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Moderate-to-long-term periodontal outcomes of subjects failing to complete a course of periodontal therapy

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Moderate-to-long-term periodontal outcomes of subjects failing to complete a course of periodontal therapy

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ABSTRACT

Background: The current retrospective cross-sectional study investigated 5-18 years treatment outcomes in subjects who did not complete a recommended course of periodontal therapy.

Methods: Sixty-five subjects who voluntarily discontinued therapy were recalled. Subject's demographic data and dental history since discontinuation of periodontal treatment were collected via questionnaires. Subject's periodontal condition, radiographic data and individual tooth-based prognosis at pre-discontinuation and recall were compared.

Results: A total of 229 teeth had been lost over time, mainly due to periodontal reasons. Upper and lower molars were most frequently lost. Rate of tooth loss (0.38/patient/year) was comparable to untreated patients. Deterioration in periodontal health in terms of increased percentage of sites with bleeding on probing (BOP) and sites with probing pocket depths (PPD) ≥ 6mm at re-examination was observed. Positive correlations were found between tooth loss and (i) years since therapy discontinued; (ii) percentage of sites with PPD ≥ 6mm at pre-discontinuation; and (iii) at re-examination. Percentage of sites with PPD ≥ 6mm at recall was positively correlated with periodontal tooth loss and negatively correlated with percentage of sites without BOP.

Conclusions: Patients not completing a course of periodontal therapy are at risk of further tooth loss and deteriorations in periodontal conditions over time.

(Word count 200)

Keywords: initial periodontal therapy; periodontal disease; prognosis; radiograph;

supportive periodontal therapy; tooth loss.

Abbreviations and acronyms: ANCOVA = analysis of covariance; ANOVA = analysis of variance; BOP = bleeding on probing; DM = diabetes mellitus; HPT = hypertension; PPD = probing pocket depth; PPDH = Prince Philip Dental Hospital; RA = rheumatoid arthritis; SPT = supportive periodontal therapy.

INTRODUCTION

Periodontal disease is characterized by gingival inflammation with subsequent pathological destruction of tooth-supporting tissues.[1] Not all individuals are equally susceptible.[2] Various biological, environmental and social factors interplay to modify periodontal disease severity and progression.[3-5]

Management of periodontal disease entails at the outset cause-related therapy, followed by surgical therapy when deemed necessary.[6, 7] This should be followed by appropriate supportive periodontal therapy (SPT).[8-12] It is well established that periodontal treatment without proper SPT is of little value.[8, 11] Compliance to routine SPT is essential, and recurrence of periodontal disease is high among non-complying individuals.[4, 11, 13] Deterioration in periodontal health occurs also in the inadequately treated patient.[14-16] This deterioration has been shown to be similar to untreated periodontitis subjects, albeit at a slower rate.[16]

Prognostication of treated periodontitis subjects at both tooth and patient level is often carried out to forecast long-term tooth survival and predict future periodontal stability after comprehensive therapy.[17-20] Such a practice is aimed at informing patients of possible treatment outcomes[21] and aids in formulation of SPT protocols.[10]

Predictors of disease intermission or progression in incompletely treated periodontitis patients are limited. Though previous report showed that periodontal

treatment without appropriate SPT appeared to slow disease progression, further tooth loss, periodontal health deteriorations especially in furcation sites and bone loss were to be expected.[8] This retrospective study aims to evaluate the moderate-to-long-term periodontal outcome of periodontitis patients who for some reason failed to a complete a course of periodontal therapy, and to determine any factors that may relate to the long-term prognosis of teeth in such patients. Unmaintained patients have a higher chance of tooth loss even when teeth have been initially classified as having a good prognosis.[8, 18-20] Deterioration or improvement in tooth prognosis may occur over time, hence re-prognostication is often needed over prolonged periods.[17] Special attention was given to categorize individual tooth prognosis at prior to discontinuation of treatment and at recall, with the intention that better treatment planning be possible for patients who are unable to accommodate the treatment schedule needed for comprehensive periodontal therapy, and to identify and advise discontinuing patients who are "at risk" of further periodontal deterioration should they refuse further intervention.

MATERIALS AND METHODS

Study design

The study design was a convenient sample, cross-sectional study carried out

according to the STROBES (Strengthening The Reporting of Observational Studies in Epidemiology) guidelines.[22, 23]

Ethics

The study protocol was approved by Ethics Committee, Faculty of Dentistry, the University of Hong Kong. Access to past records for teaching and research purposes was consented to by patients upon admission to the Prince Philip Dental Hospital (PPDH).[24] All participants signed an informed consent prior to study commencement. Personal identifiers were removed from all collected data.

