Radiological evaluation of the prevalence of bone loss, tooth wear, periodontal ligament widening, and the prevalence of mandibular torus

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Abstract

Objective: The aim of the study was to quantify the relationship between excessive occlusal forces reflected by tooth wear, Periodontal ligament space widening (PDLw), TM presence, and radiographic loss of bone support. A secondary aim was to evaluate the correlation of screening specific teeth instead of the entire dentition.

Materials and Methods: 1950 Sets of full mouth radiographic surveys were retrospectively analyzed. Radiologic quantification of loss of bone support was performed using the “Schei’s ruler” technique. Tooth wear evaluation was classified according to enamel wear in the incisal area, PDL widening was considered when over 0.2mm was measured, and the presence of mandibular torus was inspected.

Results: After collecting data from the first 400 radiographs, the correlation between specific teeth and the whole dentition was evaluated. Teeth 41 and 33 showed the best correlation scores to all examined teeth. Tooth wear and loss of bone support were significantly age-related (p<0.001). There was a statistically significant correlation between tooth wear and bone support loss (p<0.001). The odds ratio of having bone loss when tooth wear was present was 2.767. The odds ratio of having bone loss when PDLw was present was 2.585.

Conclusion: The present study found a statistically significant correlation between radiographic tooth wear, PDLw, and loss of bone support.

Clinical Relevance: The high correlation between tooth wear and radiographic bone loss helps the clinician better understand the etiology of periodontal disease. Prevention and treatment of the disease are multifactorial.

Introduction

Periodontal disease is caused by subgingival bacterial dysbiosis adversely affecting the host immune system by developing and maintaining an inflammatory process in gingival and periodontal tissues (1, 2). In epidemiologic studies, intraoral periapical radiographs are commonly employed to quantify the loss of alveolar bone support in the interproximal areas (3). However, the assessment of bone height by intraoral radiographs usually underestimates alveolar bone loss by 9–20% compared to direct measurements during surgery (4, 5). According to Albandar et al. 1986, Schei’s technique was the best in correlation to bone level measurements (6). Pathogenic occlusion is defined as excessive occlusal forces that can produce injuries to the stomatognathic system, including the jawbone, dental and periodontal tissues. These injuries may manifest as tooth wear, widening of the periodontal ligament (PDLw), and the appearance of mandibular torii (7).

Tooth wear is a multifactorial condition leading to the loss of dental hard tissues by a chemical and/or mechanical process. The prevalence of tooth wear varies widely among populations (8, 9); although incipient in most individuals, it may also lead to the loss of a relatively large part of the teeth crowns (10).
In modern occidental populations, tooth wear is usually related to parafunctional occlusal activity, exerting higher forces than masticatory functions (11, 12).

The potential relationship between occlusal and/or incisal tooth attrition and periodontitis has sparsely been evaluated.

The 1996 World Workshop in Periodontics consensus describes the information to determine whether a relationship exists between occlusion and the progression of periodontal disease as inadequate (13). However, the 1999 Consensus Report on Periodontal Disease Classification agreed that occlusal trauma results in tissue changes within the attachment apparatus due to occlusal force(s) (14).

According to the 2017 workshop, animal and human studies have indicated some association between occlusal trauma/occlusal discrepancies and the progression of periodontal disease. Nevertheless, there is a consensus that excessive occlusal forces, per se, do not initiate periodontal disease or cause loss of periodontal attachment (15).

Mandibular torus (TM) is one of the most encountered oral bone exostoses. It consists primarily of dense cortical bone without marrow. It can often present bilaterally on the lingual aspect of the mandible from the retromolar region to the symphysis, with the canine and premolar region above the mylohyoid line as the most common location (16). A strong association has been reported between clenching/grinding and the presence of TM; accordingly, their presence might be a hint for signs of parafunction (17). Al-Dwairi et al. found that occlusal forces were significantly higher in males than females and subjects with TM. (18)

Few large-scale studies examined the relationship between tooth wear, Periodontal ligament space widening (PDLw), TM presence, and radiographic loss of bone support.

The present study’s main aim was to assess radiographically relationship between excessive occlusal forces reflected by tooth wear, Periodontal ligament space widening (PDLw), TM presence, and radiographic loss of bone support.

