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ORIGINAL ARTICLE



# Periodontal status in long-term orthodontic retention patients up to 10 years after treatment – a cross-sectional study

Barbro Fostad Salvesen[a], Jostein Grytten[b,c], Gunnar Rongen[b], Odd Carsten Koldsland[d] and Vaska Vandevska-Radunovic[a]

[a]Section of Orthodontics, Institute of Clinical Dentistry, University of Oslo, Oslo, Norway; [b]Section for Community Dentistry, University of Oslo, Oslo, Norway; [c]Department of Obstetrics and Gynecology, Institute of Clinical Medicine, Akershus University Hospital, Lørenskog, Norway; [d]Section of Periodontology, Institute of Clinical Dentistry, University of Oslo, Oslo, Norway

**ABSTRACT**

**Objective:** To assess periodontal status in long-term orthodontic retention patients and investigate possible risk indicators.

**Materials and Methods:** Plaque index (PI), gingival index (GI), probing pocket depth (PPD), gingival recessions (GR) and calculus were recorded in 211 patients with or without fixed retainers.

**Results:** Periodontal parameters were within the limits of clinically healthy periodontium. The use of fixed retainers was associated with higher PI in the maxilla (ß = 1.10 [0.37]; $p < .05$). Older age was associated with higher PI in the mandible (ß = 0.27 [0.11]; $p < .05$). Smoking was associated with gingival bleeding on both palatal (ß = 0.63 [0.16]; $p < .01$) and labial sides in the maxilla (ß = 0.46 [0.20]; $p < .05$). Smoking was also associated with increased prevalence of GR in the mandible (ß = 0.24 [0.07]; $p < .01$), while use of snuff had similar effect on the labial side in the maxilla (ß = 0.35 [0.08]; $p < .01$). Higher age (ß = 0.05 [0.02]; $p < .05$) and the presence of a retainer (ß = 0.23 [0.07]; $p < .05$) were associated with calculus accumulation on the lingual side in the mandible.

**Conclusion:** The present observational study suggest that long-term fixed retainers alone have no detrimental effect on the periodontium. Additional factors may increase the risk of plaque deposits and increased probing pocket depths. Further prosepective studies are needed to confirm the present outcome.

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Confounding factors; long-term orthodontic retention; orthodontic retainers; periodontal health; periodontal parameters

## Introduction

Orthodontic treatment aims to establish good functional and aesthetic occlusion and to ensure long-term preservation of oral health [1,2]. Correcting crowded teeth enables patients to better perform oral hygiene and reduces occlusal trauma [1]. However, fixed orthodontic appliances might compromise adequate oral hygiene by increasing food residues and bacterial plaque retention [3]. Moreover, orthodontic appliances could generate similar negative effects as seen with overhanging restorations, which induce a subgingival microflora characteristic of periodontitis [4]. The incidence of gingivitis increases during orthodontic treatment and plaque retention at the gingival margin is an important aetiological factor in the development of periodontal disease [5]. Periodontitis is one of the most prevalent oral diseases [6], it increases with age and poses a significant socio-economic burden to the aging global population [7]. Therefore, it is important to identify and control the aetiological factors leading to reduced periodontal health.

A systematic review by Bollen et al. showed that malocclusion is a risk factor for periodontal disease [8]. However, orthodontic treatment of malocclusion does not seem to improve periodontal status [9–12]. On the contrary, another review by the same group demonstrated that treatment with fixed appliances had a small, negative effect on the periodontal status [9]. The overall quality of the evidence was described as weak, with only one of the included studies being a randomised controlled trial. None of the studies were adjusted for possible confounding factors. A recent systematic review [1] concluded that in short term follow-ups, orthodontic appliances seem to increase general plaque accumulation and gingivitis. After long-term follow-up, however, gingival status and periodontal values trend towards normalisation [13]. Collectively, orthodontic treatment with fixed appliances seems to exert a slight negative effect on periodontal status, particularly short-term after debonding.

