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Original Article

Radiographic Alveolar Bone Loss in Patients Undergoing Periodontal Maintenance

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Abstract

The aim of the present cross-sectional investigation was to evaluate percentage of bone loss in patients who had been one year under periodontal maintenance at the Department of Periodontology, Faculty of Dentistry, University of São Paulo by radiographic analysis.

Complete sets of periapical radiographs provided data regarding percentage of alveolar bone loss, which was correlated with arches, tooth group and proximal sites. The sample consisted of 27 men and 53 women ranging in age from 16 to 85 years (mean: 48.3 years). A total of 1,120 periapical radiographs (1,970 teeth) were digitized and analyzed with the Image Tool® software (University of Texas Health Science Center). Bone loss was defined as when the distance between the cemento-enamel junction and the alveolar bone crest was greater than 2 mm. Two examiners ($p<0.0001$) performed radiographic measurements of bone loss.

The Greenhouse-Geisser normality test and a univariate analysis of variance were used for statistical analysis.

Mean bone loss was 20.60% ($\pm$12.12). The highest level of bone loss was observed on the distal surface and in the upper arch, as well as in the upper incisors and molars.

Key words: Periodontics—Alveolar bone loss—Radiography

Introduction

Despite its limitations, radiography is a powerful auxiliary tool for the diagnosis of periodontal diseases. Careful comparative analysis of clinical and radiographic parameters permits a more accurate diagnosis.

Radiographs are used to assess severity and pattern of bone loss, root length, anatomy and position, and detect pathologic lesions and the consequences of excessive occlusal load[5]. Signs such as enlargement of the periodontal ligament space, absence of the lamina dura, bone defects (vertical or horizontal) and a

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diffuse image in the furcation area, associated with clinical signs, are suggestive of the presence of periodontal disease[2]. All of these aspects are important in the establishment of a diagnosis and periodontal treatment plan, as well as in periodontal maintenance.

Bone loss in one tooth tends to be accompanied by loss in the adjacent tooth, especially when maintenance is not performed correctly[46]. Radiographs taken from proximal sites suggestive of mild bone loss have demonstrated progression of the defect one year later[4]. The recording of systematically collected and treated data permits future comparison and evaluation of the stability of treated cases or progression of the disease. The methods used in such studies permit evaluation of alveolar bone level in a given population, which may provide useful data for treatment planning.

The objective of the present study was to evaluate radiographic bone loss as a percentage of root length in patients under periodontal maintenance. The mean percentage of alveolar bone loss of the sample was calculated and differences in bone loss between the two dental arches, different groups of teeth (incisors, canines, premolars and molars) and proximal sites were determined. We decided to carry out this study as we did not have data concerning the characteristics of the population seeking for periodontal treatment at the University of São Paulo. Moreover, the results obtained would serve as a guide to dentists concerning the dental arch, teeth and sites most susceptible to bone loss.

Materials and Methods

The study was approved by the Ethics Committee of the Faculty of Dentistry, University of São Paulo (FOUSP) (Nos. 218/02 and 241/02).

Eighty complete sets of 14 periapical radiographs (total of 1,970 teeth) were obtained from 80 patients (27 men and 53 women, age: 16 to 85 years) who had been one year under periodontal maintenance.

The periodontal maintenance program[32] at the Department of Periodontology, Faculty of Dentistry, University of São Paulo consists of:

- Medical history update, Examination, Re-evaluation (bleeding on probing, clinical attachment level, probing depth) and Diagnosis
- Re-motivation for patient compliance and Oral hygiene instruction
- Plaque and calculus removal where indicated/needed
- Treatment (scaling and root planning) of disease recurrence in re-infected sites
- Polishing (restorations if needed), fluoride application, re-scheduling

The patients were divided into two groups based on the following criteria: a) General condition group: patients with periodontitis; patients who had completed periodontal treatment and who were under periodontal maintenance; patients complying with maintenance (visiting every 3 months with no absences), and b) Oral condition: patients with at least 16 teeth who had completed periodontal treatment including evaluation of systemic health, oral hygiene instruction and motivation, root scaling and planning, adjustment of occlusion, elimination of any factor that might retain plaque (caries, iatrogenic restorations, etc.)[47] and no significant clinical attachment loss (>1 mm) over the previous year.