Subjects

The study population was selected from a list of Chinese patients (n = 1,127) treated 5-18 years prior to the commencement of this study, at the Periodontology Clinic, PPDH, the University of Hong Kong. All subjects had previously undergone supervised periodontal treatment delivered by either undergraduate dental or postgraduate Periodontology students, but who subsequently opted to be discharged from the dental hospital voluntarily prior to treatment completion. All subjects were advised to continue periodontal therapy from qualified dental practitioners upon self-discontinuation.

Subjects were recruited as described previously[11] if their records showed: 1) they were at the time of initial examination, diagnosed with what is now categorized as aggressive (AgP)[25] or chronic periodontitis (CP),[25] 2) a clear periodontal chart recording that subject's periodontal condition at baseline and immediately before case inactivation, 3) a clear panoramic radiograph taken ≤ 12 months before treatment discontinuation, with number of teeth and their location that corresponded with final periodontal chart, 4) subjects had completed at least one session of non-surgical periodontal therapy on all periodontally involved sites, 5) no periodontal surgery had been performed, 6) subjects were evaluated at least once for treatment outcome, 7) final periodontal chart showed at least one site with ≥ 6mm PPD prior to treatment discontinuation.

The sample size was restricted to a convenient sample of previously treated periodontitis patients, with records that showed clear and adequate information on previous periodontal parameters and treatment, who could be contacted and were able to attend a recall appointment.

Clinical examination, categorization and data collection

All consenting subjects completed a questionnaire to record their demographic data, general health status, oral hygiene practices, denture wearing, smoking status, past

dental visit patterns and, to the extent of their recollection, the reasons for individual tooth loss, if any, since discontinuation.[11] Clinical examination of all subjects included: total number of standing teeth, full-mouth plaque accumulation recorded in percentage, full-mouth bleeding on probing in percentage (BOP%) and full-mouth probing pocket depth (PPD) using a William's probe (Hu Friedy®, Chicago, IL, USA) measured at six sites (mesio-buccal, mid-buccal, disto-buccal, mesio-lingual, mid-lingual, disto-lingual) on each tooth. An updated panoramic radiograph was taken for comparison with the panoramic radiograph taken earlier at the time of the course of therapy which had been discontinued. Alveolar crest bone levels around individual teeth shown on panoramic radiographs taken prior to discontinuation and at re-examination were measured. The two panoramic radiographs were scanned and printed as photographs which served as duplicates. The duplicates were made using a professional desktop scanner equipped with a Super Linear Quadline charge-coupled device and multi-lens (Lanovia Quattro, Fujifilm). Markings were made on the duplicates at radiographic land-marks: mesial and distal crestal bone levels, cemento-enamel junction, and root apex. Measurements were then made using the Schei[26] ruler technique by which interdental alveolar bone loss was determined directly from a radiograph as a percentage of the corresponding tooth's root length.[27-29] The measured teeth were divided into categories with modifications based

on Becker *et al.*[8] (Table 1).

Clinical and radiographic data gathered from pre-discontinuation records and at re-examination were used as a basis for giving individual tooth prognosis. Each tooth was categorized according to criteria modified from Becker *et al*.[8] (Table 2). As protocol dictates, all patients treated in the supervised teaching clinics were examined by at least one experienced periodontal specialist at critical stages of treatment including initial examination and re-evaluation.[11] All clinical parameters recorded and reported in the patients' folders were screened by both the clinician in-charge and an experienced supervisor.

All examinations and measurements at re-examination were carried out by a single operator (PPH). A second opinion was sought (WKL) if any difficulties arose in radiographic measurements or in classifying tooth prognosis. Any discrepancies were resolved through discussion and mutual agreement.

Subjects with deteriorations in periodontal health were referred for treatment in PPDH. Those who declined or were periodontally healthy were advised to seek periodontal treatment or SPT with a qualified dental practitioner.

