©Operative Dentistry, 2019, **44-3,** 254-261

Impact of Modifiable Risk Factors on Bone Loss During Periodontal Maintenance

X Cui • E Monacelli • AC Killeen • K Samson • RA Reinhardt

Clinical Relevance

Neglecting the restoration of open contacts or missing teeth, even in patients with mild periodontitis, could increase the risk of interproximal bone loss during periodontal maintenance therapy.

SUMMARY

Objectives: The aim of this study was to analyze modifiable patient risk factors from dental chart histories and radiographs for progressive mild-moderate periodontitis during periodontal maintenance (PM).

Methods and Materials: Bitewing radiographs of 442 elderly periodontal maintenance patients were taken before and after two years of periodontal maintenance. Each progressive periodontitis (PP) patient (with at least one site of posterior interproximal bone loss of $\geq$2 mm, n=71) was matched to a periodontitis stable (PS) patient (no sites with bone loss, n=71) of the same gender and age ($\pm$five years) to control for these variables and was compared for measurements of general patient (medical history, smoking, hygiene and compliance habits) and tooth-related (bone loss, overhangs, interproximal dimensions) factors at baseline. Fisher exact and *t*-tests were used to compare groups.

Results: While the elderly PM patients with mild-moderate periodontitis were generally stable, 71 of 442 were PP patients. No significant differences from PS patients were observed at baseline with regard to the systemic factors measured. However, the PP group had less cementoenamel junction to bone length (bone loss $p<0.0001$) and more interproximal width (2.3$\pm$1.0 mm) than did the PS group (1.7$\pm$0.6 mm, $p=0.0016$). This was reflected in more open sites without adjacent tooth contact in PP (42% vs 15%, $p=0.0006$).

Conclusions: In the short term, systemic and behavior factors are of limited value in identifying mild-moderate periodontitis patients on PM at increased risk of bone loss. However, interproximal width and lack of adjacent tooth contacts are related to the likelihood of losing interproximal bone during periodontal main-

Xiaoxi Cui, SMM, College of Dentistry, University of Nebraska Medical Center, Lincoln, NE, USA

Elizabeth Monacelli, BS, College of Dentistry, University of Nebraska Medical Center, Lincoln, NE, USA

Amy C Killeen, DDS, MS, College of Dentistry, University of Nebraska Medical Center, Lincoln, NE, USA

Kaeli Samson, MA, MPH, College of Public Health, University of Nebraska Medical Center, Omaha, NE, USA

*Richard A Reinhardt, DDS, PhD, College of Dentistry, University of Nebraska Medical Center, Lincoln, NE, USA

*Corresponding author: 4000 East Campus Loop South, Box 830740, Lincoln, NE 68583-0740, USA; e-mail: rareinha@unmc.edu

DOI: 10.2341/18-041-C

tenance, suggesting the need for restorative therapy.

INTRODUCTION

Periodontitis is the result of complex interrelationships between infectious agents in dental plaque and multiple host factors. Periodontal maintenance (PM) is an important part of periodontal treatment that includes procedures performed at different intervals to aid the periodontal patient in maintaining oral health.[1-5] It has been shown[6,7] that periodontal treatment followed by long-term maintenance is successful in the preservation of the majority of patients' teeth. Most patients with milder forms of periodontitis are managed in general practices on four to six-month intervals, with the expectation that all sites will remain periodontally stable (no bone loss).[8] However, following the current population in a dental school setting for two years on PM revealed that 16% of patients had at least one site with $\geq$2 mm of interproximal bone loss.

The predictability of PM may be associated with diverse conditions, especially when a patient is exposed to one or more risk factors known to influence host response.[7,9] There is evidence that age, gender, smoking, compliance with recalls, and systemic diseases such as diabetes mellitus and osteoporosis may affect the results achieved through periodontal therapy.[2,4,9-13] Meanwhile, studies[10,11,14,15] have also shown that different tooth-related factors are associated with the long-term stability of periodontal maintenance. Clinical parameters such as pocket depth, bleeding on probing, attachment loss, and tooth mobility are recorded during periodontal maintenance to measure the periodontal condition of patients.[2,16] However, other tooth-related factors that might affect the long-term outcome of periodontal maintenance are not commonly recorded or corrected.[17-19]