Radiographs were obtained through the paralleling technique by the same operator and machine. An X-ray holder or cone positioner (Rinn XCP® holder) was used during X-ray exposure. This device enabled the film to be parallel to the long axis of the tooth and the X-ray tube head was aimed at right angles to both tooth and film, enhancing the paralleling technique.

Radiographs were excluded according to the following criteria (Fig. 1): a) visibility of anatomical landmarks, cemento-enamel junction (CEJ), alveolar bone crest (ABC), or tooth apex (AP) was not clear; b) visibility of the CEJ was compromised by presence of restorations, prostheses, overlapping images or

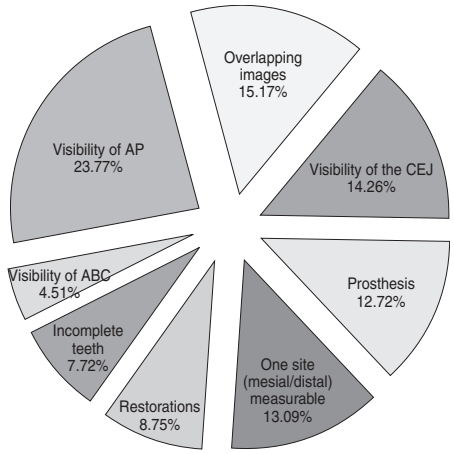

Fig. 1 Exclusion criteria for selection of radiographs

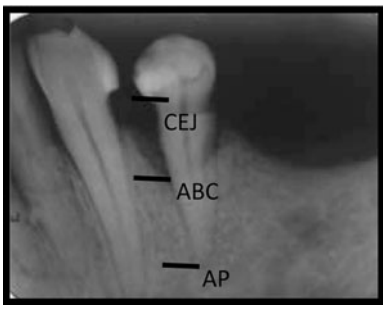

Fig. 2 Reference for alveolar bone loss assessment

incomplete X-ray image of teeth; c) only one proximal site (mesial and distal) was measurable, compromising "unit of analysis", that is, teeth.

At the end of the selection process, 45.38% (894 teeth, or 1,788 proximal sites) of the initial sample of 1,970 teeth was submitted to the analysis of alveolar bone level. From the total sample, 2,152 proximal sites (54.62%) which did not fulfill the inclusion criteria were discarded.

Radiographs were digitized with a 5,490 C Hewlett Packard scanner using an XPA device for the digitization of negatives so that no black mask adaptation was necessary. Scanning area was standardized for all films to ensure higher reliability of digitization[11]. Resolution used was 300 d.p.i. Scanned images were manipulated with the HP Precision Scan Pro software, version 3.12 (2001). Images were visualized on a computer screen and amplified (4×) with the Image Tool® software from University of Texas Health Science Center[14], and the pre-established landmarks were drawn. The distance between the CEJ and ABC, and between the ABC and AP, measured along the root surface was used to determine the presence or absence of normal alveolar bone, with bone loss thus being defined in relation to root length (Fig. 2). Each image was calibrated individually. The reference for calibration of the digitized image was the natural size of the radiographic film (Kodak DF58) of 31×41 mm[31].

The following formula was used to calculate bone level percentage on each proximal surface:

$$\frac{(\mathrm{CEJ}-\mathrm{ABC})-2\,\mathrm{mm}}{(\mathrm{CEJ}-\mathrm{AP})-2\,\mathrm{mm}} \times 100$$

Subtraction of 2 mm from the CEJ to ABC or CEJ to AP distances was adopted as the criterion in the formula used, based on histological studies on periodontally healthy teeth showing that the sum of connective tissue (1.07 mm) and junctional epithelium (0.97 mm) attachments or the distance from the top of alveolar bone crest to the bottom of the gingival sulcus[12,53], was approximately 2 mm[12,19,53]. Therefore, we chose the dentogingival junction (2 mm) for the formula, as it is not visible on the X-ray and cannot be considered as bone loss. Furthermore, an extensive review[6,18] considered the criterion of ≥2.0 mm adopted in most studies to be appropriate[1,3,21,23,29,49].

Two examiners (periodontist, general clinician) collected the data, which was grouped on spreadsheets Excel to record bone loss in mm, root length and alveolar bone level according to each proximal surface of the teeth. In order to facilitate interpretation of the data, the teeth were analyzed according to group, *i.e.*, molars, premolars, canines and incisors.