A secondary aim was to statistically evaluate the correlation between specific teeth and the entire dentition within the same individual for the assessed parameters.

**Materials And Methods**

Sets of full mouth radiographic surveys performed for patients at the same dental office dating from February 2017 through November 2019 were retrospectively analyzed. A Helsinki approval was received on July 22nd 2021 number COM-0004-21.

All X-rays were performed in the same radiologic office/facility. The first 400 radiograph sets were tested by two examiners (YB and NTG) until a correlation of 95 percent was achieved. The following radiographs were analyzed by the same examiner (YB). In case of doubt, the results were discussed with the second examiner.
In the first 400 radiographs, loss of bone support was evaluated in 12 teeth: 11, 13, 17, 22, 24, 26, 46, 44, 41, 31, 33, 37, while tooth wear and PDLw were evaluated in the six anterior lower teeth (43, 42, 41, 31, 32, 33).

A preliminary statistical analysis was performed to evaluate the results of the first 400 radiographs to statistically establish the number of individuals needed for the final sample.

Inclusion criteria:

- All patients were above 18 years
- Patients gave written informed consent to participate in the study.
- At least ten remaining teeth in each jaw
- Examined teeth did not have full crown restorations
- All patients had a complete set of intra-oral radiographs

Exclusion criteria:

- Opposing teeth were crowns/bridges
- Patients having more than a single implant in either one of the jaws

Radiographic evaluation.

Radiologic quantification of loss of bone support was performed using the “Schei’s ruler” technique (19), which transforms the bone height to a percentage of the radiographic root length (from the cementoenamel junction to the apex).

Bone support was evaluated relative to the root length and classified into three categories:

0- No loss of bone support

1- Loss of bone support was less than 30% of the root length.

2- Loss of bone support was more than 30% of the root length.

**Tooth wear evaluation:**

Tooth wear evaluation was based on Bardsley et al. classification according to the extent of enamel wear in the occlusal or incisal area, and three categories were established: (20)

0- No tooth wear.

1- Evident tooth wear involving only the enamel.

2- Tooth wear involving most or all of the enamel.
Mandibular torus (MT):

The presence of mandibular torus was categorized into three groups:

0-No presence of mandibular torus.

1-Unilateral mandibular torus.

2-Bilateral mandibular torus.

PDL widening

PDL widening was considered when over 0.2mm was measured. Results were dichotomous:

- Normal PDL space
- Widened PDL space

Statistical analyses:

The statistical analysis was performed using SPSS 20.0 statistical analysis software (SPSS Inc., Chicago, IL, USA). Categorical variables were presented as numbers and percentages, and continuous variables as means, standard deviations, and ranges.

Associations between the two categorical variables were examined using the χ² test and Fisher's exact test. The t-test or Mann-Whitney nonparametric test was used to compare differences between two independent groups when the dependent variable was either continuous or ordinal. The one-way ANOVA analysis was used to compare differences between means of more than two independent groups when the dependent variable was either ordinal or continuous. Associations between two continuous variables were examined using the Pearson correlation test or the Spearman rank-order correlation test. A two-sided p-value of < 0.05 was considered statistically significant for all analyses.

Results

Preliminary statistics: After collecting data from the first 400 radiographs, the correlation between specific teeth and the whole dentition within the same individual for the evaluated parameters evaluated.

Teeth 41 and 33 showed the best correlation scores to all examined teeth. Correlations were 0.85 for loss of bone support (for teeth 41 or 33), 0.83 for PDL widening (PDLw) (for teeth 41 or 33), and 0.97 for tooth wear (for teeth 41 or 33). When each tooth was separately evaluated, the correlations were as follows, for tooth 41: for loss of bone support was 0.72, for PDLw 0.81, and 0.93 for tooth wear. Those correlation values for tooth 33 were: 0.82, 0.78 and 0.89 respectively. Accordingly, only these two teeth were evaluated in the whole study sample.
**Study results**

A thousand nine hundred and fifty radiographic surveys were initially available. According to the inclusion and exclusion criteria, 1400 sets of radiographs were finally evaluated. Table 1 shows the numbers and percentage of loss of bone support, tooth wear, and PDLw for both sample teeth. In tooth 41, bone loss was appreciated at 55.4% and tooth wear in 54.3% of the patients; those figures were slightly higher than those for tooth 33 (40.3% and 37.9%, respectively). PDL widening was almost equal in both sample teeth (15.9% for tooth # 31 and 13.3% for tooth # 43).

