Long-Term Prognosis of Severely Compromised Teeth Following Combined Periodontal and Orthodontic Treatment: A Retrospective Study

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This retrospective study evaluated the long-term response of periodontal tissues and survival rate of teeth with advanced attachment loss and pathologic migration in 21 periodontitis patients treated with combined periodontal and orthodontic treatment. All anterior migrated teeth were in function at the end of 10 to 15 years of maintenance. Residual probing depths and clinical attachment levels improved after treatment and remained stable through the follow-up. A total of 55 hopeless teeth were lost during active therapy, as well as 6 molars over the course of the supportive periodontal therapy (for nonperiodontal reasons). In highly compliant patients, all migrated teeth with initial unfavorable prognosis showed long-term clinical stability. Int J Periodontics Restorative Dent 2020;40:95–102. doi: 10.11607/prd.4523

An increasing number of adult patients require orthodontic treatment mainly for esthetic and/or restorative reasons, and many of them are likely to have some degree of periodontal disease.1 Among patients suffering from severe periodontitis, the reduction of periodontal support is generally associated with pathologic tooth migration (PTM), especially in the anterior area, and has a prevalence of 30.03% to 55.8%.2 Such changes in the position of the teeth are believed to occur when the periodontium is no longer able to stabilize the dentition against external forces.3 Maxillary incisors are particularly susceptible to flaring and overeruption when posterior dental support is lost.4

In the treatment of these cases, an interdisciplinary approach is often required to reestablish an esthetic and functional dentition.5 Although active periodontitis is considered a contraindication to orthodontic treatment, tooth movements are still possible in patients with reduced periodontal support, provided that inflammation has been controlled. To correct flaring, overeruption, and embrasures in the anterior area, intrusion and retraction of anterior teeth are usually required. Intrusion may cause root resorption and tooth shortening, especially if the orthodontic force is heavy.6–8 Excessive proclination of the incisors can make...
the gingival tissues less resistant to plaque-induced inflammation, and labial flaring of the mandibular incisors can cause bony dehiscence and/or fenestrations with gingival recession and reduced soft tissue thickness.9,10

There is only sparse information about periodontal stability in periodontitis patients undergoing orthodontic treatment at the end of active periodontal therapy (APT).11,12

Previous studies reported both deterioration and improvement of periodontal status during orthodontic treatment of anterior dentition.11,13,14 Therefore, the aims of the present study were (1) to evaluate the clinical and radiologic long-term changes of a complex treatment, including periodontal therapy and orthodontic torque-controlled tooth movements, in periodontitis patients with PTM on anterior teeth; and (2) to investigate the prevalence of and reasons for tooth loss.

Materials and Methods

Study Design and Population

This investigation was designed as a retrospective study based on demographic and clinical data collected from records of patients who underwent periodontal and orthodontic treatment in a specialist periodontal private practice in Turin, Italy, after APT. The Institutional Ethical Committee approved the research (no. 2028/2016). All patients gave their informed consent for the statistical analysis of their data documented during the periodontal therapy. Data collection and analysis was carried out in July 2018.

Patients qualified for participation in the study if they (1) had been diagnosed with generalized severe chronic periodontitis15 (Stage IV based on the current classification16); (2) had ≥ four sites around at least six anterior teeth with clinical attachment level (CAL) and probing depth (PD) ≥ 8 mm; (3) were in good general health; (4) had PTM of maxillary and/or mandibular anterior teeth requiring fixed orthodontic treatment; (5) had complete clinical and radiographic documentation; (6) demonstrated compliance with the supportive maintenance therapy (≥ 3 visits per year, including documentation of the periodontal conditions); and (7) were followed for at least 10 years from the completion of the orthodontic therapy.

