The aim of the present study was to retrospectively evaluate the longevity of teeth and implants during a long-term period in a cohort of periodontally compromised patients, treated and maintained in a private specialist periodontal practice, and to analyze the associated risk factors. Fifty-eight patients (30 men, 28 women) who had received active periodontal therapy (APT) and regular periodontal maintenance (PM) ≥ 10 years were included and evaluated. The following were evaluated: (1) statistically significant differences of clinical parameters assessed at six tooth or implant sites (plaque scores, bleeding score, periodontal probing depth, bleeding on probing, and gingival recession) and radiographic parameters (mesial and distal bone crest loss) between patients with and without tooth/implant loss during PM; and (2) associations between the number of teeth and implants lost and potential risk factors.

During PM, the overall average tooth loss was 0.07 teeth/patient/year (0.04 teeth/patient/year for periodontal reasons), while the overall average implant loss was 0.4 implants/patient/year. The overall implant failure was 10.08%, and the rate of implant failure due to biologic reasons was 9.8%. Incidence of implant failures in patients with vs without recurrent periodontal disease was 83.3% vs 16.7% (P < .05). Results showed that in chronic periodontitis patients, ATP followed by long-term PM is successful in keeping the majority of periodontally compromised teeth. In the same patients, a higher tendency for implant loss than tooth loss was found. Int J Periodontics Restorative Dent 2021;41:89–98. doi: 10.11607/prd.4674

Periodontitis is an inflammatory disease characterized by a polymicrobial breakdown of host homeostasis and a progressive destruction of tooth-supporting structures. It is highly prevalent in populations and affects more than 65% of subjects. It is well known that, if not treated, periodontitis represents one of the biggest causes of tooth loss, whereas tooth loss rarely occurs in comprehensively treated and maintained periodontal patients. Several studies indicated that the rate of tooth loss after active periodontal therapy (APT) varies from 0.01 to 0.17 teeth/patient/year for periodontal reasons, while the overall average implant loss was 0.4 implants/patient/year. The overall implant failure was 10.08%, and the rate of implant failure due to biologic reasons was 9.8%. Incidence of implant failures in patients with vs without recurrent periodontal disease was 83.3% vs 16.7% (P < .05). Results showed that in chronic periodontitis patients, ATP followed by long-term PM is successful in keeping the majority of periodontally compromised teeth. In the same patients, a higher tendency for implant loss than tooth loss was found. Int J Periodontics Restorative Dent 2021;41:89–98. doi: 10.11607/prd.4674

1Department of Oral & Maxillofacial Sciences, University La Sapienza, Roma, Italy.

Correspondence to: Dr Renzo Guarnieri, via Canizzano 33 Treviso, 31100, Italy.
Email: renzoguarnieri@gmail.com

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supplementing natural teeth. One of the primary advantages of their use lies in the preservation of the adjacent natural tooth structure usually sacrificed to anchor fixed dental prostheses. However, due to the increasing quantity of implants used, implant failures and peri-implantitis have become an important problem in dentistry. Recent data indicated a prevalence of moderate to severe peri-implantitis of 15% for implants in function for at least 9 years, while an estimated prevalence of 22% is reported by a recent systematic review. Furthermore, it has been emphasized that dental implants in periodontally compromised patients could yield lower survival rates, higher mean marginal bone loss, and an increased incidence of peri-implantitis compared to implants placed in periodontally healthy subjects. The aim of present study was to assess the progression of periodontal disease and the onset of peri-implant disease over a long-term period in a cohort of patients with chronic periodontitis who were treated and maintained in a private specialist periodontal practice. In particular, primary objectives were to assess rates of tooth and implant loss and to analyze the associated risk factors.

Materials and Methods

Fifty-eight patients with at least 10 years of maintenance care were selected from a list of a private periodontal practice in Italy and retrospectively valuated. All patients had been consecutively enrolled and received a periodontal and implant treatment from 2002 to 2006. Because data analysis was performed without the possibility of identifying the patient (who previously was treated as part of an approved research protocol or as part of routine periodontal care using accepted therapy for each patient’s specific clinical needs), the study was exempt from an institutional board or committee approval. However, each included patient was asked to sign an informed consent, and the study was conducted in compliance with the Declaration of Helsinki.