Bitewing radiographs (BWs) are routinely obtained during PM, and radiographic bone loss is an objective measurement and an important indicator of progressive periodontitis. Maintaining stable bone levels is one of the major goals of periodontal maintenance.[20,21] Other measurements that can be easily obtained from BWs also may be important prognostic indicators. However, to our knowledge, the relationship between different radiographic tooth-related factors and alveolar bone loss in PM patients has not been thoroughly studied. It is still controversial which tooth-related factors are predictive for bone loss during PM; specifically, whether the specific measurements of the anatomy of interproximal areas, such as interproximal width, restoration overhangs, baseline bone loss, and lack of contact, are associated with the increased likelihood of subsequent crestal bone loss during PM.

The aim of this research was to compare prominent modifiable systemic patient and tooth-related factors identifiable on chart histories and radiographs in groups of mild/moderate periodontitis patients who had either shown posterior interproximal periodontitis stability or progressive periodontal bone loss during PM. The results may help dentists develop more reliable prognoses and treatment options for PM patients.

METHODS AND MATERIALS

Four hundred forty-two patients over age 45 (to eliminate aggressive periodontitis) participating in the University of Nebraska Medical Center College of Dentistry periodontal maintenance program with at least two years of regular PM therapy were chosen as subjects under an institutional review board protocol (IRB 015-14). All patients received a standard protocol of BWs, periodontal probing, oral hygiene instructions, and scaling/root planing during PM. Since all providers were not calibrated for probing measurements, bone loss on radiographs was used to determine progressive periodontitis. Guidelines conformed to the Code of Ethics of the World Medical Association (Declaration of Helsinki). Patients were deidentified, and posterior digital BWs before (baseline) and after the two-year PM period (two-year follow-up) were measured at all posterior interproximal sites (premolar and molar) from the cementoenamel junction (CEJ) or restoration margin to the crestal bone where the periodontal ligament space became uniform. A ruler tool (MiPACS Dental Enterprice Solution, Medicor Imaging, Microtek, Hsinchu, Taiwan) was used to make the linear measurements separately by two examiners masked to patient identity. The progressive periodontitis (PP) patients were defined as having at least one site of posterior interproximal bone loss measuring $\geq$2 mm between baseline and two-year follow-up on BWs. The 2-mm threshold was chosen to reflect a clinically relevant change that could be detected on non-standardized radiographs taken in clinical practice.[22] The periodontitis stable (PS) group was defined as having all sites with posterior interproximal bone change measuring $<$2 mm between baseline and two-year follow-up on BWs, and PS patients were paired to a PP by age ($\pm$five years) and gender to control for these variables. Ten percent of patients were remeasured at baseline and

Table 1: *Demographic Characteristics of the Subjects*

Characteristic	Progressive Periodontitis		Stable Periodontitis		*p*-Value
	N (SD)	% or Range	N (SD)	% or Range	
Gender					
Female	28	39.4	29	40.9	
Male	43	60.6	42	59.2	1.00
Mean age, y	72.11 (10.59)	46-95	71.76 (10.84)	47-95	0.77

Abbreviation: SD, standard deviation.

two-year follow-up by the same examiners in order to determine the reliability of measurements in this study.

Medical and dental history questionnaires at baseline were used to obtain general systemic and behavioral risk factors previously associated with periodontitis, as follows:

1. Systemic conditions from medical history: diabetes mellitus, osteoporosis, rheumatoid arthritis;
2. Smoking: Current smoker, former smoker, or never smoker;
3. Awareness of periodontal and oral disease: loose teeth, food or floss caught between teeth, diagnosed with gum disease, treated for gum disease, gums bleed when brushed, and dry mouth;
4. Oral hygiene habits: brushing frequency per week and flossing frequency per week; and
5. Compliance with periodontal recalls: numbers of maintenance appointments within two years and average visits per year for two years.