Periodontal and Orthodontic Therapy

Prior to APT, all patients received a comprehensive periodontal charting and full-mouth radiographic examination at baseline (T0). They received similar APT, which included nonsurgical therapy, extraction of teeth considered irrational to treat17 (ie, mobility degree 3 after control of inflammation and traumatic occlusion; furcation involvement ≥ degree 2, with persistent bleeding on probing; nonrestorable teeth; vertical root fractures or endo-perio lesions with unfavorable endodontic and periodontal prognosis; recurrent periodontal abscesses during nonsurgical periodontal treatment), and surgical intervention to achieve pocket closure (PD ≤ 4 mm) in all sites. Surgical therapy either consisted of an apically positioned flap with osseous resective surgery in small bone defects (≤ 3 mm) at posterior teeth, or regenerative surgery with a papilla preservation flap design in deep intrabony defects (≥ 3 mm) at both anterior and posterior teeth (enamel matrix derivative alone or in association with bone graft materials depending on defect morphology). Six months after the completion of APT (T1), patients exhibiting a full-mouth plaque score (FMPS) and a full-mouth bleeding score (FMBS) < 20% underwent the orthodontic treatment to stabilize occlusion, correct sagittal and vertical discrepancies, restore contact points and a proper anterior guidance, and improve esthetics. A full fixed orthodontic appliance with bonded brackets was used in for subjects in the maxilla, mandible, or both arches. Orthodontic treatment was performed, mainly by intrusion and controlling tipping with segmented arch technique, by an experienced orthodontist (D.G.) with a light continuous force of 10 to 15 g.18 The active force for intrusion and retraction-space closure was obtained by inserting one titanium-molybdenum–alloy cantilever (0.017 × 0.025 inches) on each side to allow low and continuous force for optimal tooth movement. Logarithmically shaped cantilevers were used to obtain simultaneous intrusion and retraction.19 Reactivation was performed every 8 to 10 weeks. During the orthodontic treatment, patients were recalled monthly by...
experienced dental hygienists; at treatment completion (T₂), they were placed on supportive periodontal therapy (SPT) with individualized intervals of 3 to 4 months. Patients were rehabilitated with fixed restorations on dental implants in the posterior area when needed. No patients received implants or prosthetic fixed restorations on anterior teeth. Mucogingival procedures were provided to improve the quality and quantity of the soft tissue when patients experienced discomfort during toothbrushing.

Evaluation of Patient Charts

After pseudonymization, demographic information and periodontal clinical data measured at T₀, T₁, T₂, and at the time of the latest maintenance visit (T₃) were entered into a data set for statistical analysis. Teeth lost during the observation period were also documented. Data from third molars were excluded. The reasons for tooth extraction were evaluated and classified as either periodontal or other (endodontic failure, caries, fracture, restorative purpose, or unknown reasons). Periodontal bone levels of treated anterior teeth were evaluated by means of ImageJ software (National Institutes of Health) on periapical radiographs taken at T₀, T₂, and T₃. Separate scorings were made at mesial and distal aspects of each anterior treated tooth. The radiographic reference points were the cementoenamel junction, the root apex, and the apical extent of bone loss (identified as the most coronal area in which the periodontal ligament retained its width). The root length (CEJRA) and the percentage of residual bone were assessed twice by two examiners (M.M.G. and E.E.) for all sets of radiographs. The mean of the four measurements was used in the analysis. If the difference in the measurements between the two examiners was greater than 0.1 mm, the examiners jointly reanalyzed the radiographic parameter to reach a consensus.

Statistical Analyses

The primary outcome measure of the study was the effect of combined periodontal and orthodontic treatment on CAL changes of anterior teeth with PTM. Numerical data were summarized as means and standard deviations, and categorical data were summarized as frequency distribution. Data from migrated and orthodontically treated teeth and from full-mouth data were separately considered in the analysis. Statistical significance of differences over time were evaluated with repeated-measures analysis of variance (FMBS, PD, CAL, radiographic data) and Friedman test (FMPS, gingival recession). Multiple comparisons were performed with post hoc tests (Tukey test and Dunn test). Kaplan-Meier tooth survival rate was calculated. P values < .05 were considered statistically significant. A statistical software program was used for data analysis (SPSS version 24.0, IBM).

Results

The records of 43 generalized chronic periodontitis subjects who had been consecutively treated between January 2003 and December 2008 were reviewed, of which 21 fulfilled the inclusion criteria. The mean age of the participants was 52.6 ± 5.9 years (range: 44 to 68 years), and females represented 76.2% of the sample. Only a small percentage of patients were current smokers (14.3%) and smoked 4 to 6 cigarettes per day. Eight of the participants underwent fixed orthodontic treatment on the anterior sextants in both arches, while the remaining 13 subjects underwent treatment on the maxilla only. The mean length of orthodontic therapy was 18.6 ± 9.0 months (range: 4 to 36 months). The SPT intervals scheduled for patients were 2 months (66.7%) and 3 to 4 months (33.3%), whereas the mean duration of SPT was 11.6 ± 1.6 years, ranging from 10 to 15 years.

