CLINICAL RESEARCH

A Retrospective Study on the Success, Survival, and Incidence of Complications of Post-Retained Restorations in Premolars Supporting Fixed Dental Prostheses with a Mean of 7 Years in Function

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Purpose: To evaluate the survival and success rates of post-and-core restorations supporting fixed dental prostheses (FDPs) after a mean time in function of 7 years and to assess the incidences of biologic and technical complications. Materials and Methods: Patients from the National Dental Center Singapore (NDCS) with endodontically treated premolars restored with post-retained FDPs from 2007 to 2009 were recruited from the Endodontic Registry and evaluated by three clinicians. A total of 265 patients with 329 treated premolars were examined clinically. Digital radiographs were also obtained. Complications were classified as tooth- or prosthesis-related. Failure and complication rates were calculated based on person-time-at-risk. Results: The mean time in function was 7.1 years. A total of 25 teeth in 23 patients were lost, resulting in a 7-year survival rate of 92.7% (95% CI: 89.5%, 95.0%). The corresponding success rate was 75.1% (95% CI: 70.5%, 79.1%). A total of 40 FDPs failed, resulting in a 7-year prosthetic survival rate of 88.6% (95% CI: 84.8%, 91.5%). Common complications observed were recurrent periodontal disease (3.9%), periapical pathology (7.3%), caries (3.9%), porcelain chipping (9.9%), and tooth fractures (5.0%). For the incidence of tooth fracture, a risk analysis yielded significant associations with the number of occluding teeth (odds ratio: 4.2; 95% CI: 1.1, 16.7) and the number of adjacent teeth (odds ratio: 4.0, 95% CI: 1.5, 10.9). Conclusion: Restoration of premolar teeth requiring root canal treatment with a post and core and crown is a viable treatment when premolar teeth have adjacent teeth. Int J Prosthodont 2020;33:176–183. doi: 10.11607/ijp.6090

Preservation of the natural dentition has always been a key therapeutic goal in dentistry. Endodontic treatment has a documented long-term history of success and allows for the preservation of teeth with treated root canal infections. 1,2 In addition, a systematic review revealed that nonvital teeth restored with crowns had a higher long-term survival than those without crown coverage. 3 However, in the absence of sufficient coronal tooth structure, the use of intraradicular posts and cores may be necessary to retain the definitive prosthesis. 4 Various prosthetic parameters have been investigated in in vitro studies on extracted teeth, 5–7 as well as in photoelastic studies 8 and finite element analyses, 9 to determine the optimal design for restoration of such teeth.

More recently, clinical outcome studies have focused on the longevity of such post-retained restorations. Published studies range from short-term 10 to long-term 11,12 follow-ups and across different prosthetic materials, such as cast post cores 13,14 and prefabricated post cores. 15,16 The traditional cast gold post-and-core technique is more time-consuming, as it requires additional clinical visits and incurs additional laboratory and material costs. In contrast, prefabricated posts are easier to use, allow for more conservative post preparations, and may have better esthetic outcomes. As the use of
prefabricated post cores became increasingly common, more comparison studies were published contrasting the outcomes of cast and prefabricated post cores.17,18 A prospective study with a mean observation period of more than 4 years18 reported high survival rates of 92.5% for teeth restored with prefabricated posts and 97.1% for teeth restored with cast post cores. Commonly reported complications included root fractures, recurrent caries, periapical disease, and loss of retention. However, the observation periods of the teeth included in the study ranged from 2 to 11.5 years. Cast post cores were also exclusively used for the restoration of anterior teeth, whereas molars were predominantly restored with prefabricated titanium posts. Studies by a Dutch group17,19 found survival rates of 83% to 92% and 71% to 80% at the tooth and restoration levels, respectively, after 17 years. There were no differences in survival probabilities among the different post-and-core restorations. A significant influence of the amount of remaining dentin was found for the survival of prefabricated post cores; however, survival data at 17 years were based on only 28% of the original sample size. These studies also included a large number of operators and had difficulties ensuring operator compliance with study protocols.