The variables (dental arches, group of teeth and proximal sites) were analyzed with the Greenhouse-Geisser normality test[13] to deter-

Table 1 Alveolar bone loss according to group of teeth

Group of teeth (p=0.505)	Number of teeth	Mean of bone loss (mm)	Median (mm)	SEM	Standard deviation	Minimum (mm)	Maximum (mm)
Upper incisors	127	27.0	27.9	16.0	0.0	69.8	2.0
Upper canines	62	17.2	15.0	14.5	0.1	64.5	3.0
Upper premolars	114	14.5	14.4	11.9	0.0	44.2	1.6
Upper molars	135	19.3	15.4	15.5	0.0	55.6	2.6
Lower incisors	138	26.2	23.0	17.0	0.0	77.4	2.0
Lower canines	69	14.9	11.7	12.4	0.0	45.7	1.6
Lower premolars	126	13.8	10.9	12.7	0.0	56.1	1.5
Lower molars	123	17.6	14.4	15.3	0.0	64.7	2.1

SEM: standard error of the mean

Table 2 Alveolar bone loss according to dental arch

Dental arch (p=0.424)	Number of teeth	Mean of bone loss (mm)	Median (mm)	SEM	Standard deviation	Minimum (mm)	Maximum (mm)
Upper arch	431	20.3	19.7	11.5	1.4	0.2	50.7
Lower arch	463	19.6	17.0	12.4	1.4	0.0	53.9

SEM: standard error of the mean

Table 3 Alveolar bone loss according to proximal site

Proximal site (p=0.308)	Number of sites	Mean of bone loss (mm)	Median (mm)	SEM	Standard deviation	Minimum (mm)	Maximum (mm)
Mesial	1,788	19.7	17.5	11.2	1.3	0.0	47.2
Distal	1,788	20.4	19.1	11.7	1.3	0.2	52.2

SEM: standard error of the mean

mine the homogeneity of variances. Since the data showed no normal distribution or homogeneity of variances, a univariate analysis of variance for repeated measures was applied[41]. Differences were considered to be significant at the 5% level ($p \leq 0.05$). Analysis of inter- and intra-examiner agreement yielded a satisfactory intra-class correlation coefficient ($p < 0.0001$).

Results

Mean alveolar bone loss in the present sample was 20.60% (±12.12). Analysis of bone loss in the different groups of teeth (incisors, canines, premolars and molars) revealed a higher level of bone loss in the incisor group ($p = 0.505$), but this difference was not significant (Table 1).

No significant difference in percentage of alveolar bone loss was observed between the upper and lower arches ($p = 0.424$), although bone loss was higher in the upper arch (Table 2).

Table 3 shows alveolar bone loss according to proximal sites. No significant difference was observed between the mesial and distal proximal surface ($p = 0.308$).

Discussion

In the present study, mean percentage of

alveolar bone loss in relation to total root length was 20.60% (range 0.09 to 36.79%). Similar studies have reported different values ranging from 22.39[30] to 34.59%[44]. This difference in values may be explained by difference in stage of periodontal disease. We observed bone loss similar to that reported by Kerbauy (1999), although their sample consisted of patients with different stages of periodontal disease, whereas we studied patients under periodontal maintenance, irrespective of the history and severity of the disease.

Regarding the dental arches, we observed a higher mean alveolar bone loss in the upper arch, but the difference between the lower and upper arch was not significant. A similar result has been reported[55], comparing bone loss between the two dental arches in 733 patients.

Anatomically, the upper arch incisors usually present the palatal gingival groove (lateral: 4.40% and central: 0.28%)[54], which is considered to be a risk area for periodontal disease[15], since the groove may provide a niche for plaque and bacteria difficult to access during scaling. Therefore, the probability of early tooth loss is higher in the upper arch than in the lower arch incisors[17]. Moreover, the molars of the upper arch contain a larger number of roots, and the possibility of furcation involvement, favoring periodontal disease, is therefore higher[38]. It should be noted that 75% of enamel pearls are found in the molars of the upper arch[40].