Clinical and Radiographic Outcomes

The overall therapeutic response is presented in Table 1. At T₀, all patients presented high FMPS and FMBS values that decreased to 16.4% ± 2.7% and 7.7% ± 3.4%, respectively, at T₁; these values remained nearly unchanged at the T₂ and T₃ examinations. Undergoing APT resulted in statistically significant improvements of whole-mouth clinical parameters (P < .005). A mean PD reduction of 1.1 ± 0.8 mm was achieved together
with a significant increase in gingival recession (0.6 ± 0.4 mm). Minor, nonsignificant changes were noted between T1 and T2 and between T2 and T3 in all clinical variables. Similar outcomes were observed when considering only orthodontically treated teeth, as summarized in Table 2. Patients experienced a mean PD reduction of 1.6 ± 0.9 mm (P < .001) at T1 and a corresponding mean increase in gingival recession of 0.8 ± 0.9 mm at T1. Stability of the clinical parameters was observed at T2 (P > .05) and during the course of SPT (T2 to T3).

Table 3 summarizes radiographic changes observed at anterior teeth. The overall alveolar bone level remained largely unchanged, while the average root length decreased from 16.57 ± 1.68 mm at T0 to 14.94 ± 1.93 mm at T3 (P < .01).

Table 1 Changes in Full-Mouth Clinical Variables (Mean ± SD) Over the Observation Period

<table>
<thead>
<tr>
<th>Variable</th>
<th>T0</th>
<th>T1</th>
<th>ΔT0–T1</th>
<th>T2</th>
<th>ΔT0–T2</th>
<th>T3</th>
<th>ΔT0–T3</th>
</tr>
</thead>
<tbody>
<tr>
<td>FMPS, %</td>
<td>49.5 ± 16.7a</td>
<td>16.4 ± 2.7</td>
<td>33.1 ± 16.4c</td>
<td>17.3 ± 2.4</td>
<td>32.2 ± 16.8c</td>
<td>19.3 ± 4.1</td>
<td>30.2 ± 17.1</td>
</tr>
<tr>
<td>FMBS, %</td>
<td>28.9 ± 14.2a</td>
<td>7.7 ± 3.4</td>
<td>21.2 ± 12.1c</td>
<td>7.5 ± 2.8</td>
<td>21.4 ± 13.1c</td>
<td>6.7 ± 2.8</td>
<td>22.2 ± 13.8c</td>
</tr>
<tr>
<td>PD, mm</td>
<td>4.3 ± 0.8a</td>
<td>3.2 ± 0.2</td>
<td>1.1 ± 0.8c</td>
<td>3.1 ± 0.2</td>
<td>1.2 ± 0.7c</td>
<td>3.0 ± 0.3</td>
<td>1.3 ± 0.7c</td>
</tr>
<tr>
<td>CAL, mm</td>
<td>5.0 ± 0.9a</td>
<td>4.4 ± 0.5</td>
<td>0.6 ± 1.2b</td>
<td>4.4 ± 0.6</td>
<td>0.6 ± 1.1b</td>
<td>4.6 ± 0.7</td>
<td>0.4 ± 1.1</td>
</tr>
<tr>
<td>REC, mm</td>
<td>0.7 ± 0.5c</td>
<td>1.3 ± 0.6</td>
<td>–0.6 ± 0.4c</td>
<td>1.3 ± 0.7</td>
<td>–0.6 ± 0.5c</td>
<td>1.6 ± 0.8</td>
<td>–0.9 ± 0.6c</td>
</tr>
<tr>
<td>No. of teeth</td>
<td>21.9 ± 3.1a</td>
<td>19.3 ± 3.9</td>
<td>2.6 ± 2.2c</td>
<td>19.2 ± 3.8</td>
<td>2.7 ± 2.2c</td>
<td>19.1 ± 3.7</td>
<td>2.9 ± 0.6c</td>
</tr>
</tbody>
</table>

T0 = baseline; T1 = reevaluation after active periodontal treatment; T2 = reevaluation after orthodontic treatment; T3 = final follow-up; FMPS = full-mouth plaque score; FMBS = full-mouth bleeding score; PD = probing depth; CAL = clinical attachment level; REC = gingival recession. An increase in recession is indicated by a negative value in that row.

aP ≤ .005; values represent changes among the four time points (repeated-measures analysis of variance or Friedman test).
bP ≤ .01; values represent longitudinal changes from T0.
cP ≤ .001; values represent longitudinal changes from T0.