The advent of successful dental implant therapy has led some clinicians to reconsider the role of conventional endodontics and posts and cores in the restoration of severely broken-down teeth. Instead, the option of extracting these teeth and replacing them with dental implants has recently been propagated. The biophysiologic differences between natural teeth and dental implants are well known. Although it has been postulated that endodontically treated teeth may have a poorer longevity than vital abutments,20 maintaining an endodontically compromised tooth may also preserve the biologic function of the periodontal ligaments. Numerous studies have shown increased tactile thresholds with implants compared to natural teeth.21–23 Others have demonstrated impaired force control with implant-supported prostheses.24,25

Many clinicians continue to be of the opinion that the restoration of an endodontically treated tooth with post-retained fixed dental prostheses (FDPs) remains a viable treatment option. Systematic reviews comparing outcomes of root canal treatment and restoration with or without posts and cores, implant-supported single crowns, FDPs, and extraction without replacement26,27 concluded that there were no significant differences in survival outcomes between root canal–treated teeth and single-tooth implants after 5 years. In another review, it was observed that the success of root canal treatment increased over time due to the potential of late healing. In contrast, the success of implant treatment decreased over time.28 Dental implants should be used to extend the dentition only when teeth are missing or could not be maintained with reasonable efforts.29

The aim of the present study, therefore, was to evaluate the survival and success rates of post-and-core reconstructions supporting FDPs of premolars in patients treated at the National Dental Centre, Singapore (NDCS), and to assess the incidences of biologic and technical complications. The secondary objective was to assess any differences in the survival of reconstructions based on the types of post-and-core systems applied.

MATERIALS AND METHODS

This study was designed and conducted as a retrospective evaluation of endodontically treated and restored premolar teeth with an observation period of at least 5 years. Patients treated from 2007 to 2009 were identified through the NDCS Endodontics Registry. Eligible patients were sequentially contacted and recruited for the study. Clinical examinations were conducted by three standardized examiners. To reduce interexaminer variability, the first five subjects were seen jointly by two examiners (P.Z.Y. and K.T. or S.Q. and K.T.). Digital periapical radiographs were taken with the paralleling technique using a device (XCP, Rinn) to minimize deviation of the x-ray beam from the long axis of the tooth.30,31 Two examiners evaluated all radiographs. The research protocol was submitted to and approved by the SingHealth Centralized Institutional Review Board (IRB Reference No: 2015/3027).

Inclusion and Exclusion Criteria

Only subjects that met the following inclusion criteria were enrolled:

• Endodontic treatment, posts and cores, and FDPs done on at least one premolar at NDCS
• Above the age of 21 years
• Identified through the Endodontics Registry (2007 to 2009)
• Contactable by telephone or mail
• Medically fit

Subjects with failed endodontic treatment and retreatment of premolar teeth done at NDCS were excluded from this study.

Clinical Examination

Biologic parameters recorded at the clinical review included the loss of teeth, presence of caries, and periodontal parameters such as probing depths, presence or absence of bleeding on probing, tooth mobility, frena, and suppuration. Patients’ subjective complaints about pain or discomfort were also recorded. Technical parameters recorded at review were prosthesis survival
and/or success (absence of any complications). Complications relating to the tooth or restoration included fractures, porcelain veneer chippings, loss of retention of the crown or post, and need for endodontic retreatment. In addition, details pertaining to the nature of the occlusal contacts (tested with shim stock foil), opposing dentition (natural, fixed, removable, or unopposed), proximal contacts (open, light, or normal contacts), and crown design (full metal, porcelain fused to metal [PFM], all-ceramic) were recorded. In the event of porcelain veneer chippings, clinical photographs were taken.

Wherever possible, the time in function until a complication occurred was noted. When the exact time of occurrence could not be determined, a range was used to represent the time-in-function up to the occurrence of the complication. The lower limit of this range was calculated from the last complication-free patient visit, and the upper limit was calculated using the date of discovery of the complication.

Outcome Definitions

Outcomes were defined at both the prosthesis level and the tooth level. Success was defined as presence in function and absence of any complications or interventions in the time period from the restoration to the date of the review, inclusive (observation period). Survival was defined as the prostheses or teeth remaining in situ with or without modifications for the observation period. Failure was defined as the loss of the prosthesis or tooth or requiring replacement with a new prosthesis or extraction of the tooth.

