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Long-term periodontal status of patients with mandibular lingual fixed retention

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SUMMARY The purpose of this study was to evaluate the periodontal tissues of patients with mandibular fixed retention for long or short periods of time. A total of 64 individuals were selected for this study using the following inclusion criteria: long-term lingual fixed retention; identical type of lingual fixed retainer bonded with the same materials; no cavities, restorations, or fractures of the mandibular anterior teeth; absence of habits and occlusal interferences; and canine guidance bilaterally. The resultant sample comprised 32 patients (mean age 25 years) who had been in retention for a mean period of 9.65 years (range 9–11 years) and an equal number retained for a period between 3 and 6 months. Plaque, gingival, and calculus indices, probing pocket depth, marginal recession, and bone level at the mandibular six anterior teeth were recorded for both groups. Demographic, clinical, and radiographic data were investigated with conventional descriptive statistics. Comparisons of the different variables between the two participant groups (long- and short-term retention) were carried out using a Mann–Whitney test for indices (plaque, gingival, and calculus), and a Fisher's exact test (two sided) for the remaining variables.

No significant difference was found with respect to the plaque and gingival indices and bone level between the two groups. The long-term group presented higher calculus accumulation, greater marginal recession, and increased probing depth ($P < 0.05$). The results of this study raise the question of the appropriateness of lingual fixed retainers as a standard retention plan for all patients regardless of their attitude to dental hygiene. They also emphasize the importance of individual variability and cautious application of retention protocols after a thorough consideration of issues related to the anatomy of tissues and oral hygiene.

Introduction

Fixed lingual retainers, bonded to mandibular anterior teeth, were introduced in the 1970s (Knelrim, 1973), and established as an integral part of orthodontic treatment to prevent relapse or secondary crowding of mandibular incisors (Little *et al.*, 1988). A survey (Keim *et al.*, 2002) showed that nearly one-third of the practitioners in the United States of America routinely use fixed retainers in the mandibular arch, a higher figure than that reported previously.

The first generation of fixed retainers, typically involved large-diameter section stainless steel round wire (0.030–0.032 inch), bonded on the lingual surface of the canines. Later, smaller diameter braided or coaxial round wires, or reduced cross-section rectangular wires of various compositions and resilience, bonded on all mandibular anterior teeth were introduced (Zachrisson, 1977, 1983; Årtun and Zachrisson, 1982). More recently, fibre-reinforced materials (Diamond, 1987; Orchin, 1990; Geserick *et al.*, 2004), as well as alumina ceramic retainers (Amundsen and Wisth, 2006) have been used.

The main advantage of the mandibular fixed intercanine retainer compared with the removable retainer is that they are invisible, are well-tolerated by patients and as such are virtually compliance free (Zachrisson, 1977). On the other hand, some of the disadvantages are attributed to the demanding technique of placing the retainer (Zachrisson, 1983) and the potential for tooth movement due to distortion or lack of passivity of the wire. Bond failures may also constitute a problem, estimated to range between 6 and 20 per cent, depending on the technique used and follow-up observation period (Dahl and Zachrisson, 1991; Årtun *et al.*, 1997). Additionally, bonded fixed retainers have been shown to increase plaque and calculus accumulation compared with removable retainers. This, however, was not found to have detrimental effects on the integrity of the dental hard tissues adjacent to the wire (Gorelick *et al.*, 1982). Interestingly, no difference in plaque accumulation was found between multistrand and plain wire lingual retainers (Årtun, 1984).

Despite the fact that there is a definitive trend to resort, at an increasingly high rate, to fixed retention in an attempt to seek long-term stability (Keim *et al.*, 2002), there is very limited information on the periodontal effects of long-term mandibular lingual fixed retention (Heier *et al.*, 1997). With fixed retention periods becoming longer, it is important to evaluate the possible effects of long-term fixed retention on the surrounding tissues.

The purpose of this study was therefore to evaluate the periodontal tissues of patients with mandibular fixed retention for long- or short-term periods of time.