Table 2 Changes in Clinical Variables (Mean ± SD) at Anterior Teeth with Pathologic Tooth Migration Over the Observation Period

<table>
<thead>
<tr>
<th>Variable</th>
<th>T0</th>
<th>T1</th>
<th>ΔT0–T1</th>
<th>T2</th>
<th>ΔT0–T2</th>
<th>T3</th>
<th>ΔT0–T3</th>
</tr>
</thead>
<tbody>
<tr>
<td>PD, mm</td>
<td>4.7 ± 0.7a</td>
<td>3.1 ± 0.4</td>
<td>1.6 ± 0.9b</td>
<td>3.2 ± 0.4</td>
<td>1.5 ± 0.8b</td>
<td>3.1 ± 0.5</td>
<td>1.6 ± 0.9b</td>
</tr>
<tr>
<td>CAL, mm</td>
<td>5.4 ± 0.9a</td>
<td>4.5 ± 0.8</td>
<td>0.9 ± 1.2b</td>
<td>4.6 ± 0.8</td>
<td>0.8 ± 1.1b</td>
<td>4.8 ± 0.9</td>
<td>0.6 ± 1.1b</td>
</tr>
<tr>
<td>REC, mm</td>
<td>0.7 ± 0.7a</td>
<td>1.4 ± 0.8</td>
<td>–0.8 ± 0.6b</td>
<td>1.5 ± 0.8</td>
<td>–0.9 ± 0.7b</td>
<td>1.7 ± 0.9</td>
<td>–1.1 ± 0.7b</td>
</tr>
</tbody>
</table>

T0 = baseline; T1 = reevaluation after active periodontal treatment; T2 = reevaluation after orthodontic treatment; T3 = final follow-up; PD = probing depth; CAL = clinical attachment level; REC = gingival recession. An increase in recession is indicated by a negative value in that row.

aP ≤ .001; values represent changes among the four time points (repeated-measures analysis of variance or Friedman test).
bP ≤ .001; values represent longitudinal changes from T0.

cP ≤ .01; values represent longitudinal changes from T0.

Table 3 Changes in Radiographic Variables (Mean ± SD) at Anterior Teeth with Pathologic Tooth Migration Over the Observation Period

<table>
<thead>
<tr>
<th>Variable</th>
<th>T0</th>
<th>T3</th>
<th>ΔT0–T2</th>
<th>T3</th>
<th>ΔT0–T3</th>
</tr>
</thead>
<tbody>
<tr>
<td>CEJRA, mm</td>
<td>16.57 ± 1.68a</td>
<td>15.87 ± 1.86</td>
<td>0.70 ± 0.77</td>
<td>14.94 ± 1.93</td>
<td>1.63 ± 1.32c</td>
</tr>
<tr>
<td>Residual bone, %</td>
<td>63.32 ± 8.22b</td>
<td>63.70 ± 8.79</td>
<td>–0.38 ± 4.3</td>
<td>63.72 ± 9.04</td>
<td>–0.40 ± 5.9c</td>
</tr>
</tbody>
</table>

T0 = baseline; T3 = reevaluation after orthodontic treatment; T2 = reevaluation after orthodontic treatment; CEJRA = root length.
aP ≤ .001; values represent changes among the three time points (repeated-measures analysis of variance or Friedman test).
bP > .05; values represent changes among the three time points (repeated-measures analysis of variance or Friedman test).
cP ≤ .01; values represent longitudinal changes from T0.
Tooth Loss and Reasons for Extraction

The total number and percentage of teeth lost, including reasons for extraction, are reported in Table 4. During APT (T₀ to T₁), patients collectively lost 55 teeth in general (31 molars, 18 premolars, and 6 monorooted teeth) and 35 for periodontal reasons. This represents mean general and periodontal-related losses of 2.6 ± 2.3 and 1.7 ± 1.4 teeth per patient, respectively. No tooth was extracted during orthodontic treatment. Over the course of 10 to 15 years of SPT, 6 additional molars were lost due to root fracture. The mean tooth survival rate was 88.1% ± 1.5% at T₁ and 86.8% ± 1.6% at T₃. No anterior tooth with SPT was lost during the observation period. Figures 1 and 2 illustrate clinical and esthetic changes observed in one patient at baseline and the 10-year follow-up.

Discussion

This study demonstrates that orthodontic treatment of the anterior dentition is a safe procedure in periodontally compromised patients who completed APT with adequate plaque and inflammation control (FMPS and FMBS < 20%) and no residual pockets (PD ≤ 4 mm). CAL loss did not occur at involved teeth during orthodontic treatment, and no anterior tooth with PTM that underwent orthodontic treatment was lost due to periodontitis recurrence during the 11-year-average period of SPT.

The effects of a combined periodontal-orthodontic approach were analyzed in previous investigations.²²–²⁴ In a series of studies, open-flap surgery was performed 7 to 10 days before orthodontic treatment for the intrusion of flared and over-erupted incisors. A significant mean PD reduction of 4.35 mm was reported, associated with a mean CAL gain of 5.50 mm at 10 months postorthodontic treatment.²²–²⁴ According to the authors, the improvement of PD was related to intrusion, retraction, and mesial movement of periodontally stable incisors because of previous flaring and/or pathologic overeruption. However, such a result probably relates to the outcome of periodontal surgery at intrabony defects rather than to orthodontic movement itself.