Concerning the groups of teeth, comparison of the percentage of bone loss showed no significant difference between the groups of teeth analyzed. The highest level of bone loss was observed in the incisors, followed by the molars, canines and premolars. This agrees with the results of other recent studies[37,42,50]. Higher precipitation of calculus is usually observed in the upper molars and lower incisors, a fact favoring the accumulation of plaque and the consequent progression of periodontal disease in these two groups of teeth[33]. Some studies have demonstrated a higher bone loss rate in molars[2,4,23,24], molars and incisors[34,46] or even a random distribution[43]. Lower bone loss was reported for canines[34]. In relation to root anatomy, which is a predisposing factor to periodontal disease[52], the lower incisor[16] presents a deeper root concavity than the lower canine[48] and lower first premolar[36]. Despite the absence of a significant correlation between clinical attachment loss and the presence of root concavities[45], this anatomical detail should not be disregarded, since it impairs the access of periodontal instruments.

Socio-economically, a higher level of bone loss was observed in the incisors than in molars. It should be noted that our sample consisted of low-income subjects who have less access to health services[20] and present greater tooth loss[10]. In this respect, the prevalence of molar extraction was found to be higher[26,35,43] in this type of patient, since maintenance of these teeth requires more complex and expensive treatment. Therefore, we cannot rule out the possibility that the longevity of incisors may be higher than that of molars, since we could not evaluate bone loss in extracted teeth.

With respect to proximal sites, the mean percentage of alveolar bone loss was higher at distal than at mesial sites, with no significant difference between sites. Suomi *et al.*[51] (1968) also found no difference in bone loss between proximal sites. The fact that distal sites had higher bone loss may also be explained by the fact that the distal surface of the lower canines, for example, is characterized by deeper and wider concavities[48]. In addition, the first upper molar presents a smaller trunk and shorter root length on the distal surface[27]. These anatomical tooth characteristics may facilitate the retention of plaque and impair plaque removal and the access of instruments to distal sites. In contrast, some studies[2,4,24] reported greater bone loss at mesial sites.

Regarding the methods used in this study, the literature has demonstrated the superiority of a scanner over other digitization methods (video camera or digital camera) in the quantification of extent of periodontal disease[25]. In the present study, we did not use a Schei *et al.*[50] and Björn *et al.*[9] ruler to measure

bone loss, since this method requires adjustment of the lines drawn with the ruler to the anatomical reference points. The time spent for analysis of each series of 14 radiographs was about 25 min, with one examiner and one annotator performing the measurements. We chose to use software for the measurement of alveolar bone level as it provides greater precision[28], in addition to easy data storage, amplification and identification of anatomical landmarks.

All measurements were obtained to within hundredths of a millimeter with the Image Tool® 3.0 software (University of Texas Health Science Center, 2003), which is available free of charge on the internet, and has been adopted in many dental studies[22,39], including some with an objective similar to the present one[8]. In order to minimize possible distortion inherent to the digitization of radiographic films, each image was individually calibrated with this software.

The relative simplicity of execution of the present method, such as easy data collection and handling, permits identification of percentage of alveolar bone loss. In addition, this method would help periodontists obtain a correct diagnosis, adequate treatment planning and longitudinal follow-up of periodontal alterations.

Regarding materials used in this study, there was a high percentage of exclusion (54.62%). One reason may be the 8 exclusion criteria adopted. Nevertheless, those strict exclusion criteria and use of periapical radiographs (more suitable than bitewings[1,7] in assessing severe bone loss) enhanced the quality of the sample analyzed.

It should be pointed out that a limitation of the present cross-sectional study was the fact that the sample was selected from a radiographic database. Therefore, this variability and the fact that multiple teeth in the same subject were considered to be independent entities may have resulted in interpretations and comparisons that might need further investigation.

In conclusion, the method used in the present study demonstrated a mean alveolar bone loss of 20.60% ($\pm$12.12). Mean alveolar bone loss was found to be higher in the upper arch, in the group of incisors and on the distal surface, but the difference was not significant. It should be emphasized that the data obtained from the radiographs are partial, mainly due to the limitations of image capture (overlapping of cortical plate, demonstration of soft tissue). We, therefore, consider the combination of radiographic and periodontal clinical data to be relevant in obtaining a broad evaluation of the modifications that occur in the periodontium and, thus, the classification and establishment of an adequate treatment plan for patients with periodontal diseases.

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