Prosthesis outcomes were limited to complications or failures directly related to the restoration and included caries related to prosthesis margins, tooth fractures, loss of retention, porcelain chipping, and other FDP complications. Tooth outcomes were limited to complications or failures affecting the tooth but independent of the prostheses, such as progressive periodontal disease and periapical pathology.

Statistical Calculations

Failure and complication rates were calculated based on the person-time-at-risk. These rates were calculated by dividing the number of events (failures or complications) in the numerator by the total exposure time (of FDPs) in the denominator. The total exposure time was calculated by taking the sum of the following:

- Exposure time of FDPs that could be followed for the whole observation period
- Exposure time up to a failure/complication of the FDPs that were lost due to failure during the observation period

Given that some patients had more than one tooth eligible for this study, robust confidence intervals were used to account for clustering within patients when a patient contributed more than one tooth to the study. Statistical analyses were done using Statistical Analysis Software 9.4 (SAS Institute).

RESULTS

The interexaminer agreement was determined to be 95.6% based on repeated radiographic evaluation of 329 cases.

A total of 659 eligible patients were identified. Eleven were deceased at the time of recall. A total of 605 patients were contacted, and 266 subjects were finally enrolled in the study. As the time in function of the FDP did not reach the minimum of 5 years, the data from one subject were eliminated; hence, 265 patients (110 men, 155 women) with a median age of 58.3 years (range: 27 to 90 years), accounting for 329 restored premolars, were included. A total of 207 (78.1%) patients had only one restored premolar, while 52 (19.6%) had 2 restored premolars and 6 (2.3%) had 3 restored premolars. Of 329 restored premolars, two-thirds (67.2%) were maxillary premolars and one-third (32.8%) were mandibular premolars. Demographics of all enrolled subjects for the study are presented in Table 1. The demographics of uncontactable subjects and those refusing to participate are included for comparison.

Post space preparations for all teeth were done with the Parapost XP System (Coltene Whaledent). Clinical documentation showed that
all posts and cores engaged 2 to 3 mm of parallel walls apically. Out of the 329 teeth assessed, 232 (70.5%) were restored with a cast gold post and core, and 97 (29.5%) were restored with a prefabricated post and direct restorative core. The mean time in function for direct posts was 6.7 years (standard deviation [SD] 1.49), and for cast posts and cores it was 7.2 years (SD 1.42).

The majority of posts (58.4%) were cemented with zinc phosphate cement (Hy-bond, Shofu). There was a near equal distribution between resin-modified glass-ionomer cements (Fuji Plus, GC) (12.8%) and resin cement (Panavia F, Kuraray Dental) (13.1%). A proportion of the sample (15.8%) did not reveal the type of cement used.

A total of 315 (95.7%) teeth were definitively restored with single-unit FDPs, while 14 (4.3%) teeth were part of 3- to 5-unit multi-unit FDPs. Of the 329 FDPs, 326 (99.1%) were PFM prostheses, and only 3 (0.9%) were full-metal prostheses.

### Survival and Complication Data

The time in function and complication data were examined for 329 teeth (Table 2). The 7-year risk for failure was 7.3% (95% confidence interval [CI]: 4.97%, 10.55%). The rate of failure was 1.08 per 100 FDP years (95% CI: 0.73, 1.59). Therefore, the overall 7-year survival rate was 92.7% (95% CI: 89.45%, 95.03%).

The overall 7-year risk for failure and complication was 24.9% (95% CI: 20.88%, 29.54%). The rate of failure and complication was 4.1 per 100 FDP years (95% CI: 3.35, 5.00). Consequently, the overall 7-year risk for complication-free teeth was 75.1% (95% CI: 70.46%, 79.12%).

### Prosthesis-Related Complications

Five categories of complications were defined as being prosthesis-related:

- Caries involving margins of the FDPs
- Fractures (including vertical root fractures and coronal fractures)
- Loss of retention
- Porcelain chipping
- FDP complications

The 7-year risk for prosthesis survival was 88.6% (95% CI: 84.84%, 91.53%), and the 7-year risk for prosthesis success was 81.2% (95% CI: 76.85%, 84.85%).