Data analysis

Data were analyzed using the statistical package SPSS 16.0 (SPSS, Chicago, IL,

USA). Standard statistical analyses were conducted to compare subject's demographic and clinical data at pre-discontinuation and at re-examination. Analysis of variance (ANOVA) with post hoc multiple comparisons was used to determine changes in (1) percentage of sites with BOP, (2) percentage of sites with PPD ≥ 6mm, (3) number of standing teeth, between pre-treatment, pre-discontinuation and re-examination. $P < 0.017$ was considered statistically significant for the above analyses. To analyze changes in individual tooth prognosis, Stuart-Maxwell χ^2 - test of overall marginal homogeneity was performed. Analysis of covariance (ANCOVA) was performed to determine possible associations between the dependent variables: tooth loss; and 13 independent variables. The independent variables were: (a) categorical data – gender, education level, current general health status, current smoking status, use of interdental-cleaning aids and tooth-brushing habit; (b) continuous data – age at recall, years elapsed since discontinuation of periodontal therapy, smoking in pack-years, percentage of sites with PPD ≥ 6mm at pre-discontinuation and at re-examination, percentage of sites without BOP (BOP = 0) at pre-discontinuation and re-examination. A second ANCOVA was performed to determine any associations between the dependant variable: percentage of sites with PPD ≥ 6mm at re-examination; and 12 of the aforementioned independent variables and one added continuous variable – periodontal tooth loss. $P < 0.05$ was considered statistically significant for the

multivariate analyses.

RESULTS

Patient demography and general profiles

A total 210 patients were identified to be possible subjects. All other patients whose records were screened had completed their prescribed periodontal therapy, and were either under SPT at the PPDH or had been discharged to seek SPT under their own arrangements.[11] Sixty-five subjects (31 male, 34 female) with clinical and radiographical data up to requirements of the recruitment criteria were successfully contacted and consented to participate in the study. Their age range at discontinuation of previous periodontal treatment was 21 - 75 years (mean 43.8 ± 11.9 years), and 30 - 82 years (mean 50.3 ± 11.3 years) at re-examination. The mean number of years elapsed since discontinuation of treatment was 9.2 ± 3.7 years, with a range of 5 - 18 years. Three (4.6%) of the previously treated subjects had received no schooling/formal education, 18 (27.7%) attended only primary school, 35 (53.9%) had received secondary school but no further education and 9 (13.8%) only had received tertiary education.

A majority of the subjects were never smokers (n = 49, 75.4%), 8 (12.3%) were current smokers with self-reported mean consumption of 2.9 ± 7.2 pack-years (min

0.07 – max 33.8 pack-years) while 8 (12.3%) were former smokers.

Regarding self-reported medical status, 43 (66.2%) subjects were at time of re-examination medically healthy, while the remaining 22 (33.8%) reported to have some medical condition. Ten (15.4% of total) of these 22 subjects did not report any systemic disease at the time of active periodontal treatment. Of the 12 (18.5% of total) that reported systemic disease at treatment, 10 (15.4% of total) reported the medical history at re-examination, while 2 (3.1% of total) had one additional medical problem. On the whole, subjects reported: hypertension (HPT) (n = 6); diabetes mellitus (DM) (n = 3); thyroid disease (n = 1); anxiety neurosis (n = 1); rheumatoid arthritis (RA) (n = 1); cardiac arrhythmia (n = 1); renal failure (n = 1); HPT, stroke and epilepsy (n = 1); HPT, RA, DM (n = 1); HPT, Parkinson's disease (n = 1); ischemic heart disease, DM (n = 1); HPT, hypothyroid (n = 1); DM, RA (n = 1); HPT and DM, with renal failure as additional problem (n = 1); HPT and DM, with prostate enlargement as additional problem (n = 1). All 22 subjects with significant medical histories were undergoing regular medical follow up.

Of the 65 subjects, only 1 (1.5%) reported having sought periodontal therapy after self-discontinuation of treatment, with the last dental visit being within 12 months of the date of re-examination. The other 64 (98.5%) reported dental visits at irregular intervals for extractions (n = 43), scaling (n = 42), restorations (n = 12),

dentures (n = 25) and other dental treatment (n = 22) since periodontal treatment self-discontinuation. None reported having sought comprehensive periodontal therapy as advised upon treatment self-discontinuation. Thirty-one (47.7%) of the subjects wore dentures at the time of re-examination, of these 5 (7.7%) wore dentures prior to treatment discontinuation ($P < 0.001$, Fisher's Exact test). Eleven (16.9%) subjects wore upper dentures only, 7 (10.8%) wore lower dentures only, while 13 (20.0%) wore both upper and lower dentures. Fifty-four (83.1%) of the subjects at re-examination reported brushing their teeth at least twice a day, 8 (12.3%) reported using single-tufted tooth-brushes on a regular basis. Forty-one (63.1%) of the study subjects reported performing interdental cleaning on a regular basis, of whom 22 (53.7%) reported using interdental brushes regularly, 13 (31.7%) reported using floss regularly while 36 (87.8%) reported use of toothpicks on a regular basis.