Table 1: Percentage of teeth concerning the severity of bone loss, tooth wear, and PDL widening

<table>
<thead>
<tr>
<th>Tooth number</th>
<th>Bone loss</th>
<th>Tooth wear</th>
<th>PDL widening</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>%</td>
<td>%</td>
</tr>
<tr>
<td>0</td>
<td>44.6</td>
<td>59.7</td>
<td>45.6</td>
</tr>
<tr>
<td>1</td>
<td>37.1</td>
<td>36.7</td>
<td>44.1</td>
</tr>
<tr>
<td>2</td>
<td>18.3</td>
<td>3.6</td>
<td>10.2</td>
</tr>
</tbody>
</table>

*p* < 0.05

Three age categories were established: 18–35 years (*n* = 357), 36–59 years (*n* = 768), and over 60 years (*n* = 261). Tooth wear and loss of bone support, however, not that of PDLw, were significantly age-related (*p* < 0.001), older people were more likely to present higher degrees of tooth wear and loss of bone support, as shown in Fig. 1.

Correlation between tooth wear, loss of bone support, and PDL widening: There was a statistically significant correlation between the degrees of tooth wear and those of loss of bone support (*p* < 0.001). Lower degrees of tooth wear were correlated to no bone loss; enhanced tooth wear correlated to the loss of bone support. This correlation was found in all three age groups. PDLw was not affected by the age of the patients.

Gender and tooth wear: Men presented more tooth wear than women for both teeth 33 and 41 (*p* < 0.001).

Gender and bone loss: Loss of bone support, was significantly higher in men (275 = 43.3%) than in women (289 = 37.8%) (*p* < 0.038).

PDLw was not affected by the patient’s gender (*P* = 0.937).
Mandibular torus: MT was diagnosed in 118 (8.4%) of radiographs, 44 (3.1%) were unilateral, and 74 (5.3%) were bilateral. Bilateral MT was significantly correlated with PDLw of tooth 41 (P < 0.048). In addition, the prevalence of bilateral MT was significantly higher in patients with PDLw in tooth 41 (16 patients- 7.2%) (P < 0.048) compared to patients without PDLw in tooth 41 (58 patients (4.9%)).

The presence of MT was not correlated with loss of bone support, tooth wear, age, or gender.

Effect of tooth wear and PDLw on the loss of bone support using one tooth analysis:

Loss of bone support was affected by tooth wear and PDLw in all age categories. Percentages of loss of bone support and its correlation to tooth wear and PDLw are presented in table 2.

Table 2: Percentage of cases presenting with BL and TW or PDLw. The differences between all cases are statistically significant (p < 0.0001)

<table>
<thead>
<tr>
<th>Loss of Bone Support</th>
<th>0</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>TW</td>
<td>64.1</td>
<td>26.7</td>
</tr>
<tr>
<td>PDLw</td>
<td>85.8</td>
<td>71.6</td>
</tr>
<tr>
<td></td>
<td>14.2</td>
<td>28.4</td>
</tr>
</tbody>
</table>

No correlation was found between loss of bone support and MT.

PDLw was not correlated to gender.

Stepwise Logistic Regression- was performed to delete the effect of age on tooth wear and PDLw. The odds ratio of having bone loss when tooth wear was present was 2.767 (95%CI 2.145–3.570). The odds ratio of having bone loss when PDLw was present was 2.585 (95%CI 1.880–3.553). The specificity of the odds ratio lo bone loss was 67.1, and the sensitivity was 76.3.

Discussion

The relationship between occlusal forces and periodontal disease remained a controversial topic (15, 21). Therefore, in the present study, tooth wear and loss of bone support were analyzed in intra-oral peri-apical radiographic surveys.

Teeth selection: We focused on two mandibular teeth- #41 and #33. The epidemiologic value of evaluating only two teeth as representative of the whole dentition is evident (22). According to Farook et al. 2020, lower incisors gave the highest interclass correlation between clinically evaluated clinical
attachment level and radiographically assessed bone level (23). Our preliminary results gave us the same indication; results obtained from teeth #33 and #41 statistically correlated to the 12 teeth initially evaluated for loss of bone support and the six lower anterior teeth to assess tooth wear and PDLw.