Tooth-related factors were measured at baseline in posterior sites with bone loss of $\geq$2 mm in the PP group and were matched to a similar interproximal location (eg, molar-molar, molar-premolar) in the paired PS patient. The tooth-related factors measured were as follows:

1. CEJ to alveolar crest length;
2. Presence or absence of adjacent tooth contact;
3. Overhanging restorations of >1 mm;
4. Interproximal contact to alveolar crest length;
5. Width of interproximal (ITP) embrasure: measured from CEJ to adjacent CEJ; and
6. CEJ to CEJ angle relative to long axis of the tooth (horizontal CEJ-CEJ=90° angle).

Baseline severity of periodontitis of study sites and of overall posterior sites were calculated according to bone loss of the site, where normal = 0 to 2 mm CEJ to alveolar crest on BW, mild = 2 to 4 mm, moderate = 4 to 6 mm, and severe = more than 6 mm.

Comparisons of categorical factors between PP and PS groups were conducted with Fisher exact tests. Comparisons of continuous factors between PP and PS groups were conducted with *t*-tests. *p*-Values of less than 0.05 were considered to be statistically significant. SAS software version 9.4 was used for analysis (SAS Institute Inc, Cary, NC, USA). Single-measures intraclass correlations (ICCs) for absolute agreement were calculated using a two-way mixed-effects model for each of the examiners, at each of the time points, using SPSS software, version 23 (IBM Corp, Armonk, NY, USA). ICCs ranged from 0.663 to 0.881. According to Cicchetti,[23] the clinical significance values of ICCs between 0.60 and 0.74 and between 0.75 and 1.00 are "good" and "excellent," respectively.

RESULTS

Each group had 71 subjects after identification of PP patients and matching to a PS patient and interproximal location. Demographic characteristics of the subjects are presented in Table 1. No significant differences were observed since patient and control groups were matched by gender and age. The mean age in the lower 70s with mild-moderate periodontitis indicates a patient population with a slow rate of bone loss in whom an episode of clinically significant bone loss might define high-impact risk factors.

Common systemic or behavioral risk factors for PP and PS groups at baseline are presented in Table 2. In general, no significant differences were observed with regard to systemic conditions, smoking, awareness of periodontal and oral disease, oral hygiene habits, and compliance with periodontal recalls. There was a trend toward more PP in diabetic patients (p=0.13).

The tooth-related factors of PP and PS groups at baseline are presented in Table 3, Figure 1. While local plaque control and instrumentation are the cornerstones of effective PM, several other local factors were significantly different between the two groups. At baseline, mean CEJ to alveolar crest length of the PP site was 1.9 $\pm$ 1.3 mm, while CEJ to alveolar crest length of the PS site was 3.0 $\pm$ 1.6 mm (p<0.0001). This indicated normal bone height (56% of cases) in PP and early bone loss in PS (54%, p=0.001). Therefore, past periodontitis was not a risk factor in future bone loss in these mild-moderate periodontitis patients on PM. As for baseline severity

Table 2: *Common Systemic or Behavioral Risk Factors at Baseline*

Systemic or Behavioral Risk Factors	Progressive Periodontitis		Stable Periodontitis		*p*-Value
	N	%	N	%	
Systemic conditions					
Diabetes mellitus	17	24	9	13	0.13
Osteoporosis	3	4	6	9	0.33
Rheumatoid arthritis	1	1	2	3	0.62
Smoking					
Current smoker	13	19	8	11	0.34
Awareness of periodontal and oral disease					
Loose teeth	8	11	9	13	1.00
Food or floss caught between teeth	44	63	38	55	0.39
Diagnosed with gum disease	42	60	37	53	0.50
Treated for gum disease	43	61	36	51	0.31
Gums bleed when brush	10	14	11	16	0.82
Dry mouth	17	24	14	20	0.68
Oral hygiene habits					
Have trouble cleaning/flossing	4	6	6	9	0.53
	Mean (SD)		Mean (SD)		
Brushing frequency per week	11.8 (4.4)		10.6 (4.3)		0.12
Flossing frequency per week	5.7 (5.2)		5.5 (4.9)		0.70
Compliance with periodontal recalls					
No. of maintenance within 2 y	4.5 (2.2)		4.6 (2.3)		0.95
Average visit per year for 2 y	2.3 (1.1)		2.3 (1.2)		0.84