After the active part of the orthodontic treatment is completed, some kind of retention is required to prevent relapse or secondary crowding [14]. Fixed retainers bonded to the lingual surfaces of the anterior teeth are commonly used

CONTACT Barbro Fostad Salvesen barbrofostad@gmail.com P.O. Box 1109 Blindern, Oslo 0317, Norway
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[15]. Their advantage is that patient compliance is not needed, but they warrant more detailed oral hygiene [16,17]. As there is no consensus among orthodontists regarding length of retention period, retainers are often prescribed indefinitely to maintain treatment result. Prolonged retention, however, may lead to negative effects on the periodontium [18]. It is therefore important to evaluate the possible effects of long-term orthodontic retention on periodontal status.

The aims of the current study were to investigate the periodontal status in long-term orthodontic retention patients and assess possible risk indicators.

## Materials and methods

### Study population

The study population comprised of patients who underwent routine orthodontic retention control between three to ten years after orthodontic treatment at the Department of Orthodontics, University of Oslo. Between October 2015 and June 2017, 216 consecutive patients were invited to participate in the study. Of these, 211 patients (115 females and 96 males) consented to inclusion, while five patients declined participation due to time constraints. The study was approved by The Regional Committee for Medical and Health Research Ethics (2015/695) and was conducted according to the declaration of Helsinki. Written informed consent was obtained from all patients.

Inclusion criteria were: (1) previous orthodontic treatment with fixed appliances on the buccal tooth surface, (2) orthodontic treatment started before 18 years of age.

Exclusion criteria were: (1) missing or extracted upper or lower incisors or canines, (2) patients undergoing/treated with orthognathic surgery, (3) craniofacial syndromes, (4) cleft lip and/or palate.

All retainers considered in this study were fixed metallic retainers bonded with composite to the lingual/palatal aspect of the six anterior teeth. To a lesser extent, only canines in the mandible were bonded. Ligature wire (Either Stainless steel or Gold Penta Twisted .0215″ Gold N'braces or blue elgiloy 0.036″ inch Rocky Mountain) were prepared on study models. The lingual surfaces of the teeth were cleaned with pumice (Reliance Orthodontics Inc, USA), then rinsed with water and dried. The enamel was pre-treated with Acid-etch (Total Etch Etching Gel 37% Ivoclar Vivadent) for 15 s, then rinsed and air-dried. A light-cured bonding agent (Light Cure Adhesive 3 M Unitek) was added to the lingual surfaces before a light-cured flowable composite (Low Viscosity Transbond Supreme LV) and retainer wire were added to the tooth surfaces and light-cured. Due to the retrospective nature of the study and an inconsistent bonding protocol with more than one specific retainer material, retainers were evaluated as one group.

### Clinical evaluation of periodontal status

The examination was performed by one investigator (BFS), trained and calibrated by a specialist in periodontology. All patients were clinically examined for the following periodontal parameters:

- Plaque index (PI) (modified after Silness and Løe, 1967) [19]. Plaque was defined as present if debris could be wiped off on inspection with an explorer.
- Gingival index (GI) (modified after Silness and Løe, 1967) [19]. Bleeding was defined as present if it occurred upon light pressure on gingival margin with an explorer.
- Probing pocket depth (PPD) was measured to the nearest mm using a pressure-sensitive probe (20 g) (University of North Carolina probe, Aesculap, Braun, Tuttlingen, Germany).
- PI, GI and PPD were recorded mesiolabially, labially, distolabially, distolingually, lingually and mesiolingually on all six anterior teeth (Figure 1). For statistical analyses, only one reading per surface was used: the worst labial and the worst palatal/lingual reading per tooth.

Gingival recession (GR) was calculated by subtracting the PPD value from the clinical attachment loss (CAL). CAL was measured from the cementoenamel junction to the bottom of the pocket to the nearest mm.

Calculus was evaluated only in the mandible on the lingual aspect of the six anterior teeth, and its presence or absence was scored for each tooth: calculus was graded as being present or not on visual inspection and with the use of a probe.