Inclusion and Exclusion Criteria

To be included in the study, each subject: (1) had to present an interproximal attachment loss > 3 mm and/or radiographic bone loss > 30% of root length in > 30% of sites before initiation of APT; (2) must have been treated with nonsurgical periodontal therapy (potentially followed by subsequent periodontal surgical therapy) and by implant therapy replacing hopeless teeth or restoring edentulous sites; and (3) had to undergo maintenance therapy every 3 to 6 months during the 10-year follow-up.

Subjects were excluded from the study if they met any of the following criteria: (1) presence of medical histories and conditions known to contraindicate periodontal and implant surgery; (2) presence of alcohol or drug abuse; (3) poor oral hygiene at reevaluation (full-mouth plaque score ≥ 30% and full-mouth bleeding score ≥ 25%); and (4) patients who abandoned PM.

Clinical Examination

For all patients, a self-reported medical history was recorded at the first visit. Since patients were all diagnosed and treated prior to the Workshop for the Development of a Classification System for Periodontal Diseases and Conditions of 2017, diagnoses had to be based according to the 1999 classification, satisfying the criteria of generalized moderate-to-severe chronic periodontitis. Diagnosis of chronic periodontitis was made on clinical, radiographic, and historical findings, which showed no rapid attachment loss, bone destruction, or familial aggregation of disease. Subjects were categorized as never smokers (who had never smoked in their lives), former smokers (who had quit smoking at least 5 years prior), and current smokers (all other patients). At the first visit (baseline = BSL), at the start of PM (T0), and at the last examination (T10), full-mouth plaque score (FMPS), full-mouth bleeding score (FMBS), periodontal probing depth (PPD), and bleeding on probing (BOP) were assessed at six sites (teeth or implants) using a periodontal probe. Moreover, gingival recession and tooth mobility were measured. Furcations involvement (FI) were assessed using a Napers probe (Hu-Friedy). Clinical attachment level (CAL) was calculated as PPD + gingival recession (REC).
Radiographic Examination

Periapical radiographs taken in the first two years (2002 and 2003) were digitized using a dedicated scanner (HP ScanJet Professional 3000, HP) with a resolution of 2,048 x 3,072 lines and converted into JPEG files. After the first 2 years, radiographs were recorded digitally. Mesial and distal bone crest loss was measured in all teeth at BSL, T0, and T10 using a customized film holder with a beam-guiding tool (Rinn, Dentsply Sirona) to obtain a repeatable exposure for all intraoral radiographs, which were always performed with the same radiologic device (Oralix AC, Gendex). For peri-implant marginal bone evaluation, a further individualized acrylic resin device was used for initial and subsequent radiographs. A computer-assisted measurement automatically provided by a software program (VixWin Platinum, Gendex) was used for radiographic measurements of JPEG files and digital radiographs. The radiographic bone loss around teeth was calculated as the difference between BSL and T10 evaluation in the distance from the cementoenamel junction (CEJ) to the bone crest area most in contact with the tooth root.

When the CEJ was not evident (due to decay, fillings, crowns, or overlapping images), its location was approximated by considering the adjacent or contralateral teeth. The peri-implant radiographic crestal bone loss was calculated by subtracting the marginal bone level at implant BSL (delivery of definitive implant-supported restorations) from the marginal bone level at T10. To account for radiographic distortion, radiographic measurements on each radiograph were adjusted for a coefficient derived from the true length of the implant–radiographic implant length ratio.

Patient Prognosis

The patient-based prognosis was retrospectively assigned using the simplified method for periodontal risk assessment proposed by Trombelli et al., taking into account a combination of following variables: smoking habit, diabetes status, number of pockets ≥ 5 mm, BOP score (%), and ratio of bone loss to age. Each parameter received different scores, and the algebraic sum of the parameter scores categorizes five risk profiles: profile 1 (low risk), 2 (low–medium risk), 3 (medium risk), 4 (medium–high risk), and 5 (high risk).

Tooth Prognosis

Tooth prognosis was retrospectively assigned to all teeth with available clinical and radiographic data. In the absence of a universally validated objective method for assigning tooth prognosis, the following variables were used from previous literature: teeth with bone loss greater than 75% and teeth that had at least two characteristics of the “questionable” category were classified as hopeless; teeth with bone loss between 50% and 75% or with an angular defect or furcation involvement were considered questionable; teeth with less than 50% bone loss or not fitting one of the two previous categories were considered good. Angular defects in interproximal areas were recorded when they extended more than 2 mm from the existing bone level to the depth of the defect or extended more than half the root length.