### Biologic Complications

**Caries.** Thirteen teeth were found to have caries related to prosthesis margins, 2 of which were treated with intraoral repairs and survived. Four teeth required extraction and were deemed as failures. The remaining 7 teeth required replacement of the existing prostheses and were considered prosthetic failures, but survived at the tooth level. The 7-year rate for caries was 0.56 per 100 FDP years, resulting in a risk of 3.9% (95% CI: 2.26%, 6.56%) after 7 years.

### Technical Complications

**Tooth Fractures.** Seventeen teeth fractured at varying time points after the prostheses had been incorporated. All fractured teeth were extracted and deemed as failures. The 7-year fracture rate was 0.73 per 100 FDP years, resulting in a risk of 5.0% (95% CI: 3.13%, 7.91%) after 7 years.

**Loss of Retention.** Three teeth were found to have decementation of the prosthesis not related to other complications such as fracture or caries. In all cases, prostheses were recemented, and the teeth were deemed to have survived. The rate for loss of retention without loss of the reconstruction was 0.13 per 100 FDP years, resulting in a risk of 0.9% (95% CI: 0.29%, 2.77%) after 7 years.

**Porcelain Chipping.** Prostheses with ceramic chipping were scored according to the modified US Public Health Service (USPHS) criteria as proposed by Sailer et al (2009).34 Thirty-four teeth were found to have varying degrees of porcelain chipping. Twelve prostheses were classified as Grade B, which allowed polishing of the chipped veneering porcelain. Fourteen prostheses were classified as Grade C, indicating porcelain chipping with exposure of the underlying framework. Eight prostheses showed extensive porcelain fracture requiring a new prosthesis.

The eight FDPs were considered as failed, whereas the remaining 26 prostheses were classified as surviving. The 7-year rate for porcelain chipping was 1.50 per 100 FDP years, resulting in a risk of 9.9% (95% CI: 7.21%, 13.63%) after 7 years.

### Table 2 Summary of Survival, Failure, and Complication Rates

<table>
<thead>
<tr>
<th></th>
<th>7-year risk (%)</th>
<th>95% confidence interval (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failure</td>
<td>7.3</td>
<td>4.97, 10.55</td>
</tr>
<tr>
<td>Failure and complication</td>
<td>24.9</td>
<td>20.88, 29.54</td>
</tr>
<tr>
<td>Success</td>
<td>75.1</td>
<td>70.46, 79.12</td>
</tr>
<tr>
<td>Prosthesis survival</td>
<td>88.6</td>
<td>84.84, 91.53</td>
</tr>
<tr>
<td>Prosthesis success</td>
<td>81.2</td>
<td>76.85, 84.85</td>
</tr>
<tr>
<td>Biologic complications</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caries</td>
<td>3.9</td>
<td>2.26, 6.56</td>
</tr>
<tr>
<td>Periapical pathology</td>
<td>7.3</td>
<td>4.97, 10.73</td>
</tr>
<tr>
<td>Progressive attachment loss</td>
<td>3.9</td>
<td>2.29, 6.63</td>
</tr>
<tr>
<td>Technical complications</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fracture</td>
<td>5.0</td>
<td>3.13, 7.91</td>
</tr>
<tr>
<td>Loss of retention</td>
<td>0.9</td>
<td>0.29, 2.77</td>
</tr>
<tr>
<td>Porcelain chipping</td>
<td>9.9</td>
<td>7.21, 13.63</td>
</tr>
</tbody>
</table>

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Table 3  Risk Factors for Prosthetic Complications