Clinical Parameters

Relevant clinical parameters of all 65 subjects before periodontal therapy, immediately before treatment self-discontinuation and at re-examination are summarized in Table 3. Of the 65 subjects re-examined, 8 (12.3%) were diagnosed with AgP,[25] while the other 57 (87.7%) were diagnosed CP.[25] Comparison of clinical parameters at re-examination between AgP and CP subjects showed no statistically

significant differences (t-test) in percentage of sites with PPD ≥ 6mm (4.3 ± 5.7% vs. 5.1 ± 9.3%, P = 0.812), BOP% (58.8 ± 15.1% vs. 48.1 ± 22.4%, P = 0.194), PI% (90.9% ± 12.1% vs. 84.5% ± 17.5%, P = 0.318), and mean tooth loss (5.4 ± 6.4teeth vs. 3.3 ± 3.2teeth, P = 0.385) between groups respectively. As such, clinical data was pooled for analyses. A total of 1,597 standing teeth were recorded at pre-discontinuation with 229 (14.3%) teeth lost at recall (mean 3.5 ± 3.7 teeth/patient). Tooth mortality revealed a mean annual adjusted tooth loss rate of 0.38 teeth/patient/year. Molars in general were lost more than the premolars and anterior teeth, with more maxillary molars lost than mandibular molars (Fig. 1). Regarding self-reported reasons for tooth loss, 191 (83.4%) teeth were lost due to periodontal reasons (mean 2.9 ± 3.3 teeth/patient); 23 (10.0%) due to caries; 15 (6.6%) due to reasons which participants could not recall. Of the 229 teeth that were lost, 42 (18.3%) initially had good prognosis, 71 (31.0%) fair, 74 (32.3%) questionable, 37 (16.2%) hopeless and 5 (2.2%) undetermined prognosis. Only a small proportion of subjects contributed to a majority of tooth loss. More than half (n = 35, 53.8%) of the subjects lost two teeth or less after discontinuation of treatment, 26 (40%) lost three-to-nine teeth, while four (6.2%) subjects lost 11-to-16 teeth contributing a quarter (24.9%, n = 57) of the tooth loss total.

Out of the total 1,597 teeth followed, 576 (36.1%) showed deteriorations in

periodontal prognosis or were extracted, 148 (9.3%) prognosis had improved, while for 844 (52.8%), the prognosis remained unchanged (Table 4). Twenty-nine (1.8%) teeth had incomplete data due to impaction, severe mal-position, or were abutments for prosthesis which impeded clinical and radiographic evaluation and could not be assessed for prognosis. Changes in individual tooth-based periodontal prognosis revealed that for teeth with good, fair, questionable and hopeless prognosis at initial determination, the condition in general worsened with time ($P < 0.001$) (Table 4).

Though one subject reported having received periodontal therapy since treatment discontinuation, that subject presented with several sites having PPD ≥ 6mm and a history of tooth loss due to periodontal reasons, thus, all 65 subjects were included in the multivariate analysis. Analysis of covariance showed that total tooth loss since discontinuation of treatment was positively associated (adjusted $R^2 = 0.466$, $F = 19.584$, $P < 0.001$) with years elapsed since treatment discontinuation ($B = 0.588$, $P < 0.001$), percentages of sites with PPD ≥ 6mm at pre-discontinuation ($B = 0.483$, $P = 0.010$) and at re-examination ($B = 0.218$, $P < 0.001$). Percentage of sites with PPD ≥ 6mm at re-examination was positively associated (adjusted $R^2 = 0.226$, $F = 10.330$, $P < 0.001$) with periodontal tooth loss ($B = 1.127$, $P = 0.002$) and negatively associated with percentage of sites without BOP at pre-discontinuation ($B = -0.125$, $P < 0.016$).

DISCUSSION

The present study evaluated the periodontal conditions and tooth loss history of periodontitis patients 5–18 years after self-initiated dropout from a course of periodontal therapy and since periodontal therapy was voluntarily discontinued prior to treatment completion, less than favorable treatment responses were expected.