Abbreviation: SD, standard deviation.

of periodontitis of overall posterior sites, the results did not show a statistically significant difference between the two groups. The baseline embrasure width from CEJ to adjacent CEJ of the PP group was wider (2.3±1.0 mm) than for the PS group (1.7±0.6 mm, $p=0.0016$). This was reflected in more sites without adjacent tooth contacts in PP (42% vs 15%, $p=0.0006$), but not in tipped teeth (CEJ-CEJ angle in PP sites=91.5°±34.5° compared to PS sites=97.9°±32.1°, $p=0.31$; Table 3). To further focus on tooth-related factors, major systemic risk factors were removed from the analysis, with results described in Table 4. Significant findings for baseline CEJ to bone, CEJ to CEJ width, and lack of contact remained after eliminating patients with diabetes, osteoporosis, rheumatoid arthritis, or current smoking habit.

The interproximal anatomy in progressive periodontitis sites was additionally characterized in Table 5, Figure 2. Amount of open contact was evenly distributed between those with <2 mm (food impaction) and those with >4 mm (self-cleansing). The most common restoration was cast crown, similar in incidence to no restoration. The incidences of opposing plunger cusps and overhanging restorations were rare. There were slightly more PP sites in the maxilla.

DISCUSSION

At baseline, the majority of patients in each group had mild chronic periodontitis, according to the diagnostic standard used in this study. All of the subjects had finished initial periodontal therapy and had gone into PM. While these patients with mild-moderate periodontitis on PM were generally stable, 16% of the patients followed in this study showed at least one site with ≥2 mm of interproximal bone loss. Periodontal maintenance has been proven[24] effective in minimizing long-term tooth loss and controlling disease progression and relapse in patients with chronic periodontitis. However, even within compliant periodontal maintenance patients, disease progression still cannot be completely stopped.[25] While results indicated that regular PM allowed for stable and relatively normal interproximal bone levels, even mild-moderate periodontitis patients on PM should be followed closely for evidence of bone loss, and risk factors associated with this event should be considered.

Table 3: *Tooth-related Factors at Baseline*

Tooth-related Factors	Progressive Periodontitis Mean (SD)	Stable Periodontitis Mean (SD)	*p*-Value
Study sites			
CEJ to alveolar crest length. mm	1.9 (1.3)	3.0 (1.6)	<0.0001*
Overhanging restorations >1 mm	3%	8%	0.37
Distance of restoration margin to bone crest, mm	1.8 (2.1)	2.3 (2.3)	0.33
Interproximal contact to alveolar crest length, mm	5.3 (1.7)	5.1 (1.6)	0.50
Interproximal contact to alveolar crest length on adjacent tooth, mm	5.1 (1.6)	5.1 (1.5)	0.65
Width of ITP embrasure, mm	2.3 (1.0)	1.7 (0.6)	0.0016*
Severity of periodontitis bone loss			0.0011*
Normal (0-2 mm)	56%	25%	
Mild (2-4 mm)	35%	54%	
Moderate (4-6 mm)	7%	14%	
Severe (>6 mm)	1%	7%	
Lack of proximal contact	42%	15%	0.0006*
CEJ-CEJ angle, (degrees)	91.5 (34.5)	97.9 (32.1)	0.31
All posterior sites			
CEJ to alveolar crest length, mm	2.7 (0.8)	2.9 (0.7)	0.12
Severity of periodontitis bone loss			0.3743
Mild	87%	94%	
Moderate	13%	6%	
Severe	0%	0%	

Abbreviations: CEJ, cementoenamel junction; ITP, interproximal; SD, standard deviation.
** Statistically significant.*

Common systemic and behavioral risk factors among PM patients that have been reported[26-31] to be associated with progression of periodontal diseases appeared to show less impact on PP and PS groups than did local factors in the two-year follow-up period. However, there was a trend toward more PP in diabetic patients (p=0.13). Previous studies[28,32] have supported that poorly controlled diabetes acts as a risk factor in development of periodontitis and that long-term periodontal care provided in a clinical setting improves long-term glycemic control among individuals with type 2 diabetes. Working with the patient's physician may also modify glycemic control to reduce this risk factor. Unfortunately, most health questionnaires usually contain no information of hemoglobin A1C levels. This study reinforces that large populations with hemoglobin A1C information are needed to fully assess the impact of diabetes on mild-moderate periodontitis patients on PM.