Subjects and methods

The record of individuals participating in the study group were selected from a larger pool of patients treated at the practice of the first author, using the following inclusion criteria: lingual fixed retention for a period of at least 9 years; identical type of lingual fixed retainer; no cavities, restorations, or fractures on the mandibular anterior teeth; absence of habits and occlusal interferences; and canine guidance bilaterally. Thirty-two patients (11 males, 21 females, mean age 25 years) who had been in retention for a mean period of 9.65 years (range 9–11 years) were recalled for an examination and a comprehensive periodontal evaluation. These patients had been treated by the same orthodontist with a 0.022-inch edgewise appliance. In all cases, the fixed mandibular retainer was placed following the completion of treatment and was constructed intraorally using a braided 0.195-inch wire (Wildcat, GAC, Central Islip, New York, USA), bonded with a two-phase paste adhesive (Excel, Reliance Orthodontics, Itasca, Illinois, USA), by the same clinician. At the time of placement of the retention wire, all patients were instructed to undertake meticulous dental hygiene and to visit their dentist annually for monitoring of the periodontal status. Regarding the recall for the study, patients were asked to avoid visiting the dentist for a period of at least 1 month prior to the recall appointment at the orthodontic office.

The control group consisted of 32 patients treated by the same orthodontist who had undergone similar treatment, who had their treatment completed and received a similarly constructed fixed lingual retainer 3–6 months before the recall. Before this appointment, all patients were instructed not to visit the general dentist for dental cleaning. The patients were informed of the purpose of the study and consent was obtained.

For both groups, the following clinical variables were assessed by a periodontist:

1. Plaque index (PI), as described by Löe (1967), was evaluated with a disclosing agent (Dual Tone, Young Dental, Earth City, Missouri, USA) on the buccal and lingual surfaces for all mandibular anterior teeth (incisors and canines).

   Plaque accumulation was categorized using the following scale:
   - 0: absence of plaque
   - 1: plaque disclosed after running the probe along the gingival margin
   - 2: visible plaque
   - 3: abundant plaque.

   The results of the PI were averaged for all six mandibular teeth and a mean value for each subject was estimated.
2. Gingival index (GI) as described by Löe (1967) was estimated on a participant basis as an average of the measurements of the individual GI on the mesial, lingual, buccal, and distal surfaces of the six selected teeth according to the following scale:
   - 0: absence of inflammation
   - 1: mild inflammation, with a slight change in colour and subtle change in texture; no bleeding on probing
   - 2: moderate inflammation with a moderate glazing, redness, oedema, and hypertrophy; bleeding on pressure
   - 3: severe inflammation with marked redness and hypertrophy tendency to spontaneous bleeding ulceration.
3. Calculus index (CI) evaluated as an estimate of the coronal extension of supragingival calculus and/or the presence of separate flecks of a continuous band of subgingival calculus (Greene and Vermillion, 1960). The following scale was used:
   - 0: absence of calculus
   - 1: presence of calculus covering up to one-third of the tooth surface
   - 2: presence of calculus covering up to two-thirds of the tooth surface and/or the presence of separate flecks of subgingival calculus
   - 3: presence of calculus covering more than two-thirds of the tooth surface and/or the presence of a continuous band of subgingival calculus.

   The results of the CI were averaged for all six mandibular teeth and a mean value for each subject was calculated.
4. Probing depth (PD), measured with a periodontal probe (NC 15, Hu-Friedy, Chicago, Illinois, USA), was recorded as the distance from the gingival margin to the most apical part of the sulcus. Six readings were carried out per tooth (mesiobuccal, mesial, distobuccal, mesiolingual, lingual, distolingual). PDs smaller than or equal to 3 mm (PD $\leq$ 3 mm) received a value of zero, while readings larger than 3 mm (PD > 3 mm) were assigned a value of one. Data analysis included the resultant entries per individual.
5. Marginal recession, defined as the distance between the cementoenamel junction (CEJ) and the gingival margin was measured with a periodontal probe (NC 15, Hu-Friedy). Scores in millimetres were recorded only when a recession was present, i.e. when the CEJ was visible. Data analysis included the resultant recordings per participant.
6. Bone level, defined as the distance from the CEJ to the alveolar crest on radiographs. For this purpose, two digital periapical radiographs were taken of each subject including the mesial of the lower canines, and all four mandibular incisors, using the Elitys radiographic unit (Trophy, Kodak, New York, USA). The parallel cone technique was used with a Rinn XCP holder (Dentsply, York, Pennsylvania, USA) and a 10 mm probe (NC 15) was placed at the lingual side of the teeth prior to taking the radiographs in order to calibrate measurements using the integrated digital radiography software (Trophy RVG; Figure 1). Bone level (B-CEJ) readings smaller

than 2.5 mm received a value of zero, while readings larger than 2.5 mm were given a value of one. Data analysis included the resultant recordings per subject.