In the present study, no periodontal changes occurred after orthodontic tooth movement, but APT was completed at least 6 months before the start of orthodontic treatment. Furthermore, the abovementioned studies tested the efficacy of a combined periodontal-orthodontic approach in intrabony defects, while the current research did not differentiate defect types.²²–²⁴ In general, mean PD reduction was greater in studies involving vertical defects when compared to the present data, which pooled sites with varying severity of involvement. This supports the fact that orthodontic treatment on healthy but reduced periodontium neither positively nor negatively affects residual periodontal support.

It still remains questionable if a new connective tissue attachment could be created by means of orthodontic intrusion alone. Some studies²⁵,²⁶ suggest that PD improvement may not imply the creation of a new attachment, even if histologic studies on monkeys may support this possibility.²⁷ In the present study, no changes in CAL occurred after orthodontic treatment, but patients achieved periodontal stability before orthodontic movement began. Interestingly, the annual CAL loss rate during maintenance in the present study was 0.02 mm/year, which is considerably less than the rate of 0.1 mm/year reported in a long-term follow-up study.²⁸ This ultimately supports that periodontal conditions may be maintained in the long term when adequate SPT is provided, irrespective of

<table>
<thead>
<tr>
<th>Table 4 Reasons for Tooth Extraction During the Follow-up Period</th>
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<tbody>
<tr>
<td><strong>Number (%) of teeth extracted per time period</strong></td>
</tr>
<tr>
<td><strong>Cause</strong></td>
</tr>
<tr>
<td>Periodontal lesion</td>
</tr>
<tr>
<td>Root fracture</td>
</tr>
<tr>
<td>Endodontic failure</td>
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<tr>
<td>Carious lesion</td>
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</tbody>
</table>

T₀ = baseline; T₁ = reevaluation after active periodontal treatment; T₂ = reevaluation after orthodontic treatment; T₃ = final follow-up.
orthodontic treatment. However, the possibility of CAL gain during orthodontic treatment remains questionable.

PD reduction at the end of SPT was in line with another report that implied similar surgical approaches, with approximately 1 mm of mean PD reduction in pockets of 4 to 6 mm at the end of APT. Recession increase during the maintenance period was in line with values from

Fig 1 (a) Clinical view of advanced generalized periodontitis in a 44-year-old patient. (b) Cast models showing migration of maxillary incisors. (c) Orthodontic treatment (intrusion and continuous arch) after APT. (d) Facial, (e) lateral, and (f) anterior views 10 years after completion of the combined periodontal and orthodontic treatment.
another long-term study.\textsuperscript{29} Despite a trend toward increased recession, no differences were found comparing teeth with or without orthodontic movement. This contrasts the mean recession reduction of 1.08 mm reported by Melsen et al.\textsuperscript{25} This could be interpreted as an effect of periodontal treatment. In fact, due to esthetic concerns, anterior teeth with pockets have been treated with nonsurgical therapy or regenerative surgery. This may have caused progressive recession during SPT, which in turn might have compensated for the effects of intrusion on the crown length.\textsuperscript{30}

Root resorption may occur as a consequence of intrusion. Importantly, root resorption did not stop at the end of orthodontic treatment but continued over time. This should be kept in consideration when treating patients with reduced periodontal support. Despite a significant apical resorption, the amount of bone support remained almost constant during follow-up. This could be explained by the fact that some remineralization of the bone surrounding the periodontally compromised teeth may have occurred during APT.

The present study has some limitations. A retrospective study is prone to selection, performance, and reporting bias. However, long-term outcomes like tooth loss are often not feasible to assess prospectively. In addition, change of tooth axis by the orthodontic treatment prevented a reliable superimposition of intraoral radiographic images based on anatomic landmarks. Thus, radiographic data should be considered only suggestive of dental and bone changes. Last, the authors considered strict inclusion criteria, limiting the number of available patients.

\textbf{Conclusions}

Within the limits of this investigation, the data indicate that orthodontic tooth movement has no major
effects on a healthy but reduced periodontium in patients enrolled in a strict maintenance care program; therefore, it can be considered a safe procedure for the management of patients previously affected by severe forms of periodontitis. Further long-term prospective trials are needed.

Acknowledgments

No competing financial interests exist. The authors report no conflicts of interest related to this study.

References