Implant Prognosis

Implant prognosis was retrospectively assigned to all implants with available clinical and radiographic data. In the absence of a universal validated objective method for assigning implant prognosis, the following variables were used from available literature: medical history (eg, radiation therapy to the head and neck, chemotherapy, xerostomy, vitamin D deficiency); number of implants placed (one or more); keratinized tissue thickness (≤ 2 or > 2 mm); type of surgery performed (immediate implant placement, early implant placement, staged implant placement); and type of prosthetic restoration (screwed or cemented, single or multiple).

Therapy

APT included appropriate initial therapy consisting of motivation, oral hygiene instruction, and scaling and root planing with the aim to reduce periodontal pathogens to a minimal level. When indicated, this was followed by additional periodontal and peri-implant surgery.
and conservative, endodontic, orthodontic, or prosthetic treatment if necessary. At the reevaluation (3 to 6 months after initial therapy), if PPD was > 6 mm or between 4 and 6 mm with BOP, additional access flap surgery for root debridement and pocket elimination was performed. Teeth with a hopeless prognosis were extracted during APT. Implant-placement surgery was performed after appropriate initial therapy during APT and when good motivation and compliance from each patient (FMPS < 30%; FMBS < 25%) was assured.

Dental implants were placed, under local anesthesia, by the same operator (R.G.) according to the manufacturer’s instructions. Implants were placed in edentulous and postextraction sites without grafting or regenerative procedures. No implants were placed in regenerated bone. The number and position of implants in each patient were determined after a thorough diagnosis of the anticipated needs for the planned prosthesis and the presence of anatomical limitations. Abutment connection was carried out 3 to 6 months postsurgery by the same operator and were selected according to the intermaxillary space. All patients were provided with implant-supported fixed restorations. All restorations were fabricated in order to facilitate both oral hygiene procedures and the probing along their circumference. At T0, probing measurements were also recorded around the implants. The following criteria were adopted to evaluate the clinical success of APT: no PPD ≥ 4 mm, minimal BOP (< 25%), and low Plaque Index (< 30%); esthetically satisfactory periodontal situation, absence of pain, and satisfactory function; and bone loss < 1.5 mm at 1 year and < 0.2 mm annually thereafter. Absence of mobility, pain, infection, and radiolucent area around the implant were considered parameters of implant success.

Compared to BSL bone levels, radiographic proximal bone loss of at least three threads at 1 year, associated with BOP and suppuration, were considered parameters for diagnosis of peri-implantitis. At an individualized interval of 3 to 6 months, each patient received PM that included staining of plaque, reinstruction and remotivation, professional tooth cleaning, and mechanical subgingival debridement of residual pockets, followed by polishing using rubber cups and polishing paste with exhaustive application of a fluoride gel. If deterioration in periodontal parameters was detected (PPD ≥ 4 mm + BOP or PPD ≥ 5 mm without BOP), nonsurgical therapy or open flap debridement to access diseased root/implant surfaces for cleaning/irrigation was performed. No pocket elimination surgery, osseous resection, or augmentation of intrabony defects was undertaken. All implants that experienced peri-implantitis before being removed had previously been subjected to nonsurgical therapy with mechanical cleaning and local anti-infective treatments. If nonsurgical treatment failed, surgical intervention with open debridement was performed. No reconstructive surgical therapy was performed at peri-implantitis–related bone defects. Systemic or topical antibiotic therapy was used in cases of acute exacerbation of periodontal/peri-implant disease.

Statistical Analysis

Public domain online software (Rao–soft) was used to calculate the minimal number necessary for statistical evaluation.

The primary outcomes of the study were tooth and implant losses. Secondary outcomes were changes in periodontal and peri-implant clinical parameters (FMPS and FMBS; average PPD, BOP, REC, and CAL; and percentage of teeth and implants with PPD measuring 1 to 4, 5 to 6, and > 6 mm) and radiographic bone levels. Normality of the parametric data distribution was evaluated by Shapiro–Wilk test. One-sample t test was used to detect significant changes between BSL and reevaluation for FMPS, FMBS, and average PPD, BOP, CAL, and PPD subcategories.

In the patient-level data analysis, incidence of tooth and implant loss were the primary outcomes. The secondary outcome was the number of teeth and implants lost during periodontal maintenance (PM). Poisson regression was used to evaluate the associations between the number of teeth lost and implants removed and the potential risk factors. Differences between patients with or without tooth loss and implant failure during PM were calculated with chi-square analysis. All analyses used two-sided tests,
and the level of statistical significance was set at 5%. In the tooth- and implant-level data analysis, generalized estimating equations were used to evaluate the associations between the incidence of tooth/implant loss and potential risk factors. SPSS version 16.0 (IBM) was used for statistical analysis.