A statistically significant correlation was found between tooth wear and age. A higher prevalence of tooth wear was observed among males, older people, and patients with periodontal disease (24). Age dependence is in accordance with Cunha-Cruz (2009), who claims that tooth wear is normal and an expected consequence of aging. The mandibular central incisors at a mean height of 0.25 mm over ten years (25). In the present study, at least half of the enamel thickness was no longer present by the average age of 57.98 for tooth #33 and 59.71 for tooth #41. Contrary to our findings, more considerable wear of tooth #41(0.85mm) compared to #33 (0.7) mm has been reported in a teenage population study.

A positive correlation between alveolar bone loss and age was found. However, earlier loss of bone support appreciated in tooth 41 compared to 43. Other in vivo (19) and in vitro studies demonstrated that bone support loss seems more prominent in the lower incisors than in the cuspids (19, 26, 27 ). However, the association between alveolar bone loss and age does not inevitably reflect the aging process. Individual exposure to etiologic risk and/or behavioral factors could have an important role. (6, 28, 29)

The present study found a statistically significant correlation between radiologic tooth wear, PDLw, and loss of bone support. Since both outcomes are age-dependent, patients were stratified into three age groups, 18–35 years, 36–59 years, and over 60 years. This correlation was consistent and significant for all age groups. Regression analysis showed an odds ratio for loss of bone support in patients with tooth wear of 2.767 (95% CI = 2.145 to 3.570), proving that tooth wear and bone loss are related, irrespective of the patient's age. The OR for this correlation was more robust for tooth #41 than for tooth #33. A correlation between tooth wear and periodontal parameters (attachment level, bleeding on probing, and recessions) was reported only for posterior teeth (30).

Non-treated parafunctional habits are associated with increased attachment loss and worse prognosis. (31).

Zero bone loss was significantly more common in women than men for both examined teeth; however, statistically significant only for tooth 33. Males have more severe tooth wear than females, and the tooth wear of the lower canines was more minor than the incisors (32, 33 ). Zero tooth wear was significantly more prevalent in women than in men.

When we dichotomized bone loss (yes or no), men had significantly more teeth with bone loss than women in tooth #33.

The presence of MT was not correlated with other signs of parameters. It is hypothesized that one of the causes of MT is excessive occlusal forces (18). However, our study could not confirm this assumption. Maybe the radiologic evaluation of TM is difficult, and the number of TM was underestimated.
Strength And Limitations

Strength:

- The present study included a large sample of patients compared to previous similar studies.
- The group includes patients of all ages.
- Radiologic evaluation of loss of bone support was performed using intraoral periapical radiographs, which is the gold standard, and analysis was performed using the Schei ruler, which has proven to be the most reliable. (34, 35)
- All radiographs were performed in the same radiographic institute by one radiographic technician.
- An easy and friendly method for evaluating tooth wear, loss of bone support, and PDLw is described. It can be used for big-data studies.
- Two teeth were significantly representative of bone support evaluation, PDL widening, and tooth wear, meaning that in epidemiologic studies, these two teeth might represent the entire dentition.

Limitations:

- Only two teeth instead of 12 for evaluation of loss of bone support and six for tooth wear evaluation. Nevertheless, the correlation was excellent for tooth wear (0.97) and very good for loss of bone support (0.85) and PDLw (0.83).
- The older population group was relatively small due to inclusion and exclusion criteria concerning natural dentition.

Declarations

Ethical Approval: A Helsinki approval was received on July 22nd, 2021, number COM-0004-21.

Competing interests: None- No financial or personal nature.

Authors' contributions: All authors have made substantial contributions to conception and design of the study. NTG, NF and YB have been involved in data collection and data analysis. NTG, CN and RK have been involved in data interpretation, drafting the manuscript and revising it critically and have given final approval of the version to be published.

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**Figures**

![Mean Age of Patients with Tooth Wear, Bone Loss and PDL widening](image)

**Figure 1**

Mean ages of tooth wear, bone loss, and PDL widening (Post-Hoc Tukey b<sup>a,b</sup>)