### Statistical analysis

Sample size calculation was performed before study onset using SPSS 25.0.0.1 (IBM Corporation). The necessary sample size was 200 when using an $\alpha$-level of 0.05, a power of 0.8 and an estimated 10% prevalence level of GR. Remaining statistical analyses were done using SAS/STAT 14.01. Descriptive statistics were used for demographic and clinical data. The dependent variables were defined in the following ways, illustrated as an example in Figure 1(A) for the maxilla and (B) for the mandible:

- Each palatal and lingual surface of a tooth received the score 1 if plaque/gingival bleeding was present at one or more of each of the three sites. If not present at any site, the score was 0. Thus, for the front teeth in each jaw the score ranged from (0–6) labially and (0–6) palatally/lingually. Mean values were calculated for the total labial and palatal or lingual surfaces both in the maxilla and the mandible.
- Each palatal and lingual surface of a tooth received the probing depth/gingival recession in mm for the site with the highest value. Mean values were calculated for the total labial and lingual surface in both the maxilla and the mandible.

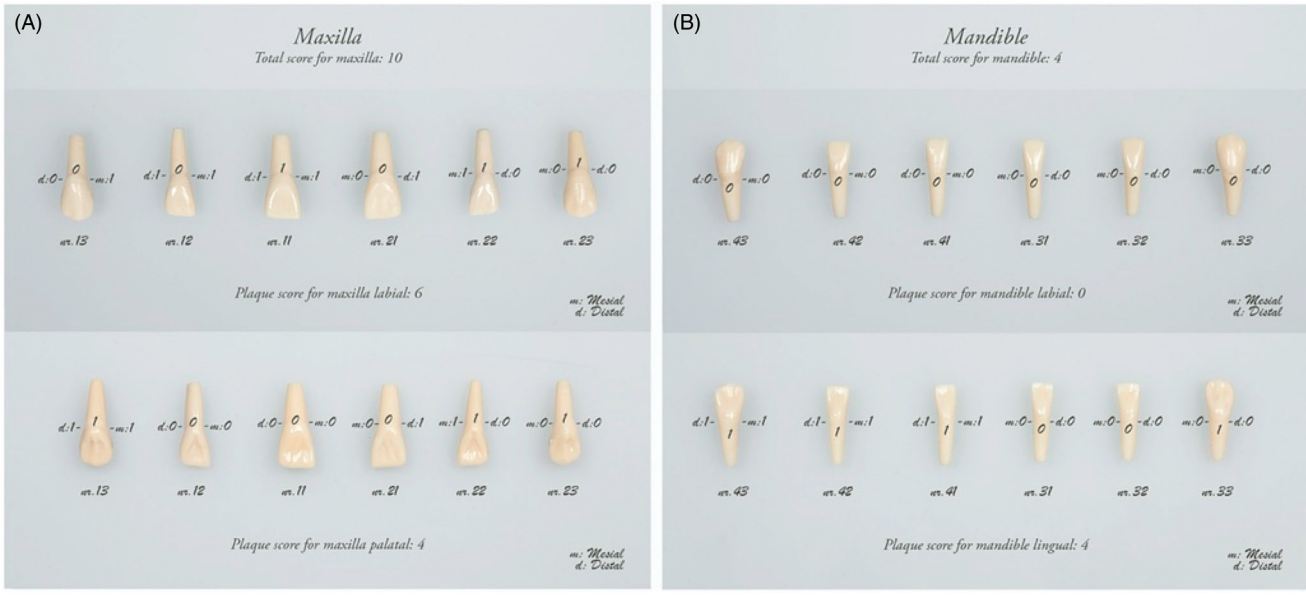


**Figure 1.** Example of how the dependent variable plaque was defined and scored in the maxilla (A) and the mandible (B).

- The lingual surface in the mandible received the score 1 if calculus was present at one or more of each of the three sites of a tooth. If no calculus was present at any site of a tooth, the score was 0. For the mandible the score ranged from (0–6) lingually. Mean values were calculated for the total lingual surface of the mandible.