Results

Of the 58 patients included in the study, 30 (51.7%) were men and 28 (48.3%) were women, and the mean (SD) age was 55 (6.8) years. Forty-six patients (79.3%) had never smoked, and none were former smokers. The total observation period during PM was 124 months (SD: 18.8 months; range: 118 to 136 months). During ATP, in all patients who presented sites with PPD ≥ 6 mm or between 4 to 6 mm with BOP, additional access flap surgery for root debridement and pocket elimination was performed in all patients. At T0, 6.7%, 27.3%, and 65.9% of teeth had hopeless, questionable, and good prognoses, respectively. At T10, 5.8%, 25.4%, and 68.6% of teeth were considered hopeless, questionable, and good, respectively. The number of teeth and implants present at BSL and the number of teeth extracted and implants inserted during ATP and PM are reported in Appendix Table 1.

The overall average tooth loss during PM was 0.07 teeth/patient/year. All teeth were extracted in the last 5 years of follow-up. Thirty-one patients experienced tooth loss during PM (range: 1 to 2 teeth per patient). Overall, 78 teeth (1.3/patient) were extracted from BSL to T10.

During PM, 12 implants were removed from 12 patients: Two implants were extracted at the sixth year, 4 at the seventh year, and 6 at the eighth year (0.4 implants/patient/year). The overall implant failure was 10.08%, and the rate of implant failure due to biologic reasons was 9.8%. The mean (SD) implant survival time was 8.3 (0.6) years. Differences between patients with and without tooth loss and implant failures at the end of follow-up are reported in Appendix Table 1.

The overall mean value of PPD, CAL, FMPS, and percentage of PPD 1 to 4 mm, 5 to 6 mm, and > 6 mm significantly decreased between BSL and T0 (P < .001) and then remained largely stable during the 10-year follow-up period. FMBS increased from T0 to T10 (P < .001). Figure 1 shows the mean values of PPD and CAL recorded around teeth and implants at baseline BSL, T0, and T10.

Figure 1 Mean PPD and CAL values recorded around teeth and implants at baseline BSL, T0, and T10.

The overall mean value of PPD, CAL, FMPS, and percentage of PPD 1 to 4 mm, 5 to 6 mm, and > 6 mm significantly decreased between BSL and T0 (P < .001) and then remained largely stable during the 10-year follow-up period. FMBS increased from T0 to T10 (P < .001). Figure 1 shows the mean values of PPD and CAL recorded around teeth and implants at BSL, T0, and T10. Around teeth, the mean (SD) PPD values at BSL, T0, and T10 were 3.8 (0.9) mm, 1.8 (0.6) mm, and 2.0 (0.7) mm, respectively; this showed a statistically significant decreasing during APT (P < .001), but no significant changes were observed during PM. The percentage of PPD 1 to 4 mm increased significantly at T0 (P < .001), associated with a concomitant reduction in the percentages of PPD 5 to 6 mm and > 6 mm (P < .001). The percentages remained stable, without statistically significant differences, until T10. Around implants, the mean (SD) PPD value at BSL, T0, and T10 was 2.2 (0.6) mm, 2.1 (0.3) mm, and 3.6 (2.1) mm, respectively. It showed no statistically significant change during APT and a significant increase during PM (P < .001). The percentage of PPD 1 to 4 mm decreased significantly during the 10-year follow-up period.
The percentage of teeth with bone loss < 30%, 30% to 50%, and > 50% at BSL, T0, and T10.

The percentage of implants with bone loss < 30%, 30% to 50%, and > 50% at BSL, T0, and T10.

study period ($P < .001$), associated with concomitant increased percentages of PPD 5 to 6 mm and > 6 mm ($P < .001$).

The percentage of teeth with bone loss < 30%, 30% to 50%, and > 50% at BSL, T0, and T10 is shown in Fig 2. The percentage of teeth with bone loss < 30% increased significantly during ATP ($P < .001$) and remained almost stable between the end of ATP and T10. The percentage of teeth with bone loss 30% to 50% and > 50% decreased significantly between the end of ATP and T10 ($P < .001$), and increased nonsignificantly during PM.