It was interesting to notice that in our study more than 40% of patients at baseline did not realize that they had gum disease. This may reflect insufficient previous patient education. With a better understanding about their periodontal diseases, they may have better home care and compliance.

Currently, there are several risk factor assessment tools for the prevention of periodontitis progression based on long-term analysis. The majority of the tools are variations of a few basic approaches, in particular of the Periodontal Risk Calculator, PRC,[33] and of the Periodontal Risk Assessment, PRA,[34] using bone loss as one major parameter. The previous studies mainly focused on moderate to severe periodontitis patients. Our findings indicated

Table 4: *Tooth-related Risk Factors Without Systemic Risk Factors*

Factors	Without Diabetes PP/PS	Without Smokers	Without Diabetes, Osteoporosis, RA,and Smokers
CEJ to bone, mm	1.9/2.9 (p=0.0002)	1.8/3.0 (p<0.0001)	1.8/3.0 (p=0.0001)
CEJ to CEJ, mm	2.3/1.7 (p=0.0015)	2.3/1.7 (p=0.0014)	2.3/1.6 (p=0.005)
Lack of proximal contact, %	47/15 (p=0.0001)	45/15 (p=0.0005)	45/16 (p=0.003)

Abbreviations: CEJ, cementoenamel junction; PP, progressive periodontitis; PS, periodontitis stable; RA, rheumatoid arthritis.

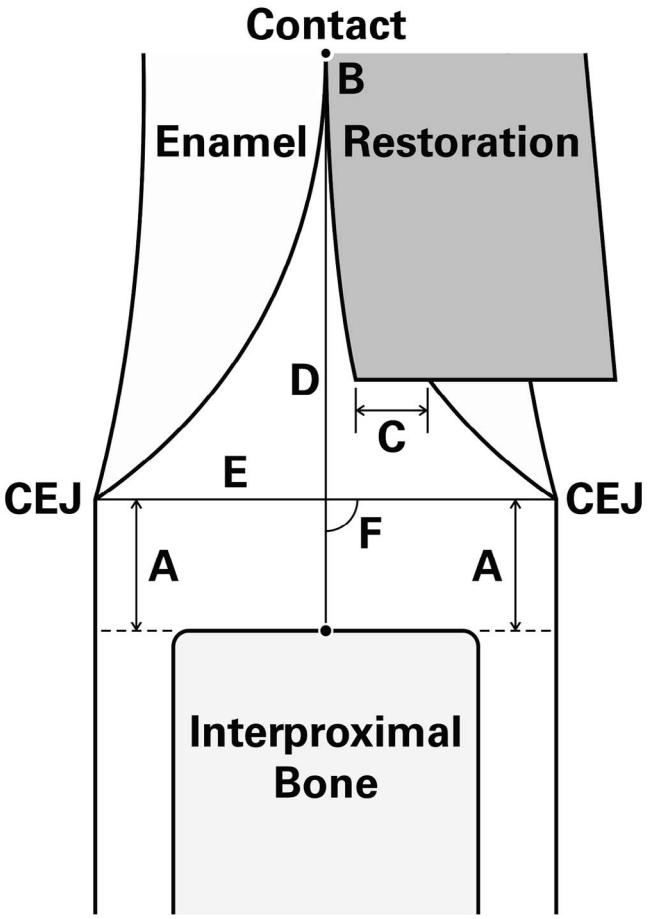

Figure 1. *Measurements for tooth-related factors. (A) CEJ to alveolar crest length; (B) Presence or absence of adjacent tooth contact; (C) Horizontal overhanging restorations of >0.25 mm; (D) Interproximal contact to alveolar crest length; (E) Width of CEJ to CEJ; and (F) CEJ to CEJ angle relative to long axis of the tooth.*

that for mild chronic periodontitis patients, bone loss and initial periodontitis severity may not be able to predict future bone loss and short-term progression of disease. Previous tools also used systemic risk factors and local soft-tissue measurements, but interproximal anatomy, as in Tables 3 through 5, was not analyzed.