Periodontal prognostication is regarded as an essential part of periodontal treatment.[18-20] Tooth prognosis is often used to aid both patients and clinicians in deciding whether treatment is worthwhile, and it assists the clinician in determining which treatment modality to adopt.[17, 18] Data gleaned from clinical parameters and radiographic bone measurements to assess changes in prognosis may be useful in evaluating alterations in periodontal health over time.[8] In a retrospective study, like the present one, reliability of pre-discontinuation clinical data is unknown due to considerable inter-examiner variability. Prognostication of teeth at pre-discontinuation was carried out by comparing both clinical recordings and radiographic information which were readily available from the patient records. Panoramic radiographs are adequately informative for periodontal diagnosis and treatment planning.[31] With the use of the Schei ruler technique to measure the amount of radiographic alveolar bone loss,[26, 27] balanced against available clinical data, retrospective prognostication according to published criteria[8] could be carried out. Only those previously treated

subjects whose clinical data had been duly checked and counter-signed by a qualified periodontal specialist were included.

Changes in tooth-based periodontal prognoses over time showed a generally deteriorating pattern when pre-discontinuation records were compared with re-examination results (Table 4). Teeth with initially good prognoses remained quite stable with 70.5% (n = 637) unchanged, 24.9% (n = 225) having deteriorated and 4.6% (n = 42) extracted at re-examination. However, for teeth with initially fair prognosis, only 33.4% (n = 143) remained as having a fair prognosis, 31.6% (n = 56) teeth with questionable prognosis remained as questionable, and 13.6% (n = 8) hopeless prognosis remained hopeless, signifying major changes in projected prognoses compared with actual moderate-to-long-term outcomes[18] in these patients who had discontinued proper periodontal treatment and refused SPT (Table 4). The trend in changes of prognoses suggest that teeth with little periodontal disease involvement, thus assigned good prognoses, tend to remain unaffected by disease over time, while assignment of an accurate prognosis to teeth with an initial prognosis of less than good is less reliable.[18-20] However, loss of teeth with good prognoses (4.6%) was slightly higher than in patients who had received comprehensive periodontal treatment but who were not maintained (3.0%).[8] Only 13.6% (n = 8) of teeth deemed hopeless from pre-discontinuation records remained hopeless but had not been lost,

while 23.7% (n = 14) pre-discontinuation hopeless teeth showed improvements with 3.4% (n = 2) reaching a good prognosis. Reports on the retention of hopeless teeth and the effect on adjacent supporting tissues have varied,[32-35] but significant improvements in periodontal conditions of hopeless teeth from the initial prognosis have been reported.[18, 35]

Several studies have provided criteria for prognostication of periodontally involved teeth.[8, 17, 18] However, maintainability of furcation entrances,[18, 19] clinical attachment loss,[18, 19] presence and control of local and/or systemic factors,[17] in this study were not properly calibrated or always available.[11] Radiographic data from panoramic radiographs were readily available, and estimation of bone loss with the Schei[26] ruler technique was shown to be reliable,[27] hence, a modification of prognostic parameters put forward by Becker *et al.*[8] to classify teeth according to information on percentage of radiographic bone loss, probing pocket depth and furcation involvement was adopted. Though a fair comparison of the method of prognostication used in the current study with other reports on periodontal prognosis cannot be carried out, general similarities in the pattern of change in prognoses of teeth, especially those that had been classified as having an initial good prognosis[8, 18] suggest that the method of classification employed is informative within the limits of this study.

Tooth loss was used as an indicator of the end stage of periodontal disease.[8, 11, 36] Similar to a previous report on tooth loss in patients who received comprehensive periodontal therapy but were not offered SPT, the primary reason for tooth loss in this study was periodontal (83.4%), with tooth loss patterns being bilaterally symmetrical, more pronounced in the upper arch. and most frequently affecting upper and lower first and second molars, and lower incisors (Fig 1).[11] Canines were most resistant to tooth loss.[11, 37] Tooth loss in this group of patients (0.38/patient/year) was slightly higher but comparable to untreated periodontal patients at 0.36/patient/year.[38] Nevertheless, when mean tooth loss per patient (3.5 ± 3.7 teeth/patient) was considered, this figure was lower than in untreated elderly Chinese over a six-year period (5.3 teeth/patient).[39] Tooth mortality due to all reasons for these patients was shown to be positively associated with number of years elapsed since discontinuation of periodontal therapy, and the percentage of sites with PPD ≥ 6mm at both pre-discontinuation and re-examination. Compliance towards periodontal treatment and SPT is crucial in maintaining periodontal health and reducing tooth loss.[4, 11, 36] The studied periodontitis patients who had voluntarily not completed their suggested course of treatment, also reported erratic dental visits over the 5–18 years period. Thus it is unsurprising that the longer they were devoid of periodontal treatment, the higher the chance they would experience disease

progression and encounter tooth loss.[8, 11, 39]