The percentage of implants with bone loss < 30%, 30% to 50%, and > 50% at BSL, T0, and T10 is shown in Fig 3. The percentage of implants with bone loss < 30% remained almost unvaried during ATP, and decreased between T0 and T10 with statistical significance ($P < .001$). The percentage of implants with bone loss 30% to 50% decreased significantly between BSL and T0, increasing significantly during PM ($P < .001$). At T10, the mean (SD) value of bone loss around teeth was 1.5 (0.9) mm and was 3.1 (1.2) mm around implants.

During PM, 12 of 58 patients showed deterioration of periodontal parameters (PPD ≥ 4 mm + BOP or PPD ≥ 6 mm without BOP) and experienced the loss of 34 teeth. Ten of these patients also experienced the loss of 1 implant. Forty-six patients who did not show deterioration of periodontal parameters experienced the loss of 9 teeth and 2 implants. Figures 4 and 5 show the radiographic status of a patient.
without and a patient with recurrent periodontal disease, respectively, before treatment and at T10. The percentage of implant loss in patients with vs without recurrent periodontal disease (83.3% vs 16.7%) was statistically significant ($P < .001$; Appendix Table 2). Poisson regression (Appendix Table 3) showed that age, smoking habit, number of pockets 5 to 6 mm and $> 6$ mm, the mean ratio of bone loss to age, and FMBS $> 25\%$ during PM were associated with an increased risk of implant failure during PM. Appendix Table 4 shows the associations between clinical risk factors at T0 and incidence of tooth and implant loss using tooth- and implant-level data. CAL, FI, percentage of bone loss $> 50\%$, and hopeless prognosis at T0 were associated with a higher risk of tooth loss. Smoking, CAL $< 3$ mm, percentage of bone loss $> 50\%$, and cemented restorations at T0 were associated with a higher risk of implant loss.

**Discussion**

In the present study, 90% of periodontally compromised teeth treated with ATP and maintained with PM survived over the 10-year study period. Moreover, between the start of PM and T10, the distribution of teeth according to assigned questionable prognosis decreased by 1.9%, while the percentage of teeth with assigned good prognosis increased by 3.6%. This confirms outcomes of other studies on the efficacy of periodontal therapy and maintenance programs in preventing tooth loss during middle- to long-term observation periods.5,6,23
Although the literature indicated that ATP followed by long-term PM is successful in keeping the majority of patients’ periodontally compromised teeth, it is generally believed that teeth with an unfavorable prognosis should not be treated periodontally because the prognosis of complex periodontal therapy may not match the high levels of success of implant treatment. Taking the end of ATP as the same starting point for evaluating the longevity of treated teeth and implants, outcomes of the current study showed that after ATP and PM, chronic periodontitis patients experienced a higher loss rate for implants than teeth. In this respect, after 10 years, the overall average tooth loss was 0.07 teeth per patient per year, while the overall implant loss was 0.4 implants/patient/year.

The percentages of implant survival (90%) are similar with those reported by Karoussis et al., who found an implant survival rate of 90.5% after 10 years of function in chronic periodontitis patients treated and maintained with PM. The same 10-year survival rate (90%) in periodontally compromised patients treated and maintained with PM was found by Roccuzzo et al. The question of whether chronic periodontitis patients are more at risk for implant failure has received increasing attention in the last years. Although first studies conducted on this topic have reported that the difference in implant survival rates between patients with and without a history of periodontitis is not significant, to date there is a growing evidence to support a less favorable prognosis of dental implants placed in patients with a history of chronic periodontitis following successful periodontal therapy. According to the collected data, the implant longevity evaluation as a function of time indicated that during the first 5 years of follow-up, the cumulative implant survival rate was 100% and...
decreased dramatically between 6 and 10 years, reaching a cumulative survival rate of 90.5% at T10. This result, indicating a higher susceptibility for implant failure in patients with a history of periodontitis that become evident after a prolonged period of function, has previously been discussed in studies by Karoussis et al.\(^{14}\) and Roccuzzo et al.\(^{12}\) who speculated that it could be connected to multiple episodes of peri-implant infections. Both periodontitis and peri-implantitis have been proven to be associated with several host susceptible genes, such as interleukin-1, interleukin-6, tumor necrosis factor-alpha, and transforming growth factor beta.\(^{26,27}\) Therefore, patients with past or present periodontitis could be at greater risk of infection, peri-implantitis, bone loss, and eventually implant failure.\(^{28}\) Biologic problems (peri-implantitis) caused 9.8% of implants in the present study to fail. Moreover, during the 10-year follow-up period, the percentage of implants with a PD > 6 mm and a bone loss > 50% showed increases of 13.5% and 3.1%, respectively, whereas the same percentages around teeth showed decreases of 8.0% and 10.7%, respectively. Although the clinical conditions may be different in sites where implants replaced teeth lost for periodontal reasons vs sites where teeth were kept, and the risk may vary according to site specificity/tooth morphology, the collected data seem to indicate that chronic periodontitis patients who underwent ATP and PM experienced a significantly higher prevalence of peri-implantitis than recurrent periodontitis. Poisson regression showed that age, smoking habit, number of pockets 5 to 6 mm and ≥ 5 mm, FMBS > 25%, and the mean ratio of bone loss to age at start of PM were associated with both the number of teeth lost and the number of implant failures during PM. Therefore, one can speculate that with the same starting risk conditions, implants in chronic periodontitis patients treated with ATP and maintained in PM presented a lower longevity than natural teeth. A better long-term outcome for teeth than for implants after ATP and PM has also been reported by a recent systematic review.\(^{11}\)