Ordinary least square regression models were computed using the various periodontal parameters as the dependent variable and presence/absence of fixed retainers in the maxilla or mandible as the exposure variables.

One regression analysis was carried out for each clinical parameter labially and lingually for each jaw. Altogether, 16 separate regression analyses were carried out. In each analysis, the following confounding variables were adjusted for age in years, gender, smoking (yes/no), use of snuff (yes/no), number of tooth extractions, duration of orthodontic treatment in months, and years since debonding.

To evaluate the intra-rater reliability of the clinical scores, PPD in 30 patients were re-measured by the same investigator (BFS). Intra-class correlation coefficients and Cohen's kappa statistics were calculated to assess the strength of agreement. The clinical scores demonstrated good reliability as indicated by high intra-class correlation coefficient (0.8) and Cohen's kappa statistics (0.89).

## Results

The study included 211 patients with mean age 20.9 years (range 15-30). Descriptive statistics of the cohort are given in Table 1. The mean values for PI were somewhat higher in the mandible than in the maxilla, being highest for the mandibular lingual surface (Table 2). The mean GI was between 0.1 (±0.4) on the maxillary palatal surfaces and 0.3 (±0.7) on the mandibular labial surface. The highest PPD score was recorded on the labial surface of the mandible (Table 2). Only one patient had a periodontal pocket $\geq$ 8 mm.

PI score in the maxilla on the palatal aspect was increased in patients with retainers and in smokers ($p < .05$) (Table 3). In the mandible, higher age was associated with a high PI score lingually ($p < .05$), while having a retainer was not a significant risk indicator for plaque accumulation ($p = .06$).

Smoking was significantly associated with higher GI score on the labial and palatal aspects of the maxilla, but not in the mandible. For the lingual mandibular surface, the duration of orthodontic treatment was associated with a higher GI score ($p < .05$) (Table 4). Fixed retainers were not associated with increased PPD score (Table 5). However, longer duration of orthodontic treatment, was associated with increased PPD score ($p < .01$) (Table 5). In the mandible, male gender was associated with increased PPD score both on the labial and lingual aspects ($p < .05$).

Presence of GR was significantly higher in the mandible, both lingually and labially, in patients who smoked ($p < .10$). Use of snuff, however, was associated with presence of GR in the maxilla, on the labial side ($p < .01$). No other variables were associated with higher prevalence of GR (Table 6). There were only 15 patients with GR. The largest recession was 3 mm.

Having fixed retainers and older age were the only variables significantly associated with increased calculus in the mandible ($p < .01$) (Table 7).

**Table 1.** Descriptive statistic of the patients.

| | Mean (range) | *N* (%) |
|---|---|---|
| Number of patients | | 211 |
| Retainer in the maxilla | | 116 (55) |
| Retainer in the mandible | | 156 (74) |
| Retainer in the maxilla and mandible | | 99 (47) |
| Females | | 116 (55) |
| Smokers | | 6 (3) |
| Using snuff | | 61 (29) |
| Age in years | 20.9 (15-30) | |
| Number of tooth extractions | 1.2 (0-4) | |
| Duration of orthodontic treatment in months | 23.4 (0-72) | |
| Years since debonding | 6.3 (3-10) | |