Percentage of sites with PPD ≥ 6mm has been shown to be predictive of further periodontal disease progression.[14, 15] These patients showed a statistically significant reduction in number of sites with PPD ≥ 6mm between pre-treatment and pre-discontinuation. However, this reduction was not maintained, and a slight increase in percentage of sites with PPD ≥ 6mm at re-examination compared to pre-discontinuation was observed. However, this increase was not statistically significant. Residual PPD ≥ 6mm reflects an incomplete therapeutic outcome and sites with PPD ≥ 6mm have been shown to deteriorate over time increasing chances of tooth loss.[15] The percentage of sites with residual PPD ≥ 6mm at pre-discontinuation was associated with increased chances of tooth loss in these patients, suggesting that incomplete treatment without proper SPT may lead to periodontal disease progression and eventually tooth loss. Increases in percentage of sites with PPD ≥ 6mm at re-examination was also associated with tooth loss over the long term, suggesting that deterioration in periodontal health, as seen in the increased number of sites with PPD ≥ 6mm at recall, was the reason for most of the tooth loss.

Percentage of sites with PPD ≥ 6mm at re-examination is an expression of current periodontal condition.[11] Percentage of sites with PPD ≥ 6mm at

re-examination was associated with periodontal tooth loss. The use of periodontal tooth loss as an independent variable in the second multivariate analysis was deemed appropriate as it better reflects the end-point of periodontal disease progression. Absence of BOP at pre-discontinuation was negatively correlated with percentage of sites with PPD ≥ 6mm at re-examination conforming to previous studies.[11, 40, 41] It appears that significant reductions in BOP after periodontal therapy provided some protection against disease progression for these patients who had discontinued their treatment. Absence of BOP has been shown to be a good predictor for periodontal health and stability.[40, 41] Following periodontal treatment, reduction in clinically detectable signs of inflammation in the form of absent BOP may signify a lower risk for disease recurrence or progression in such sites,[11, 42] and the results indicated as such.

LIMITATIONS

Data retrieved from retrospective studies often have limitations. However, it seems that no other comparable long-term studies on inadequately treated periodontitis patients without SPT have been reported. For ethical reason, clinical trials of incomplete therapy would not be tenable, thus, retrospective follow up studies, despite their limitations, and correlation analysis of factors that may be associated with

adverse outcomes can still be informative.[11, 43] The biggest constraint in this study would be in terms of recruitment of patients who had previously discontinued treatment. The number of patients who had opted to discontinue treatment before completion was rather limited. Dental treatment for the Hong Kong public is mainly provided by private practitioners.[44] As such most patients who are accepted for treatment in the hospital-based dental clinic would usually prefer continuing treatment there.[11] Furthermore many of the subjects initially identified (n = 210) who had chosen not to continue treatment in the dental hospital could not be contacted or refused to partake in the study, leaving only 65 subjects with records up to the required quality available for re-examination. All these attended for re-examination. Subjects who attended re-examination may have been rather motivated patients with good treatment outcome. However, comparable results in terms of tooth loss rate and changes in tooth prognoses with previous reports,[8, 18, 38] lends support to the generalizability of the results observed.

The validity of the clinical records had previously been discussed,[11] and the reliability of the information gained from subject-based questionnaires needs further clarification, but the validity of the use of questionnaires has been studied, and varying results have been shown within an acceptable range (66-95%) in different studies.[45, 46] Moreover, all subjects re-examined had previously been persistently

reminded about their periodontal condition. As such it would be fair to expect that this group of former-patients would have a recollection no worse than most people regarding changes in their oral health.[11]

Use of dental panoramic radiographs for alveolar bone level assessments may be limited due to distortions, overlaps and lack of standardization.[47, 48] However, in view of better patient tolerance and time efficiency,[31] such radiographs are most often employed for periodontal assessment within the PPDH, providing a convenient record for radiographic comparisons to be carried out. Dental panoramic radiographs are adequately informative for periodontal evaluations[31] and have been shown to be comparable to conventional intra-oral radiographs in assessing alveolar bone levels.[47] Within the limits of this study, use of the Schei ruler technique[26] on panoramic radiographs for assessment of alveolar bone levels at pre-discontinuation and re-examination was considered reliable.

