,93,116,117] evaluated 3 of

the 5 complications, and 13 publications[81,85,86,91,94,97-100,112,114,118,120] covered 2 of the 5 complications. Twenty-four[73-78,82,87-90,92,95,96,101,102,104,107,109-111,113,115,119] of the 48 studies only reported on 1 of the 5 complications.

## Debonding

Forty-eight studies[73-120] evaluated the incidence of debonding. A total of 1481 of 7029 prostheses debonded (mean incidence of 21% with a range of 0.0% to 52%). The rate of debonding varied with the length of the clinical study. There were 11 studies with less than 2 years of postplacement evaluation[73,77,78,81-83,85,87,89,97,105] and a mean debonding rate of 10%. Twenty-six studies[74-76,79,80,86,90-94,96,98-101,108,109,111-116,119,120] ranged in length from 2 to 5 years with a mean debonding rate of 20%. A mean debonding rate of 24% was associated with the 11 studies[84,88,95,102-104,106,107,110,117,118] evaluating prostheses for periods in excess of 5 years.

Debonding was evaluated in relationship to arch, arch location (anterior versus posterior), presence of abutment tooth preparation, gender, age, span length, and occlusal forces. These factors were assessed in a sufficient number of studies to be included in this article. Other factors (abutment mobility, trauma, bonding area) were evaluated but not in a sufficient number of studies (3 or more) to be reported.

Maxillary and mandibular debonding rates were compared in 27 studies. Six studies[76,78,91,113,115,117] reported increased debonding in the maxilla, 8 studies[77,90,93,98-100,109,116] found higher debonding in the mandible, and 13 studies[79,84,86,87,95,103,104,106-108,111,112,118] found no significant difference between arches. No conclusive trend was noted.

Twenty-three studies compared anterior and posterior prostheses. Higher posterior debonding rates were reported in 8 studies,[77,90,93,98,99,113,116,117] whereas higher anterior debond rates were found in 4 studies.[82,91,96,123] No significant differences were reported in 11 studies.[84,87,100,103,104,106-108,111,112,118] Again, no conclusive trend was observed.

A comparison was made between minimal/no abutment tooth preparation and a retentive tooth preparation in 9 studies. The retentive tooth preparations were not always illustrated but frequently were described as having 1 or more of the following features: proximal guiding surface, extended over a broad area of the teeth, proximal grooves, pinholes, and rests. Three studies[86,109,118] reported no significant effect as the result of tooth preparation, whereas 5 studies[84,101,106,107,124] reported substantial debonding rate decreases when the teeth were prepared. In these 5 studies, prostheses without retentive tooth preparations had a mean debonding rate of 47%, whereas those with retentively prepared abutments exhibited a mean debonding rate of 11%.

The effect of gender was evaluated in 8 studies. No significant difference was reported in 5 studies[87,96,104,111,115], whereas 3 studies[79,98,103] reported a higher debonding rate in male patients. No conclusive trend was noted.

Four studies[87,104,115,121] reported higher debonding rates in young patients, whereas 2 other studies[96,103] found no significant difference. Two studies described "young" as being less than 20 years old, and another study indicated "young" as being less than 30 years old. A possible trend toward higher debonding rates with young patients was noted.

Six studies[87,98,100,104,111,118] assessed the effect of span length by reporting data regarding prostheses longer than 3 units in length,[87,118] prostheses with more than 1 pontic,[100,104,111] or prostheses with more than 2 retainers.[98,100,104] Three of the 6 studies[86,99,103] provided debonding incidence percentages that permitted comparisons of short and longer span prostheses. Three of the studies reported the comparison as being either higher with prostheses over 3 units in length,[118] 2 times the number of debondings with more than 2 retainers,[98] or debonding at an earlier time when there was more than 1 pontic.[111] The mean debonding incidence of short span prostheses was 25%. The longer span prostheses had a mean debonding rate of 52%.

Eight studies[78,79,85,89,91,94,103,117,121] evaluated the effect of occlusal forces on the debonding rate. Two of these studies indicated that 70%[121] and 45%[89] of the debonding was associated with prostheses placed in the presence of heavy occlusal forces. The other studies when combined indicated that 22% of the debondings (31 of 143 debondings) were attributable to heavy occlusal forces.

## Abutment tooth discoloration

The presence of metal on the lingual surface produced discoloration of abutment teeth. This complication, the second most common, was reported in 7 studies.[79-81,103,105,106,108] Five of the studies[80,81,103,105,108] provided a percentage incidence, whereas 2 others[79,106] reported its occurrence but did not indicate the number of prostheses affected by this complication. The 5 studies, when combined, indicate that 62 of 343 prostheses exhibited tooth discoloration for a mean incidence of 18% and a range of 3% to 37%.

## Abutment tooth caries

Twenty-two studies[79,80,83,84,86,93,94,98,100,103,105,106,108,109,112,114,116-118,121,122,134] reported on the occurrence of caries. The mean incidence of caries for the 22 studies was 7% (242 of 3426 prostheses affected by caries). A finding of no caries was reported in 9 studies.[79,80,83,84,93,105,116,117,122] Six studies[86,94,98,106,121,134] reported a caries incidence of less than 2%, and 7 stud-

ies[100,103,108,109,112,114,118] reported an incidence greater than 2%. The incidence range was from 0.0% to 12%. Of the 13 studies reporting the presence of caries, seven[86,98,100,106,108,109,112] reported the caries occurred in conjunction with debonded retainers, four[94,103,114,118] did not indicate whether the retainer was bonded or debonded, and 2 studies[121,130] stated the caries incidence was not associated with debonding.