**Table 2.** Descriptive statistics of the clinical parameters ($N = 211$).

| Parameter | Mean number of sites (standard deviation) | Mean number of mm (standard deviation) |
|---|---|---|
| Plaque index | | |
| Maxilla 13–23 | | |
| Labial | 2.8 (2.3) | |
| Palatal | 2.4 (2.6) | |
| Mandible 33–43 | | |
| Labial | 3.2 (2.7) | |
| Lingual | 4.2 (2.5) | |
| Gingival index | | |
| Maxilla 13–23 | | |
| Labial | 0.2 (0.6) | |
| Palatal | 0.1 (0.4) | |
| Mandible 33–43 | | |
| Labial | 0.3 (0.7) | |
| Lingual | 0.2 (0.7) | |
| Calculus | | |
| Mandible 33–43 | | |
| Lingual | 0.7 (0.5) | |
| Probing pocket depth | | |
| Maxilla 13–23 | | |
| Labial | | 2.9 (0.7) |
| Palatal | | 2.9 (0.7) |
| Mandible 33–43 | | |
| Labial | | 3.0 (0.8) |
| Lingual | | 2.7 (0.7) |
| Gingival recession | | |
| Maxilla 13–23 | | |
| Labial | | 0.1 (0.4) |
| Palatal | | 0 (0) |
| Mandible 33–43 | | |
| Labial | | 0.1 (0.3) |
| Lingual | | 0 (0.2) |
| Clinical attachment loss | | |
| Maxilla 13–23 | | |
| Labial | | 2.9 (0.8) |
| Palatal | | 2.9 (0.7) |
| Mandible 33–43 | | |
| Labial | | 3.1 (0.8) |
| Lingual | | 2.8 (0.8) |

**Table 3.** Clinical predictors of plaque index.

| | Maxilla | | Mandible | |
|---|---|---|---|---|
| Independent variables | Labial | Palatal | Labial | Lingual |
| Retainer in the maxilla | 0.44 (0.35) | 1.10 (0.37)* | | |
| Retainer in the mandible | | | 0.39 (0.47) | 0.81 (0.43) |
| Age in years | 0.05 (0.10) | −0.05 (0.10) | −0.05 (0.12) | 0.27 (0.11)* |
| Female | −0.33 (0.35) | −0.08 (0.37) | 0.03 (0.40) | −0.13 (0.38) |
| Smoking | 0.59 (0.94) | 2.79 (0.99) | −0.73 (1.08) | −0.21 (0.99) |
| Use of snuff | 0.95 (0.58) | −0.07 (0.61) | −0.23 (0.67) | −0.55 (0.62) |
| Number of tooth extractions | −0.16 (0.09) | −0.12 (0.10) | −0.21 (0.11) | −0.03 (0.10) |
| Duration of orthodontic treatment in months | | | | |
| Mmoths | 0.02 (0.02) | 0.10 (0.02) | 0.02 (0.02) | −0.01 (0.02) |
| Years since debonding | −0.05 (0.12) | 0.01 (0.13) | −0.03 (0.15) | −0.23 (0.14) |

Regression coefficients with standard errors in brackets.
*$p < .05$.

**Table 4.** Clinical predictors of gingival index. Regression coefficients with standard errors in brackets.

| | Maxilla | | Mandible | |
|---|---|---|---|---|
| Independent variables | Labial | Palatal | Labial | Lingual |
| Retainer in the maxilla | 0.13 (0.07) | 0.05 (0.06) | | |
| Retainer in the mandible | | | −0.07 (0.11) | −0.03 (0.10) |
| Age | −0.01 (0.02) | −0.01 (0.02) | 0.04 (0.03) | 0.02 (0.03) |
| Female | 0.003 (0.07) | 0.03 (0.06) | 0.02 (0.10) | −0.09 (0.09) |
| Smoking | 0.46 (0.20)* | 0.63 (0.16)** | 0.51 (0.27) | 0.30 (0.24) |
| Use of snuff | −0.16 (0.12) | −0.06 (0.10) | −0.15 (0.16) | −0.07 (0.14) |
| Number of tooth extractions | −0.002 (0.02) | −0.02 (0.02) | −0.01 (0.03) | −0.02 (0.02) |
| Duration of orthodontic treatment in months | −0.01 (0.004) | −0.0004 (0.003) | −0.01 (0.01) | −0.01 (0.005)* |
| Years since debonding | 0.03 (0.03) | 0.03 (0.02) | −0.03 (0.03) | 0.002 (0.03) |