As far as the present authors know, few studies have evaluated the influence of periodontitis-progression risk determinants on onset and development of peri-implantitis in periodontally compromised and treated patients. Residual periodontal pockets > 5 mm at the end of ATP found by Pjetursson et al.\(^{29}\) correlated to a significant risk for the development of peri-implantitis and implant failures. Moreover, Lee et al.\(^{30}\) documented that patients with at least one residual periodontal pocket > 6 mm had a significantly greater mean peri-implant pocket depth and radiographic bone loss than patients with no residual periodontal pockets > 6 mm. Among subjects in the present study who presented implant failures, 10 of 12 patients had a residual periodontal pocket > 5 mm, while only 2 patients had a residual periodontal pocket 1 to 4 mm. Nine of these 10 patients with residual periodontal pockets > 5 mm who experienced an implant failure also presented the loss of at least one tooth. These findings could suggest that it is the presence of recurrent, rather than a history of, periodontal disease that represents a risk factor for peri-implantitis. Therefore, the absence of residual periodontal pockets > 5 mm should be considered an important aim of PM in chronic periodontitis patients after ATP.

Different types of implants with different surface characteristics were present in the sample of subjects evaluated in the present study. Although no apparent differences were observed clinically between the systems, it is not rejected that the difference in surface characteristics could have influenced the results. Another limit of the current study is the sample of patients, which is relatively small, obtained in a single private practice, and observed retrospectively. In addition, multivariate analyses regarding influencing factors have to be interpreted with caution because of the number of included factors.

**Conclusions**

Results showed that in chronic periodontitis patients, ATP followed by long-term SPT is successful in keeping the majority of periodontally compromised teeth. In the same patients, a higher tendency for implant loss than tooth loss was found.

**Acknowledgments**

The authors declare no conflicts of interest.

Conceptualization: R.G., L.T.; formal analysis:

References


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### Appendix Table 1 Differences Between Patients With and Without Tooth Loss and Implant Failures at the End of Follow-up