<table>
<thead>
<tr>
<th>Effect</th>
<th>Outcome</th>
<th>Odds ratio</th>
<th>95% CI</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of occluding pairs</td>
<td>Overall outcome</td>
<td>2.6</td>
<td>1.30, 5.05</td>
<td>.007</td>
</tr>
<tr>
<td>(≤ 5 vs ≥ 10)</td>
<td>Tooth fracture</td>
<td>4.2</td>
<td>1.07, 16.65</td>
<td>.040</td>
</tr>
<tr>
<td>No. of adjacent teeth</td>
<td>Technical</td>
<td>2.6</td>
<td>1.38, 4.81</td>
<td>.003</td>
</tr>
<tr>
<td></td>
<td>Tooth fracture</td>
<td>4.0</td>
<td>1.50, 10.86</td>
<td>.006</td>
</tr>
</tbody>
</table>

If prostheses with minor porcelain chipping that do not require any form of clinical intervention were excluded from the analysis (n = 11), a total of 23 prostheses would require either polishing or refabrication of the prostheses. This accounted for a revised 7-year rate for porcelain chipping of 1.01 per 100 FDP years, resulting in a risk of 6.8% (95% CI: 4.57%, 10.04%) after 7 years.

FDP Complications

Two prostheses had complications related to multi-unit FDPs. Both prostheses were three-unit FDPs involving a premolar and a molar abutment. One prosthesis had to be sectioned and the molar abutment removed due to a vertical root fracture. The second prosthesis had recurrent caries on the molar abutment. Rate and risk for multi-unit FDP complications were not calculated due to the small number of such units included in this study.

Risk Factors for Prosthesis-Related Complications

Odds ratio analysis was used to identify potential associations of tooth fracture, technical complications, and overall outcomes (Table 3).

Number of Occluding Antagonistic Pairs. The total number of occluding antagonistic pairs was found to have a statistically significant association with the risk of tooth fractures and overall outcomes. When comparing between 1 and 5 antagonistic pairs of occlusal contacts vs 10 or more, odds ratio estimates of 4.2 (95% CI: 1.07, 16.65) for fractures and 2.6 (95% CI: 1.30, 5.05) for overall outcomes were determined. However, data on the distribution of antagonistic pairs of occlusal contacts in the dentition were not captured.

Number of Adjacent Teeth. The number of teeth adjacent to an endodontically restored premolar was found to have a statistically significant association with the risk for tooth fracture and technical complications. When comparing two adjacent teeth vs one adjacent tooth, odds ratio estimates of 4.0 (95% CI: 1.50, 10.86) for tooth fracture and 2.6 (95% CI: 1.38, 4.81) for technical complications were calculated, respectively. Due to the lack of lone-standing premolars, the odds ratio comparison for two adjacent teeth vs no adjacent tooth could not be determined.

Other Factors. Other factors such as type of cement, secondary use of the restored tooth as an FDP or removable dental prosthesis (RDP) abutment, location of restored tooth, type of post-and-core restoration, and type of opposing dentition did not show any statistically significant associations with survival.

Tooth-Related Complications

Two categories of biologic complications were identified at the tooth level: periapical pathology and progressive periodontal disease.

The 7-year rate of biologic complications was 2.37 per 100 FDP years, resulting in a risk of 15.3% (95% CI: 11.95%, 19.42%) after 7 years.

Biologic Complications

Periapical Pathology. The Periapical Index (PAI)35 was used in the radiographic evaluation of the periapical status of treated teeth. Twenty-four teeth were identified as having radiographic evidence of periapical pathology (PAI score ≥ 3). Two of these teeth were deemed to have failed due to endodontic reasons (pain). One tooth failed due to continued root resorption, whereas another failed due to a persistent and enlarged periapical lesion after apicoectomy.

The rate of periapical pathology was 1.09 per 100 FDP years, resulting in a risk of 7.3% (95% CI: 4.97%, 10.73%) after 7 years.

Progressive Periodontal Disease (Attachment Loss). Thirteen teeth were found to have progressive attachment loss as indicated by increased probing depths of 5 mm or more. Of these 13 teeth, 3 were documented to have severe progressive attachment loss and had been removed.

The rate of progressive attachment loss was 0.57 per 100 FDP years, resulting in a risk of 3.9% (95% CI: 2.29%, 6.63%) after 7 years.