Width of interproximal embrasure was wider in PP at baseline than in PS. Wider ITP may be caused by tipped teeth or open spaces between the studied tooth and adjacent tooth. Our results indicated that lack of interproximal contacts (open contact or missing tooth) played a larger role than did tipped teeth. This was true when patients with other major systemic risk factors (diabetes, osteoporosis, rheumatoid arthritis, and smoking) were removed from the analyses (Table 4). Further characterization of the interproximal anatomy of progressive periodontitis sites (Table 5) indicated that open contact that

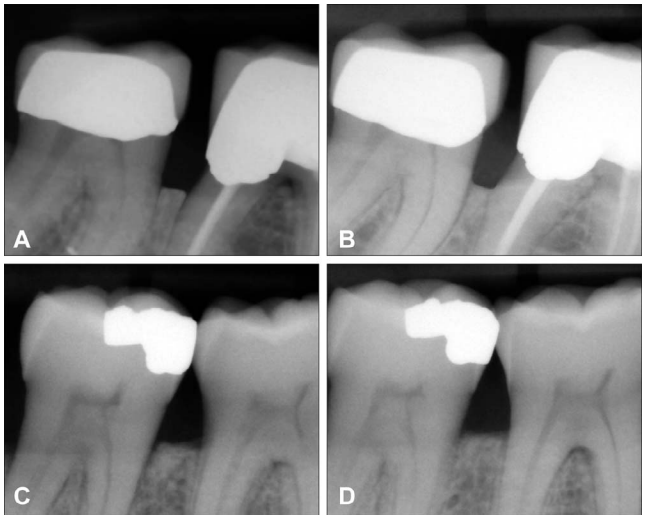

Figure 2. *Interproximal radiographic anatomy. Top panel shows molar-molar open interproximal contact and bone loss on #30 distal between baseline (A) and two years of periodontal maintenance (B). Bottom panel shows molar-molar contact and minimal molar interproximal bone change between baseline (C) and two years of periodontal maintenance (D).*

could promote food impactions (<2 mm) and those which were likely self-cleansing (>4 mm) were evenly distributed, suggesting that even wide-open interproximal areas would benefit from tooth replacement to help prevent interproximal periodontal bone loss.

Two-thirds of teeth in PP sites had restorations, most commonly cast crowns. However, horizontal overhangs were rare, especially large ones, which

Table 5: *Characterizing Interproximal Factors in Progressive Periodontitis (PP)*

Factor	Measurement	Percentage
Contact dimension	Closed	58
	Open <2 mm	20
	Open >4 mm	22
Type of restoration	None	33
	Amalgam	18
	Resin	3
	Cast crown	32
	PFM (porcelain-fused to metal)	12
	Chrome crown	2
Opposing plunger cusp	No	95
	Yes	5
Arch	Maxilla	59
	Mandible	41
Amount horizontal overhang	None	89
	0.25-1.0 mm	8
	>1 mm	3

have been shown[35] to contribute to periodontal bone loss. Likewise, the low incidence of plunger cusps did not seem to contribute to interproximal bone loss.

The relatively short period of follow up and the small sample size were limitations of our study, particularly in terms of analysis of systemic risk factors. However, interproximal periodontal anatomy easily measured on BWs showed highly significant difference in PP sites and suggests some restorative treatments to change the risk profile.

CONCLUSIONS

While PM patients with mild-moderate periodontitis are generally stable, they still should be followed closely for evidence of bone loss. Lack of interproximal contacts is related to the likelihood of losing interproximal bone during periodontal maintenance, suggesting the need for restorative therapy.

Acknowledgements

We thank John Delaet, Nolan Jeffres, and Mattie Bertels from the University of Nebraska Medical Center (UNMC) College of Dentistry for collecting some of the data for this project. The authors have no competing interests relative to this project. This work was supported by the UNMC College of Dentistry Student Summer Research Fellowship (FY17-06, FY17-07).

Regulatory Statement

This study was conducted in accordance with all the provisions of the local human subjects oversight committee guidelines and policies of the University of Nebraska Medical Center IRB. The approval code for this study is IRB 015-14.