<table>
<thead>
<tr>
<th></th>
<th>Teeth, n (%)</th>
<th></th>
<th>Implants, n (%)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No loss</td>
<td>Loss</td>
<td>Total</td>
<td>No failure</td>
</tr>
<tr>
<td>Total patients, n (%)</td>
<td>27 (46.5)</td>
<td>31 (53.4)</td>
<td>58 (100)</td>
<td>46 (79.3)</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>12 (44.4)</td>
<td>16 (51.6)</td>
<td>28 (48.2)</td>
<td>21 (45.6)</td>
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<tr>
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<td>15 (55.6)</td>
<td>15 (48.4)</td>
<td>30 (51.8)</td>
<td>25 (54.4)</td>
</tr>
<tr>
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<td></td>
<td>&lt; .001</td>
<td>&lt; .001</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>≤ 45</td>
<td>21 (77.7)</td>
<td>10 (32.2)</td>
<td>31 (53.4)</td>
<td>28 (60.8)</td>
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<tr>
<td>&gt; 45</td>
<td>6 (22.3)</td>
<td>21 (67.8)</td>
<td>27 (46.6)</td>
<td>18 (39.2)</td>
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<td>&lt; .001</td>
<td>&lt; .001</td>
</tr>
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<td>Smoker</td>
<td>5 (18.5%)</td>
<td>6 (19.3)</td>
<td>12 (20.6)</td>
<td>1 (2.1)</td>
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<tr>
<td>Nonsmoker</td>
<td>22 (81.5)</td>
<td>25 (80.7)</td>
<td>46 (79.3)</td>
<td>45 (97.9)</td>
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<td>Systemic conditions</td>
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<tr>
<td>Healthy</td>
<td>17 (62.9)</td>
<td>25 (80.6)</td>
<td>42 (72.4)</td>
<td>36 (78.3)</td>
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<td>Hypertension</td>
<td>4 (14.8)</td>
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<td>6 (10.3)</td>
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<td>4 (6.8)</td>
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<tr>
<td>Hyperthyroidism</td>
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<td>2 (3.4)</td>
<td>1 (2.1)</td>
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<tr>
<td>Dysmetabolic syndrome</td>
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<td>2 (3.4)</td>
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<td>2 (4.3)</td>
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<td>&lt; .001</td>
<td>&lt; .001</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>≤ 25%</td>
<td>4 (14.9)</td>
<td>4 (12.9)</td>
<td>8 (72.4)</td>
<td>40 (86.9)</td>
</tr>
<tr>
<td>&gt; 25%</td>
<td>23 (85.1)</td>
<td>27 (87.1)</td>
<td>50 (86.3)</td>
<td>6 (13.1)</td>
</tr>
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<td>PPD</td>
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<td>&lt; .001</td>
<td>&lt; .001</td>
<td>&lt; .001</td>
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<tr>
<td>1–4 mm</td>
<td>17 (62.9)</td>
<td>2 (6.5)</td>
<td>19 (32.7)</td>
<td>38 (82.6)</td>
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<tr>
<td>5–6 mm</td>
<td>10 (37.1)</td>
<td>6 (19.3)</td>
<td>16 (27.5)</td>
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<td>&gt; 6 mm</td>
<td>0 (0)</td>
<td>23 (74.2)</td>
<td>23 (39.8)</td>
<td>0 (0)</td>
</tr>
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</tr>
<tr>
<td>&lt; 30%</td>
<td>18 (66.6)</td>
<td>2 (6.4)</td>
<td>20 (34.6)</td>
<td>44 (95.6)</td>
</tr>
<tr>
<td>30–50%</td>
<td>6 (22.2)</td>
<td>10 (32.2)</td>
<td>16 (27.5)</td>
<td>2 (4.4)</td>
</tr>
<tr>
<td>&gt; 50%</td>
<td>3 (11.2)</td>
<td>19 (61.4)</td>
<td>22 (37.9)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Bone loss/age</td>
<td></td>
<td>&lt; .001</td>
<td>&lt; .001</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>≤ 4 mm</td>
<td>24 (85.1)</td>
<td>2 (6.4)</td>
<td>26 (43.1)</td>
<td>42 (91.3)</td>
</tr>
<tr>
<td>&gt; 4 mm</td>
<td>3 (14.9)</td>
<td>29 (93.6)</td>
<td>32 (57.9)</td>
<td>4 (8.7)</td>
</tr>
</tbody>
</table>

FMBS = full-mouth bleeding score; PPD = periodontal probing depth.
## Appendix Table 2 Patients Experiencing Tooth/Implant Loss and Peri-implantitis

<table>
<thead>
<tr>
<th></th>
<th>Total</th>
<th>Experiencing tooth loss</th>
<th>Not experiencing tooth loss</th>
<th>Experiencing implant loss</th>
<th>Not experiencing implant loss</th>
<th>Developing peri-implantitis</th>
<th>Not developing peri-implantitis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients with successful APT</td>
<td>46</td>
<td>9 (19.5%)</td>
<td>37 (80.5%)</td>
<td>2 (4.3%)</td>
<td>44 (95.7%)</td>
<td>2 (4.3%)</td>
<td>44 (95.7%)</td>
</tr>
<tr>
<td>Patients needing surgical periodontal/peri-implantitis therapy during PM</td>
<td>8</td>
<td>8 (75%)</td>
<td>0 (0%)</td>
<td>6 (75%)</td>
<td>2 (25%)</td>
<td>2 (25%)</td>
<td>0 (0%)</td>
</tr>
<tr>
<td>Patients needing nonsurgical periodontal/peri-implantitis therapy during PM</td>
<td>4</td>
<td>4 (100%)</td>
<td>6 (75%)</td>
<td>4 (100%)</td>
<td>0 (0%)</td>
<td>6 (75%)</td>
<td>0 (0%)</td>
</tr>
</tbody>
</table>

All values are shown as n (%).