Statistical analysis

Demographic, clinical, and radiographic data were investigated with conventional descriptive statistics. Comparisons of the different variables between the two groups were undertaken using the Mann–Whitney test for indices (plaque, gingival, and calculus), and Fisher's exact (two-sided) for tests producing ordinal data (PD, clinical attachment loss, and bone level). All data analysis was performed with the Statistical Package for Social Sciences (SPSS Inc., version 14.0, Chicago, Illinois, USA) and the level of statistical significance in all analyses was set to 0.05.

Results

Table 1 shows the distribution of demographic variables in the two groups. The gender distribution, Angle classification, and the number of extractions were the same in the two groups. In contrast, age demonstrated a statistically significant difference with the short-term retention group showing, on average, a 9-year difference relative to the long-term group.

Table 2 shows the PI, GI, and CI scores for the long- and short-term groups. No difference was found for PI and GI, whereas the long-term group showed significantly higher CI scores.

Tables 3–6 depict the findings for PD, marginal recession, and bone level measurements. A significantly higher prevalence of deep pockets (≥4 mm) and marginal recession was found for the long-term retention group. It should be noted, however, that out of eight subjects exhibiting recessions, two showed a lingually located recession. No difference was noted with respect to bone level between the groups.

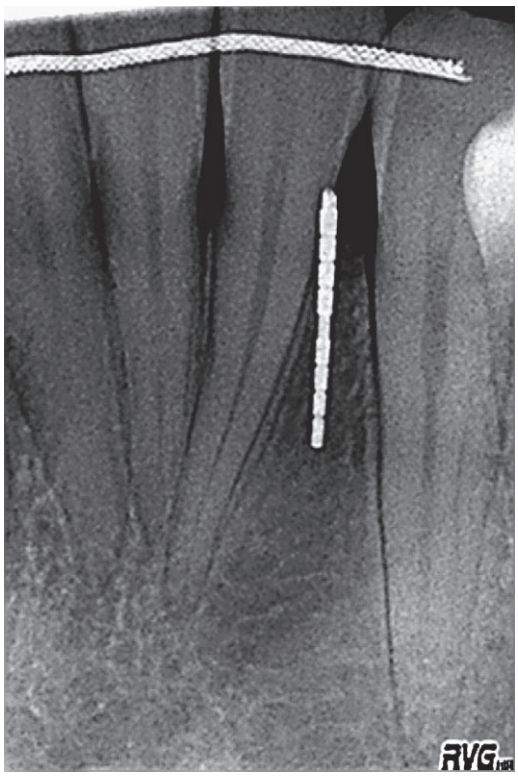

Figure 1 Radiograph of a patient with bone loss (periodontal probe is attached for estimation of loss).

Discussion

Use of lingual fixed retainers in the mandibular arch offers the advantage of a lack of occlusal interferences and the necessity for bonding the wire in the proximity of free gingiva. On the other hand, bonding of this type of retainer in the maxillary ach is often complex since the opposing mandibular incisors occlude with the wire or adhesive, whereas gingival orientation of the wire to avoid premature contacts may promote gingival reactions.

The use of indices initially focused on individual patient needs, such as assessing the progression of pathology or hygiene compliance in specific arch sites. However, their application has expanded to involve research with the objective of characterizing the periodontal status of a population and the effectiveness of treatment protocols. The latter application constitutes an inappropriate use because indices scores, which are basically ordinal data, are treated as nominal, and a mean and standard deviation from multiple measurements are extrapolated. Apart from this inappropriateness, the results obtained have no physical meaning: for example, a PI index of 1.4 does not mean that the area of tooth covered by plaque is 1.4 times higher than that with an index of 1. Nonetheless, since their introduction, there have been numerous publications on this issue and this fact coupled with their popularity as a research tool, render their use valid in the comparative assessment of periodontal status of patients before and after the initiation of treatment or a change in hygiene routine (Löe, 1967).

The results of this study suggest that the placement of lingual fixed retainers for long periods promote calculus accumulation, marginal recession, and increased PD, but has no effect on plaque and gingival indices or bone level.