DISCUSSION

The results of the present study indicate that a high number of biologic and technical complications may occur in endodontically treated premolars reconstructed with posts and cores. Moreover, the total number of complications amounted to 24.9% after 7 years. This proportion falls within the outcomes of previous studies of a similar nature but other treatment modalities. As an example, the success rate of 75.1% in the present study compares favorably to that reported in a recent systematic review,36 where the success rate after 5 years of implant reconstructions in function was 72.9%. In other words, post-and-core–reconstructed, endodontically treated premolar teeth appear to yield success rates similar to those reported for implant-supported reconstructions. This, in turn, means that reconstruction of a nonvital
tooth with a post and core represents a treatment that is as equally effective as an implant reconstruction.

In interpreting the outcomes of the present study, a few limitations of the study design must be discussed. The current clinical analysis was retrospective in nature. Due to the inherent problems with retrospective studies, the impact of varying amounts of coronal tooth structure on survival outcomes could not be determined. Previous studies, both in vitro and clinical, have indicated the importance of remaining coronal tooth structure on the outcomes of endodontically treated teeth. In the present study, the best available treatment at the time was performed. This often included surgical crown lengthening (84 out of 329 cases) to achieve a ferrule effect.

Out of a total of 659 patients eligible for this study, 604 were contacted and 266 were recruited. This accounted for a recall rate of 44.0%. Uncontactable patients accounted for 27.8% of patients eligible, and 26.2% of patients refused to participate. A comparison of the patients who did not participate in the study with those who did revealed no major differences in the demographic parameters between these two groups. Hence, the cohort examined may indeed be representative of NDCS patients treated with post-and-core restorations supporting FDPs. A sample of 47 patients who declined to participate were interviewed over the phone for their reasons for refusal. Commonly cited reasons were busy schedules (n = 33), immobility (n = 3), and prior bad experiences (n = 2). Most patients interviewed (n = 33) reported no problems with their treated tooth, 3 patients claimed to have their tooth extracted prior to the telephone call, 2 patients had endodontic treatment redone, and 9 were unsure of the current status of their treated teeth.

Assuming that patients who were unsure of the condition of their previously treated teeth had experienced no problems or minor problems that had gone unnoticed by the patient, this results in a survival rate of 89.3%, which is comparable to the survival rate (88.6%) reported in the examined cohort. However, self-reported outcomes from phone interviews should be interpreted with caution, especially as results are skewed toward patients’ perceptions and because complications that have occurred may have gone unnoticed by the patient.

As opposed to previously published retrospective cohort studies, all the subjects participating in the present study were recalled and physically examined by three standardized examiners. No data were obtained through telephone interviews or on the basis of insurance claims, apart from the sample survey for reasons for refusal mentioned, and the results of which were not used for analysis. Hence, a calculation of time in function for all the reconstructions was possible and renders the results able to be compared with each other.

In the present study, premolar teeth were selected for examination. The decision to restrict the study to only premolar teeth reduced variability in the study parameters associated with tooth configuration. Hence, the results of the present study are limited to treatment outcomes for premolar teeth.

Most studies reporting on endodontically treated premolars were restricted to in vitro studies. Consequently, there are few clinical trials focusing on premolars alone.

As opposed to the results of the present study, Ferrari et al reported an overall success rate of only 60% and a survival rate of 94.1% for endodontically treated premolars over a period of 6 years. In this study, success was defined as absence of absolute and relative failures, whereas survival was defined as absence of absolute failure. Even lower survival rates were reported with success rates of 63.3% to 90.0% and survival rates of 86.6% to 100% over a period of only 4 years. Both studies focused on the use of fiber posts with composite cores and included the restoration of severely compromised teeth, such as those with an absence of ferrule. These could have contributed to the lower survival rates.

In the present study, both prefabricated posts (30%) and cast posts and cores (70%) were applied. In an older study, success rates of 89.3% to 93.9% for endodontically treated and restored premolars were reported, although it was not clear whether these teeth were restored with both posts and cores and with crowns. The present study reported a 7-year overall success rate of 75.1% and a survival rate of 92.7%. However, direct comparisons with the studies mentioned may be limited, as differences in types of restoration and definitions of outcomes are evident.