CONCLUSIONS

Within the limits of this study, tooth loss in periodontitis patients who have failed to complete recommended periodontal therapy appears to be similar to those untreated.[38] The presence of residual PPDs ≥ 6mm after treatment indicates a likelihood of periodontal health deterioration[11, 14, 15] and exposes patients to a risk of further tooth

loss. The longer patients remain untreated for periodontal disease, the higher the chances of deteriorations in periodontal conditions leading to eventual tooth loss. However, decrease in percentage of sites with BOP after periodontal therapy appeared to have conferred some protection against further periodontal breakdown, even in the absence of periodic SPT. Patients who choose not to adhere to recommendations for comprehensive periodontal therapy must be reminded that inadequacies in their treatment are a risk for further periodontal deterioration, and increased possibilities of tooth loss over time are to be expected.

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LEGEND

Fig. 1 Tooth loss (n = 229) according to tooth type.

Table 1. Tooth-based radiographic bone level categories

	Radiographic bone level categories
Category I	less than 50 % bone loss on all discernable root surfaces; no radiographic evidence of furcation involvement for multi-rooted teeth
Category II	between 50 % - 75 % bone loss (on mesial and/or distal aspects), with radiographic evidence of furcation involvement for multi-rooted teeth
Category III	more than 75 % but not total bone loss (on mesial and/or distal aspects), with radiographic evidence of furcation involvement for multi-rooted teeth
Category IV	total bone loss (bone loss beyond the apex/apices) on the mesial and/or distal aspects, including furcation areas of multi-rooted teeth
Category V	tooth missing (extracted/exfoliated prior re-examination)

Modified from Becker *et al.*[8]

Table 2. Tooth-based periodontal prognosis categories

	Categories used in assigning prognosis[§]
Good	Category I upon radiographic examination; clinically PPD ≤ 4 mm, no furcation involvement on multi-rooted teeth
Fair	Category I upon radiographic examination; clinically PPD ≥ 5 mm and/or Class I furcation involvement only on multi-rooted teeth; or Category II upon radiographic examination; clinically PPD ≤ 5 mm and/or Class I furcation involvement only on multi-rooted teeth
Questionable	Category II upon radiographic examination; clinically PPD 6 - 8 mm and/or Class I or II furcation involvement on multi-rooted teeth; or Category III upon radiographic examination; clinically PPD ≤ 5 mm and/or Class I or II furcation involvement on multi-rooted teeth
Hopeless	Category II upon radiographic examination, PPD > 8 mm; or Category III upon radiographic examination, with PPD ≥ 6 mm; or Category IV upon radiographic examination (All with furcation involvement class II or above on any root surfaces of multi-rooted teeth)
Undetermined	Undetermined

[§]Please refer to Table 1 for radiographic bone level categories; furcation recorded according to Glickman's classification;[30] modified from Becker *et al.*[8]

Table 3. Mean ± standard deviation and range, full-mouth clinical parameters of participants (n = 65)

	Before initial periodontal therapy[I] [1]	Before discontinuation of periodontal therapy[I] [2]	Re-examination [3]	Multiple comparison[¶]	*p*-value
Plaque%	ND	ND	85.3 ± 17.0 (36.8 - 100)		
Bleeding on probing%	72.7 ± 24.9 (18.1 - 100.0)	23.0 ± 19.4 (2.3 - 79.2)	49.4 ± 21.8 (8.3 - 100.0)	[1] > [3] > [2]	< 0.001
% sites with probing pocket depth ≥ 6 mm	12.9 ± 12.0 (0.6 - 51.2)	2.2 ± 1.9 (0.5 - 12.2)	5.0 ± 8.9 (0 - 64.6)	[1] > [2], [3]	< 0.001
Number of teeth	26.2 ± 3.9 (13 - 32)	24 6 ± 4.8 (12 - 32)	21.1 ± 5.9 (8 - 32)	[1] > [2] > [3]	< 0.001

ND: not determined
[I]Measurement as recorded in participants' clinical records
[¶]One-way repeated measure ANOVA with Bonferonni multiple comparison

Table 4. Changes in individual tooth prognosis

	Re-examination						
Pre-discontinuation	Good	Fair	Questionable	Hopeless	Undetermined	Extracted	Total
Good prognosis	637	168	39	18	0	42	904
Fair prognosis	100	143	84	30	0	71	428
Questionable	10	24	56	13	0	74	177
Hopeless	2	5	7	8	0	37	59
Undetermined	0	0	0	0	24	5	29
Total	749	340	186	69	24	229	**1597**

Stuart-Maxwell Test ($\chi^2 = 98.28$, df = 4, $p < 0.001$)

Prognosis of teeth to the left of grey-shaded boxes had deteriorated over the study period; prognosis of teeth to the right of the grey-shaded boxes had improved compared to "pre-discontinuation"; grey-shaded boxes – tooth status "pre-discontinuation" and at "re-examination" having the same prognosis.