Calculus accumulation relates to the increased availability of retentive sites for microbial colonization, which are being calcified at a later stage. It is probable that retainers increase the calculus presence through the resin margins, which extend lingually to the free gingiva, offering a substrate favouring biofilm precipitation. In general, the outcome of biofilm adsorption is dependent on the biological fluid flow rate at the site of contact, the type of interfacial interactions involved, and the attachment strength with the substrate (White, 1997).

The multiplicity of oral flora and biofilm changes accompanying the placement of a material in the oral cavity emphasize the necessity for meticulous fabrication of

Table 1 Demographic and clinical characteristics of the two groups in the study.

		Groups				
		Retention 3–6 months ($n=32$)		Retention 9–11 years ($n=32$)		
		Mean or %	SD	Mean or %	SD	P*
Gender (%)	Male	34.4		37.5		NS
	Female	65.6		62.5		
Age (years)		16.4	1.26	25	1.29	<0.05
Angle classification (%)	I	59.4		53.1		
	II	37.5		46.9		NS
	III	3.1		0		
Treatment (%)	Non-extraction	68.8		62.5		
	Extraction	31.2		37.5		NS

NS, non-significant; SD, standard deviation.
*P value for comparison of group means by t-test or differences in proportions by chi-square test.

Table 2 Comparison of periodontal (PI), gingival (GI), and calculus indices (CI) scores between the long- and short-term retention groups.

Groups	PI			GI			CI		
	Mean	SD	P*	Mean	SD	P*	Mean	SD	P*
Retention 3–6 months	0.55	0.44	NS	1.01	0.31	NS	0.48	0.50	<0.05
Retention 9–11 years	0.76	0.54		1.29	0.45		1.21	0.88	

NS, non-significant; SD, standard deviation.
*P value for comparison of group means by Mann–Whitney U-test.

lingual retainers. A firm adaptation of the wire to the lingual tooth surface is critical, along with the application of a very thin layer of adhesive, which should not extend beyond the middle two-thirds of the lingual crown surface. Care must be taken to ensure clearance of the resin from the interproximal and gingival areas. For greater control, a layer of varnish should be applied to the lingual tooth surface area where resin is undesirable prior to acid etching, to prevent resin impregnation into these areas.

The increased marginal recession in long-termed retained mandibular teeth documented in this study may have many explanations. Although it could correlate with the increased calculus accumulation, since the latter has been found to significantly promote recession (Albandar and Kingman, 1999; Susin *et al.*, 2004), it seems that in these subjects, a direct connection between the placement of retainers and recession is unlikely due to the buccal location of recession in the majority of subjects.

Additionally, proclination of mandibular incisors induced by treatment has been linked to decreased attachment levels, contributing to recession (Yared *et al.*, 2006). Even though this hypothesis has not been unanimously accepted (Ruf *et al.*, 1998; Allais and Melsen, 2003), there is a possibility that proclined mandibular incisors retained with a fixed bonded appliance for long periods of time may cause attachment loss. The investigations which rejected the involvement of incisor proclination in recession, did not consider the long-term presence of a bonded appliance on the proclined teeth for a period of 10 years. This may differentiate the effect of proclination, potentially inflicting additional changes in the periodontium.

In this study, the numbers of extractions in each group were randomly distributed thus excluding the possibility that the recession may be treatment associated, such as excessive protrusion of incisors.

It may be worth noting that because of the difficulty in following the same population for a decade, this study included different samples with a mean age difference of 9 years. The effect of this age difference may have a discriminating action in modifying some of the variables recorded in this study. In general, recession tends to increase with age (Vehkalahti, 1989; Thomson *et al.*, 2006), because of the accumulation of damage and microbial action over the years, the higher probability for disease and smoking, as well as inappropriate brushing techniques. The latter has been demonstrated through studies in individuals who brushed frequently and presented higher recession than those who brushed less frequently (Serino *et al.*, 1994). A factor, which differentiates the effect of brushing on recession in this investigation is that the former studies

focused almost exclusively on premolars and molars and not mandibular incisors.