*$p < .05$, **$p < .01$

**Table 5.** Clinical predictors of periodontal pockets. Regression coefficients with standard errors in brackets.

| | Maxilla | | Mandible | |
|---|---|---|---|---|
| Independent variables | Labial | Palatal | Labial | Lingual |
| Retainer in the maxilla | −0.11 (0.11) | −0.43 (1.01) | | |
| Retainer in the mandible | | | 0.02 (0.13) | 0.19 (0.12) |
| Age in years | −0.01 (0.03) | −0.24 (0.29) | −0.01 (0.03) | 0.03 (0.03) |
| Female | 0.02 (0.11) | −1.36 (1.01) | −0.30 (0.11)* | −0.26 (0.11)* |
| Smoking | 0.29 (0.28) | −0.32 (2.72) | −0.01 (0.31) | 0.28 (0.28) |
| Use of snuff | 0.16 (0.18) | −0.94 (1.68) | 0.02 (0.19) | −0.03 (0.17) |
| Number of tooth extractions | −0.04 (0.03) | 0.29 (0.27) | −0.04 (0.03) | −0.02 (0.03) |
| Duration of orthodontic treatment in months | 0.02 (0.01)* | −0.03 (0.05) | 0.01 (0.01) | 0.01 (0.01) |
| Years since debonding | 0.04 (0.36) | 0.56 (0.36) | 0.05 (0.04) | 0.007 (0.04) |

*$p<.05$.

**Table 6.** Clinical predictors of gingival recession. Regression coefficients with standard errors in brackets.

| | Maxilla | Mandible | |
|---|---|---|---|
| Independent variables | Labial | Labial | Lingual |
| Retainer in the maxilla | 0.04 (0.05) | | |
| Retainer in the mandible | | −0.05 (0.05) | 0.02 (0.03) |
| Age in years | −0.001 (0.01) | −0.01 (0.01) | 0.001 (0.01) |
| Female | 0.10 (0.05) | 0.04 (0.04) | 0.01 (0.03) |
| Smoking | 0.13 (0.14) | 0.37 (0.12)* | 0.24 (0.07)** |
| Use of snuff | 0.35 (0.08)** | −0.05 (0.07) | −0.03 (0.04) |
| Number of tooth extractions | 0.01 (0.01) | 0.01 (0.01) | 0.004 (0.01) |
| Duration of orthodontic treatment in months | 0.002 (0.003) | −0.002 (0.002) | −0.001 (0.001) |
| Years since debonding | 0.02 (0.02) | 0.03 (0.02) | 0.01 (0.01) |

*$p<.05$, **$p<.01$.

**Table 7.** Clinical predictors of calculus index. Regression coefficients with standard errors in brackets.

| | Mandible |
|---|---|
| Independent variables | Lingual |
| Retainer in the mandible | 0.23 (0.07)* |
| Age in years | 0.05 (0.02)* |
| Female | 0.03 (0.07) |
| Smoking | −0.16 (0.18) |
| Use of snuff | 0.10 (0.11) |
| Number of tooth extractions | 0.01 (0.02) |
| Duration of orthodontic treatment in months | −0.001 (0.003) |
| Years since debonding | −0.04 (0.02) |

*$p<.05$.

## Discussion

In the current study, periodontal parameters were recorded, and their association with potential risk indicators was investigated in long-term orthodontic retention patients. The results show that the levels of PI, GI, and PPD, as well as the presence of GR and calculus are within the limits of clinically healthy periodontium in orthodontic patients up to ten years after debonding.

Defining periodontal health is important in order to establish a common reference point from which to assess disease. Four levels of periodontal health have been proposed: (1) pristine periodontal health; (2) well-maintained clinical periodontal health, with a structurally and clinically sound periodontium; (3) periodontal disease stability, with a reduced periodontium; and (4) periodontal disease remission, with a reduced periodontium [20]. In the present study, no systematic registration of periodontal status was done prior to orthodontic treatment. However, treatment would not have been initiated in presence of active periodontal disease. All orthodontic patients are as a routine screened for periodontal disease before onset of orthodontic treatment. Considering the periodontal status registered in the follow-up period, sound periodontium can be assumed in this particular population prior to fixed appliances.