APT = active periodontal therapy; PM = periodontal maintenance.
### Appendix Table 3  Tooth and Implant Loss During PM (Poisson Regression Analysis)

<table>
<thead>
<tr>
<th></th>
<th>Tooth loss during PM (n = 43)</th>
<th>Implant failure during PM (n = 12)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Risk ratio</td>
<td>P</td>
</tr>
<tr>
<td>Male</td>
<td>0.82</td>
<td>.365</td>
</tr>
<tr>
<td>Age (&gt; 45 y)</td>
<td>1.07</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Systemic conditions</td>
<td>0.81</td>
<td>.678</td>
</tr>
<tr>
<td>Smoking habit</td>
<td>1.12</td>
<td>&lt; .001</td>
</tr>
<tr>
<td><strong>Number of pockets</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1–4 mm</td>
<td>0.78</td>
<td>.768</td>
</tr>
<tr>
<td>5–6 mm</td>
<td>1.91</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>&gt; 6 mm</td>
<td>1.97</td>
<td>&lt; .001</td>
</tr>
<tr>
<td><strong>Bone loss</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt; 30%</td>
<td>0.61</td>
<td>.022</td>
</tr>
<tr>
<td>30%–50%</td>
<td>0.94</td>
<td>.342</td>
</tr>
<tr>
<td>&gt; 50%</td>
<td>0.98</td>
<td>.071</td>
</tr>
<tr>
<td>FMBS &gt; 25%</td>
<td>1.11</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Bone loss/age</td>
<td>1.42</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>One or more implants placed</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Keratinized tissue thickness &lt; 2 mm</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Surgery required</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><strong>Type of restoration</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cemented</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Single</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>

PM = periodontal maintenance; FMBS = full-mouth bleeding score.
### Appendix Table 4 Odds Ratios of Tooth and Implant Loss During PM

<table>
<thead>
<tr>
<th>Risk factors at T0</th>
<th>Risk factors at T10</th>
</tr>
</thead>
<tbody>
<tr>
<td>OR (95% CI)</td>
<td>OR (95% CI)</td>
</tr>
<tr>
<td></td>
<td>P</td>
</tr>
<tr>
<td></td>
<td>P</td>
</tr>
</tbody>
</table>

**Tooth loss**

- **Male**
  - OR: 1.22 (95% CI: 0.491)
  - P: .491
  - OR: 1.31 (95% CI: 0.594)
  - P: .594

- **Age (> 45 y)**
  - OR: 1.11 (95% CI: 0.378)
  - P: .378
  - OR: 1.07 (95% CI: 0.408)
  - P: .408

- **Smoking habit**
  - OR: 1.59 (95% CI: 0.345)
  - P: .345
  - OR: 1.38 (95% CI: 0.376)
  - P: .376

- **CAL < 3 mm**
  - OR: 1.68 (95% CI: < .001)
  - P: < .001
  - OR: 3.66 (95% CI: < .001)
  - P: < .001

- **Percentage of bone loss > 50%**
  - OR: 1.02 (95% CI: < .001)
  - P: < .001
  - OR: 1.24 (95% CI: < .001)
  - P: < .001

- **Furcation involvement**
  - OR: 8.13 (95% CI: < .001)
  - P: < .001
  - OR: 9.06 (95% CI: < .001)
  - P: < .001

- **Hopeless prognosis**
  - OR: 8.27 (95% CI: < .001)
  - P: < .001
  - OR: 9.87 (95% CI: < .001)
  - P: < .001

- **Keratinized tissue thickness < 2 mm**
  - OR: –
  - P: –

- **Surgery required**
  - OR: –
  - P: –

- **Type of restoration**
  - **Cemented**
    - OR: 2.42 (95% CI: < .001)
    - P: < .001
  - **Single**
    - OR: 1.06 (95% CI: 0.412)
    - P: 0.671

**Implant loss**

- **Risk factors at T0**
  - OR (95% CI): 1.16 (0.377)
  - P: .409

- **Risk factors at T10**
  - OR (95% CI): 1.42 (0.187)
  - P: < .001

Tooth- and implant-level data were used to calculate the odds ratios.

**PM** = periodontal maintenance; **T0** = beginning of PM; **T10** = 10-year final follow-up; **CAL** = clinical attachment level.

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**Appendix Fig 1** Flowchart of the study’s 58 patients evaluated over 10 years. **BSL** = baseline; **APT** = active periodontal therapy; **PM** = periodontal maintenance; **SPT** = supportive periodontal therapy; **T0** = start of PM; **T10** = final 10-year follow-up.