A small number of studies have included distribution of recession site per tooth type. Susin *et al.* (2004) found, in a group between 14 and 29 years of age, marginal recession of 29.5 per cent with approximately 29 per cent prevalence on lower incisors, and around 9 per cent for lower canines. Thomson *et al.* (2000) evaluated the periodontium of 914 individuals, all 26 years of age, and found marginal recession equal to or larger than 1 mm in 70 per cent of the sample. Regarding the location of marginal recession, approximately half of the mandibular canines and incisors were affected. The sample studied in this investigation, with an average age of 26 years, showed a 25 per cent marginal recession of the anterior mandibular region, and in view of the aforementioned findings, it may be argued that the marginal recession rate of this sample exhibited patterns which were no worse compared with those reported by Thomson *et al.* (2000). Thus, orthodontic retention may not have affected the recession prevalence in the long-term sample. However, it was not specified in the studies by Susin *et al.* (2004) and Thomson *et al.* (2000) whether the sample included individuals, who received, at some point, orthodontic treatment and were fitted with lingual retainers.

PD increase seems to be independent of age, with the exception of subjects where heavy smoking and negligent oral hygiene establish an early periodontal breakdown and premature onset of periodontal disease; however, these parameters should not be attributed to age-induced alterations (Erdemir and Bergstrom, 2006). Thus, more likely, increased PD should be attributed to long-term irritation of tissues induced by the retainer.

Bone level in this research was shown not to vary between the two groups. Nonetheless, there is some scepticism over the reliability of periapical radiographs in revealing the extent of this treatment side-effect because of the orientation of the crown and the lack of information on the labial and lingual bony plates. Although a standard screening examination relies on periapical radiographs to assess bone levels, research on autopsy material has revealed bone dehiscence and fenestrations, which were not depicted on radiographs (Wehrbein *et al.*, 1995). Therefore, the screening examination as employed in this study possesses a high false negative value because of its inability to detect loss at specific areas.

The findings of this investigation should be interpreted with caution because cultural variations and oral hygiene may have an effect on the examined variables. Clinical trials have demonstrated a cultural variability in a number of orthodontic treatment parameters. For example, clinical failure rate of brackets has shown a preference to male participants in a Scandinavian population (Adolfsson *et al.*, 2002), in contrast to other European countries, whereas failure in some cases is confined to a specific side (Pandis *et al.*, 2006). Thus, the level of oral hygiene of the participants, along with other dietary factors may have a pronounced effect on altering the results of some of the variables examined.

Table 3 Comparison of probing depth interval scores between the long- and short-term retention groups.

Probing depth interval (mm)	Groups		
	Retention 3–6 months (%)	Retention 9–11 years (%)	*P**
<3	96.8	71.8	<0.05
>3	3.2	28.2	

**P* value for comparison of proportions by Fisher's exact test.

Table 4 Comparison of marginal recession interval scores between the long- and short-term retention groups.

Marginal recession interval (mm)	Groups		*P**
	Retention 3–6 months (%)	Retention 9–11 years (%)	
<1	100	75	<0.05
>1	0	25	

**P* value for comparison of proportions by Fisher's exact test.

Table 5 Location of recessions observed in the long-term retention group. Only sites with recession ≥1 mm are shown.

Recession location						
Subject	Left canine mid-buccal (mm)	Left lateral mid-buccal (mm)	Left lateral mid-lingual (mm)	Left central mid-buccal (mm)	Left central mid-lingual (mm)	Right central mid-buccal (mm)
1	2	4		2		3
2				1		
3				1		
4				1		
5			1			
6			1		1	
7				3		
8				1		

Table 6 Comparison of bone level data between the long- and short-term retention groups.

Bone level interval (mm)	Groups		
	Retention 3–6 months (%)	Retention 9–11 years (%)	*P**
<2.5	93.7	90.6	NS
>2.5	6.3	9.4	

NS, non-significant.
**P* value for comparison of proportions by Fisher's exact test.

Conclusions

The findings of this study, albeit taking into account the foregoing limitations, suggest that long-term retention with mandibular-bonded appliances results in some changes in the periodontal condition of subjects with retainers, which in most cases is confined to a minute increase in various indices and parameters. The clinical impact of these changes may be overestimated in this study, particularly for those variables which show age dependence. However, the findings emphasize the value of individual variability and cautious application of retention protocols after a thorough consideration of anatomic, hygiene, social, and cultural factors. Most importantly, the evidence presented highlights the importance of close monitoring of patients through frequent recalls.

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