Conflict of Interest

The authors of this manuscript certify that they have no proprietary, financial, or other personal interest of any nature or kind in any product, service, and/or company that is presented in this article.

(Accepted 25 June 2018)

REFERENCES

1. Moser P, Hammerle CH, Lang NP, Schlegel-Bregenzer B, & Persson R (2002) Maintenance of periodontal attachment levels in prosthetically treated patients with gingivitis or moderate chronic periodontitis 5-17 years post therapy *Journal of Clinical Periodontology* **29(6)** 531-539.
2. Page RC, Martin J, Krall EA, Mancl L, & Garcia R (2003) Longitudinal validation of a risk calculator for periodontal disease *Journal of Clinical Periodontology* **30(9)** 819-827.
3. Fardal O & Linden GJ (2005) Re-treatment profiles during long-term maintenance therapy in a periodontal practice in Norway *Journal of Clinical Periodontology* **32(7)** 744-749.
4. Seirafi AH, Ebrahimi R, Golkari A, Khosropanah H, & Soolari A (2014) Tooth loss assessment during periodontal maintenance in erratic versus complete compliance in a periodontal private practice in Shiraz, Iran: A 10-year retrospective study *Journal of the International Academy of Periodontology* **16(2)** 43-49.
5. Costa FO, Cota LO, Cortelli JR, Cyrino RM, Lages EJ, & Oliveira AP (2015) Surgical and non-surgical procedures associated with recurrence of periodontitis in periodontal maintenance therapy: 5-Year prospective study *PLoS One* **10(10)** e0140847.
6. Hirschfeld L, & Wasserman B (1978) A long-term survey of tooth loss in 600 treated periodontal patients *Journal of Periodontology* **49(5)** 225-237.
7. Fardal O Johannessen AC, & Linden GJ (2004) Tooth loss during maintenance following periodontal treatment in a periodontal practice in Norway *Journal of Clinical Periodontology* **31(7)** 550-555.
8. Leavy PG & Robertson DP (2017) Periodontal maintenance following active specialist treatment: Should patients stay put or return to primary dental care for continuing care? A comparison of outcomes based on the literature *International Journal of Dental Hygiene* **16(1)** 68-77.
9. Chambrone LA & Chambrone L (2006) Tooth loss in well-maintained patients with chronic periodontitis during long-term supportive therapy in Brazil *Journal of Clinical Periodontology* **33(10)** 759-764.
10. Dannewitz B, Zeidler A, Hüsing J, Saure D, Pfefferle T, Eickholz P, & Pretzl B (2016) Loss of molars in periodontally treated patients: Results 10 years and more after active periodontal therapy *Journal Clinical Periodontology* **43(1)** 53-62.
11. Chambrone L, Chambrone D, Lima LA, & Chambrone LA (2010) Predictors of tooth loss during long-term periodontal maintenance: A systematic review of observational studies *Journal of Clinical Periodontology* **37(7)** 675-684.
12. Checchi L, Montevecchi M, Gatto MR, & Trombelli L (2002) Retrospective study of tooth loss in 92 treated periodontal patients *Journal of Clinical Periodontology* **29(7)** 651-656.
13. Garcia MN, Hildebolt CF, Miley DD, Dixon DA, Couture RA, Spearie CL, Langenwalter EM, Shannon WD, Deych E, Mueller C, & Civitelli R (2011) One-year effects of vitamin D and calcium supplementation on chronic periodontitis *Journal of Periodontology* **82(1)** 25-32.
14. Fisher S, Kells L, Picard JP, Gelskey SC, Singer DL, Lix L, & Scott DA (2008) Progression of periodontal disease in a maintenance population of smokers and non-smokers: A 3-year longitudinal study *Journal of Periodontology* **79(3)** 461-468.
15. Reinhardt RA & Killeen AC (2015) Do mobility and occlusal trauma impact periodontal longevity? *Dental Clinics of North America* **59(4)** 873-883.
16. Nevins M (1999) Periodontal pocket—predictable treatment *Compendium of Continuing Education in Dentistry* **20(5)** 467-470.
17. Wang HL, Burgett FG, & Shyr Y (1993) The relationship between restoration and furcation involvement on molar teeth *Journal of Periodontology* **64(4)** 302-305.