### Porcelain fracture

The presence of fractured porcelain was assessed in 15 studies.[79-81,84,85,91,93,103,105,106,108,116,122,123,128] The mean incidence for the 15 studies was 3% (38 of 1126 prostheses experienced porcelain fracture). Four studies[79,80,122,123] reported no fractures, and the 11 other studies[81,84,85,91,93,103,105,106,108,116,128] reported incidences ranging from 0.8% to 8%.

### Periodontal disease

The effect of the prosthesis on abutment tooth periodontal health was reported in 15 studies.[8] Seven of the studies[8,28,32,34,50,62,68] found no periodontal problems or no increased incidence of periodontal disease, and 4 reported the presence of mild inflammation.[12,46,52,60] In 1 study,[49] there was 1 abutment tooth that was extracted after 4 years because of a progressive periodontal condition. Three studies reported statistically significant changes that were not considered to be clinically relevant by the authors of all 3 articles.[37,59,61] Factors evaluated in these studies included plaque index, gingival index, pocket depth, attachment level, and gingival recession.

## POSTS AND CORES

There are 12 clinical studies[16,143-153] that report the total number of posts and cores evaluated and the total number of complications encountered. There were 279 complications found among the 2784 posts and cores in the 12 studies, producing a mean complications incidence of 10%. Among the 12 studies, observation times were as short as 1 year and as long as 25 years. The average study length was about 6 years. Additional studies[33,154-161] have been published with clinical data about post and core complications, but they did not present the total number of complications encountered, or they only presented data regarding 1 or 2 types of complications. One study[162] performed a meta-analysis of available studies, and 1 study[163] developed a mechanical longevity estimation model.

Three studies[16,146,150] evaluated the posts and cores for periods between 1 to 4 years and recorded a mean complications incidence of 11%. One of the 3 studies[146] indicated the posts were observed over periods from 2 to 10 years. Because a mean observation time was not disclosed, a decision was made to include this data with the 1- to 4-year studies. Nine studies[143-145,147-149,151-153] evaluated the posts over periods between 5 and 10 years, with a mean complications incidence of 10%. One study[145] evaluated posts over 1 to 25 years, and there also was no information about the average observation time. A decision was made to include this data in the group that included studies longer than 4 years.

**Table V.** Most common post and core complications

| | Number of posts and cores studied/affected | Mean incidence |
|---|---|---|
| Post loosening | 2596/135 | 5% |
| Root fracture | 3043/95 | 3% |
| Caries | 1047/16 | 2% |
| Periodontal disease | 283/6 | 2% |

The following 4 complications were evaluated in 3 or more studies and were therefore included in this article: post loosening, root fracture, caries, and periodontal disease (Table V). One study[144] presented data regarding all 4 of these complications, whereas 5 studies[146-148,150,152] presented data for 3 of the 4 complications. Five studies[16,145,151,155,161] covered 2 of the complications, and 2 studies[154,158] reported on only 1 complication. The effect of the tooth position in the arch was assessed in 6 studies,[147,151-153,159,161] but specific incidence numbers were not published, thereby preventing any calculations. Three of the 6 studies noted higher failure rates in the anterior maxilla,[151-153] and 2 studies[147,161] indicated the position of the tooth in the arch was not a significant factor. Three other factors (root perforations,[145,160] bent/fractured posts,[146,152] and endodontic failures[147,148]) were evaluated, but incidence data were only available in 2 studies. Therefore the data were not included.

### Post loosening

Eleven studies[16,144-148,150-152,155,161] provided numerical data related to post loosening. A total of 135 of 2596 posts loosened from the root for a mean incidence of 5% (range of 0% to 10%).

### Root fracture

There were 13 studies[16,144-148,150-152,154,155,158,161] with root fracture incidence data. Two studies[154,158] only reported data related to root fractures and did not comment on other complications or the overall complications incidence. Ninety-five fractures were recorded in 3043 teeth, producing a mean incidence of 3% (range of 0% to 11%).

### Caries

Four studies[144,146,150,152] reported on the presence of caries. Of the 1047 posts and cores evaluated in the 4

studies, 16 were affected by caries. The mean incidence was 2% with a range from 0.8% to 9%.

### Periodontal disease

Three studies[144,147,148] identified the number of teeth restored with posts and cores that failed because of periodontal reasons. Six failures were recorded in the 283 teeth evaluated, producing a mean incidence of 2% (range from 1% to 3%).

## SUMMARY

The complications information presented in this study identifies trends that can be effectively used to develop treatment plans that optimize success and to communicate appropriate expectations to patients. Conventional fixed partial dentures had the greatest complications incidence (27%), with resin bonded prostheses having a comparable incidence (26%). Single crowns (11%) and posts and cores (10%) had comparable complications incidences. All-ceramic crowns had the lowest incidence (8%) of complications.

The most common complications associated with conventional fixed partial dentures were caries (18% of abutments and 8% of prostheses), need for endodontic treatment (11% of abutments and 8% of prostheses), loss of retention (7% of prostheses), esthetics (6% of prostheses), periodontal disease (4% of prostheses), tooth fracture (3% of prostheses), and prosthesis/porcelain fracture (2% of prostheses). With resin bonded prostheses, the most common complications were debonding (21% of prostheses), tooth discoloration (18% of prostheses), caries (7% of prostheses), and porcelain fracture (3% of prostheses). The most common complications associated with conventional single crowns were need for endodontic treatment (3%), porcelain fracture (3%), loss of retention (2%), periodontal disease (0.6%), and caries (0.4%). The most common post and core complications were post loosening (5%), root fracture (3%), caries (2%), and periodontal disease (2%). With all-ceramic crowns, the most common complications were crown fracture (7%), loss of retention (2%), need for endodontic treatment (1%), and caries (0.8%).

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