The most frequent biologic complication of the post-and-core–treated nonvital teeth in the present study was periapical pathology (7.3%). Comparing this proportion to studies on endodontic success, the endodontic success rate of the present study was higher than previously reported success rates of 68% to 85%² and 74% to 98%. It should be noted that results from the present study were based on periapical radiographs taken at the point of review, and no comparisons with previous treatment or postoperative radiographs were made. Due to the retrospective nature of the study, standardized radiographs were not performed for examination of the periapical status of the teeth. In addition, no distinction was made between development or regression of previously healed or persistent lesions.

The most common prosthesis-related complications in the present study were porcelain veneer chipping, with 34 teeth (10.3%) found to have this in varying degrees. Although this figure was higher compared to the...
risk of 2.6% reported for single crowns,43 a previous study on implant-supported single crowns performed in the same institution10 showed similar results.

Significantly higher odds for tooth fracture were reported in the present study for the number of adjacent teeth, indicating that the loss of one or both adjacent teeth next to the incorporated restoration represents an increased risk for tooth fracture. This is in line with results from previously published clinical studies.44–48 Raedel et al44 found a statistically significant decrease in survival times for teeth with no adjacent neighboring teeth (10.6 years) compared to teeth with at least one adjacent proximal contact (13.8 years). A retrospective review46 of clinical records for 203 teeth found that teeth with 2 proximal contacts had better survival estimates than teeth with 0 or 1 proximal contact. In another study,47 root canal–treated teeth with less than 2 proximal contacts had three-times greater odds of being lost. Similar results were identified in another study.45 The systematic review49 of survival outcomes of endodontically treated teeth yielded that teeth with two proximal contacts were associated with significantly higher survival.

In the present study, only premolar teeth were studied, eliminating the potential for confounders according to tooth type. In addition, teeth with secondary functions, such as FDP or RDP abutments, were excluded from analysis, as some studies have shown that the secondary use of teeth may be detrimental to survival.49,50 Significantly higher odds for fracture were reported in this study for patients with a reduced number of occluding antagonistic pairs. In contrast to the shortened dental arch concept,51 occluding contacts in anterior teeth were included in the statistical calculations in the present study. This takes into account the varied occlusal schemes of all 265 patients enrolled in the study and ensured no loss of data. Even though a strict adherence to the criteria of the shortened dental arch concept was not followed, the results of this study indicate that with fewer teeth left in the dental arch, occlusal loading on the remaining restored dentition may be higher, and this may predispose to tooth failure on the weakened post-and-core reconstructions. This has not been reported in any studies published to date.

Future directions for research should include prospective studies to better investigate the effects of amount and location of remaining coronal tooth structure on the outcomes of endodontically treated teeth. Extended observation periods and increased sample sizes where premolar teeth act as RDP or FDP abutments will also be helpful in determining long-term treatment outcomes. Increased incidences of complications may be observed, contributing valuable data for OR analysis.

**CONCLUSIONS**

The results of the present study indicate that endodontically treated teeth with post-and-core reconstructions yielded a success rate of 75.1% after 7 years in function. Such success is comparable to or even surpasses success rates presented in systematic reviews for implant-reconstructed single crowns. Hence, preservation of endodontically treated teeth remains one of the most important paradigms in clinical dentistry.

**ACKNOWLEDGMENTS**

The authors report no conflicts of interest.

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Literature Abstract

Single Crowns on Tooth Toot-Resected Molars: A Retrospective Multicentric Study

Data regarding single-tooth restorations on molars treated with root resection and separation are limited. The purpose of this retrospective study was therefore to evaluate the clinical success and survival rates of single crowns on root-resected molars. A total of 86 molars were treated with root resection or hemisection, prepared with feather-edge margins, and restored with single crowns in 73 patients. The patients were clinically evaluated during regular recall appointments in 2018. Data were analyzed using descriptive statistics. The mean follow-up time was 88.7 months (standard deviation 70.6; range 6 to 284). Six failures were recorded during the observation period for a cumulative survival rate of 93%. In this retrospective evaluation, single crowns on root-resected molars with feather-edge margins had clinical outcomes similar to those reported for single crowns on implants in the molar area. First molars and molars with two retained roots showed better survival rates than second molars.