18. Bhusari PA & Chopra R (2011) A morphological survey of root grooves and their influence on periodontal attachment loss *Saudi Dental Journal* **23(2)** 91-97.
19. Costa FO, Lages EJ, Cota LO, Lorentz TC, Soares RV, & Cortelli JR (2014) Tooth loss in individuals under periodontal maintenance therapy: 5-Year prospective study *Journal of Periodontal Research* **49(1)** 121-128.
20. Halperin-Sternfeld M, & Levin L (2013) Do we really know how to evaluate tooth prognosis? A systematic review and suggested approach *Quintessence International* **44(5)** 447-456.
21. Payne JB, Nummikoski PV, Thompson DM, Golub LM, & Stoner JA (2013) The association between clinical and radiographic periodontitis measurements during periodontal maintenance *Journal of Periodontology* **84(10)** 1382-1390.
22. Hausmann E, Allen K, & Clerehugh V (1991) What alveolar crest level on a bite-wing radiograph represents bone loss? *Journal of Periodontology* **62(9)** 570-572.
23. Cicchetti DV (1994) Guidelines, criteria, and rules of thumb for evaluating normed and standardized assessment instruments in psychology *Psychological Assessment* **6(4)** 284.
24. Renvert S & Persson GR (2004) Supportive periodontal therapy *Periodontology 2000* **36** 179-195.
25. Kocher T, Konig J, Dzierzon U, Sawaf H, & Plagmann HC (2000) Disease progression in periodontally treated and untreated patients—a retrospective study *Journal of Clinical Periodontology* **27(11)** 866-872.
26. Miyamoto T, Kumagai T, Lang MS, & Nunn ME (2010) Compliance as a prognostic indicator. II. Impact of patient's compliance to the individual tooth survival *Journal of Periodontology* **81(9)** 1280-1288.
27. Bahrami G, Vaeth M, Kirkevang LL, Wenzel A, & Isidor F (2016) The impact of smoking on marginal bone loss in a 10-year prospective longitudinal study *Community Dentistry and Oral Epidemiology* (Epub).
28. Costa KL, Taboza ZA, Argelino GB, Silveira VR, Montenegro R Jr, Haas AN, & Rego RO (2017) Influence of periodontal disease on changes of glycated hemoglobin levels in patients with type 2 diabetes mellitus: A retrospective cohort study *Journal of Periodontology* **88(1**) 17-25.
29. Esfahanian V, Shamami MS, & Shamami MS (2012) Relationship between osteoporosis and periodontal disease: Review of the literature *Journal of Dentistry (Tehran)* **9(4)** 256-264.
30. Tang Q, Fu H, Qin B, Hu Z, Liu Y, Liang Y, Zhou L, Yang Z, & Zhang R (2017) A possible link between rheumatoid arthritis and periodontitis: A systematic review and meta-analysis *International Journal of Periodontics Restorative Dentistry* **37(1)** 79-86.
31. Payne JB, Reinhardt RA, Nummikoski PV, Dunning DG, & Patil KD (2000) The association of cigarette smoking with alveolar bone loss in postmenopausal females *Journal of Clinical Periodontology* **27(9)** 658-664.
32. Merchant AT, Georgantopoulos P, Howe CJ, Virani SS, Morales DA, & Haddock KS (2002) Effect of long-term periodontal care on hemoglobin A1c in type 2 diabetes *Journal of Dental Research* **95(4)** 408-415.
33. Page RC, Krall EA, Martin J, Mancl L, & Garcia RI (2002) Validity and accuracy of a risk calculator in predicting periodontal disease *Journal of the American Dental Association* **133(5)** 569-576.
34. Lang NP & Tonetti MS (2003) Periodontal risk assessment (PRA) for patients in supportive periodontal therapy (SPT) *Oral Health & Preventive Dentistry* **1(1)** 7-16.
35. Jeffcoat MK & Howell TH (1980) Alveolar bone destruction due to overhanging amalgam in periodontal disease *Journal of Periodontology* **51(10)** 599-602.