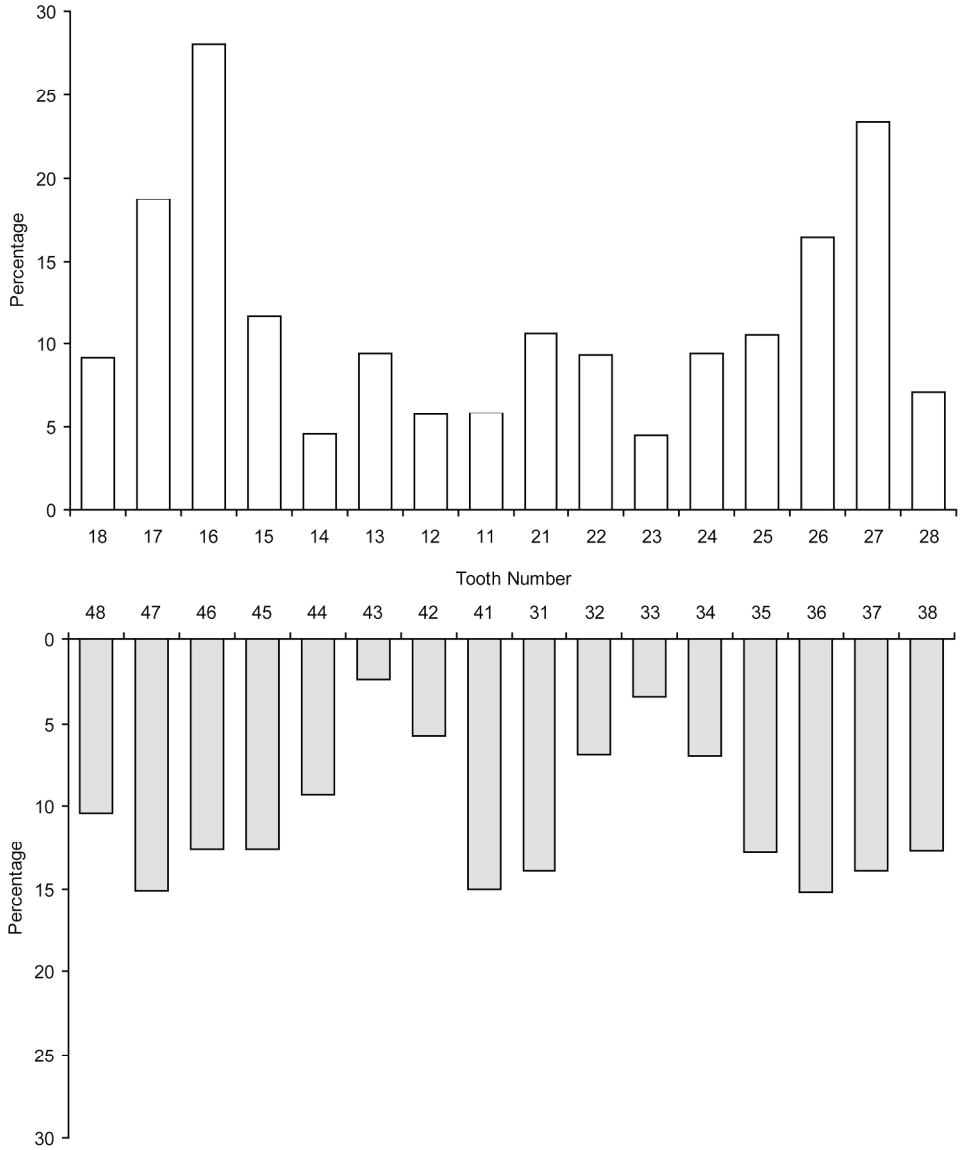

Fig. 1 Tooth loss (n = 229) according to tooth type.

238x280mm (300 x 300 DPI)