Various clinical signs, including plaque and calculus accumulation, bleeding on probing, GR, and increased PPD can indicate damage to periodontal tissues caused by fixed retainers. However, as fixed appliances may also impede the periodontal tissues, some have argued that the effects of retention treatment cannot be distinguished from that of the fixed appliances until at least three months [14] to two years [21] after debonding. In the present study, patients were clinically assessed three to ten years after debonding, which ensured that the periodontal parameters were not directly affected by the treatment.

Having a retainer was significantly associated with plaque accumulation in the maxilla and calculus accumulation in the mandible. Increased plaque accumulation in patients with maxillary bonded retainers has been reported in short-term [22] and long-term orthodontic retention patients [2], while one study showed decreased presence of plaque three years in retention [17]. Furthermore, more pronounced calculus formation has been shown in patients with fixed retainers when compared to removable, or no retainers [18,23,24], but the evidence is described as low [21]. Nevertheless, the levels of plaque and calculus deposits in this study were low and did not seem to have detrimental effect on the periodontium. This is in line with the results of a recent systematic review concluding that fixed retainers are compatible with periodontal health [25].

Smoking is a well-documented risk factor of periodontitis [26] and is associated with less gingival bleeding. In our study, however, smoking was associated with an increased GI score. It might be that increased plaque deposits combined with poorer hygiene regimen contributed to increased

gingival bleeding. Smoking and use of snuff were also associated with increased occurrence of GR, both in the maxilla and in the mandible. The associations between GR and smoking have previously been documented [27,28] and smokers are, in general, at higher risk of severe periodontitis [29]. Using snuff, on the other hand, does not seem to be associated with periodontal disease [29], but might exert local effects, yielding GR at site of placement [28]. As the number of smokers and snuff users in the present study was very low, the results must be interpreted with caution.

PPD was not increased in patients with retainers in the current study. This is in keeping with Liu and co-workers who showed stable pocket depth during a 12 month follow-up with fixed retainers [30]. However, others have shown increased PPD following retention treatment for nine to 11 years, when compared to retention treatment for three to six months [18].

The length of retention and extraction therapy did not have any significant association with the investigated periodontal parameters. Reports on the effect of extraction on, particularly, GR are unanimous and show no correlation [24,31]. However, results concerning retention period and periodontal health are inconsistent. Some periodontal parameters show short-term improvements after debonding, while other show no change or deteriorate with time [18,23,32]. Long-term orthodontic retention patients have shown higher calculus accumulation, greater GR and increased PPD, compared to short-term orthodontic retention patients [18]. Without baseline measurements to compare with, these results could probably be age-related, as shown in this study. PI and calculus accumulation significantly increased with age; a variable well known to affect periodontal health.

It is important to be aware of the predictive limitations of cross-sectional studies, with the exposure and outcome being assessed simultaneously. In the present study, no baseline periodontal measurements were accessible. However, all orthodontic patients are routinely screened for periodontal disease before onset of orthodontic treatment. This is not quantified by specific periodontal measurements in the journal, but random sampling of periodontal measurements is standard protocol. The periodontal health is also under supervision of the public dental health service/DOT. Hence, we assume that the majority of the patients were periodontally healthy when orthodontic treatment was initiated. The lack of information regarding hygiene regimen before, during and after treatment is another limitation. On the other hand, to our knowledge, no other study has investigated such a great number of patients. Moreover, they were treated at the same department and received same instructions regarding hygiene protocol.

## Conclusion

In conclusion, long-term orthodontic retention patients seem to have clinically well-maintained periodontal health. Fixed retainers alone do not seem to be associated with detrimental effects on periodontal health. In that respect, long-term orthodontic retention treatment generally appears to be safe. However, additional factors, including age and gender, may increase the risk of plaque deposits and increased probing pocket depths. Further prospective studies are needed to confirm the present outcome.

## Disclosure statement

No potential conflict of interest was reported by the author(s).

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