

Removable thermoplastic appliances as orthodontic retainers—a prospective study of different wear regimens

Sylvia Jäderberg*, Ingall Feldmann**,*** and Christer Engström****

*Orthodontic Clinic, Hudiksvall, **Orthodontic Clinic, Public Dental Service, Gävleborg County Council, Gävle, ***Centre for Research and Development, Uppsala University/Gävleborg County Council, Gävle and ****Department of Orthodontics, Eastman Institute, Public Dental Health, Stockholm County Inc., Sweden

Correspondence to: Sylvia Jäderberg, Orthodontic Clinic, Norrmalsgatan 2, SE-852 34 Sundsvall, Sweden.
E-mail: sylvia.jaderberg@lvn.se

SUMMARY The aim of this prospective study was to evaluate and compare stability after 6 months of Essix retainer use. Patients' perceptions of wearing the retainer were also evaluated. A total of 69 patients, 53 girls and 16 boys [mean age 15.7 years, standard deviation (SD) 1.96], were included in the study and randomized into two groups with different wear regimens; full-time wear for 3 months and thereafter at night (group A) compared to full-time wear for 1 week and thereafter at night only (group B). Sixty patients completed the study and thus, group A comprised 30 maxillary retainers and 18 mandibular retainers and group B 30 maxillary and 18 mandibular retainers. Little's irregularity index (LII), overjet, and overbite were measured at debond (T_1) and after 6 months (T_2). Differences within and between groups were analysed with a Mann–Whitney test. At T_2 , all patients completed a questionnaire in order to evaluate their experience of wearing an Essix retainer and how they complied with the given instructions.

Differences in LII during T_1 – T_2 were 0.44 and 0.49 mm for group A and B, respectively, but with no significant difference between the groups. There were also no significant changes in overjet and overbite within or between the groups during T_1 – T_2 . According to the responses to the questionnaire, the retainer was well tolerated by the patients. It was therefore concluded that the Essix retainer is sufficient for maintaining the results after orthodontic treatment and that night-time wear is adequate.

Introduction

Stabilization is the phase that aims at maintaining the teeth in a corrected position after orthodontic treatment. Without a phase of retention, there is a high risk of the teeth returning to their original position, which is known as relapse. In order to prevent relapse, almost every patient will require stabilization with some type of retainer after orthodontic treatment.

One of the most commonly used retainers is the bonded wire retainer, which has the advantages of not requiring compliance and of satisfying the aesthetic demands of the patient. It may however be difficult for the patient to notice if the retainer has come loose from a single tooth and also to detect if this situation causes the tooth to move (Colett, 1998). Placement of a bonded wire retainer is also time consuming and technique sensitive (Zachrisson, 1977; Lee, 1981; Dahl and Zachrisson, 1991) and for some individuals, it is difficult to maintain good oral hygiene (Heier *et al.*, 1997). While removable appliances are more beneficial with regard to oral hygiene, they require a long period of full-time use (24 hours/day), which is an obstacle for many adolescents (Bennett *et al.*, 2001).

Essix retainers were introduced as an aesthetic, comfortable, and inexpensive alternative to traditional bonded retainers and removable appliances (Lindauer and Shoff, 1998). Since the Essix retainer also allows normal physiological

movements of the teeth, the occlusion has an opportunity to settle. A further advantage is that wear regimens can be varied which is not possible with bonded retainers (Parker, 1989). Full-time wear of the Essix retainer immediately after removal of the fixed appliance is recommended but there are various opinions concerning the length of time it should be worn, although the time for reorganization of the periodontal fibres after orthodontic treatment is considered to be, on average, a minimum of 232 days (Reitan, 1967; Proffit and Fields, 2007). Wang (1997) recommended 2 months full-time wear after debond, Lindauer and Shoff (1998) 3 months wear, and Rowland *et al.* (2007) 1 week's wear.

The extension of the thermoplastic retainers varies from canine to canine in both jaws (Sheridan *et al.*, 1993; Lindauer and Shoff, 1998), all teeth included in the maxillary jaw and premolar to premolar in the mandibular jaw (Wang, 1997) to all teeth included in both jaws (Rowland *et al.*, 2007).

In order to satisfactorily maintain the result after orthodontic treatment, the Essix retainer (as well as other removable appliances) demands good compliance (Sheridan, 1991). Deterioration in the fit of the retainer during the stabilization period is a strong indicator of a lack of compliance. However, since the Essix retainer is semi-elastic, minor relapses can be corrected with full-time use (Sheridan *et al.*, 1993; Colett, 1998).

There are only a limited number of studies that have evaluated thermoplastic appliances as an orthodontic retainer (Sheridan *et al.*, 1993; Lindauer and Shoff, 1998; Rowland *et al.*, 2007). In a recently published systematic review, Littlewood *et al.* (2006) stated that there is insufficient research data at present on retention on which to base clinical practice. There is, thus, a need for more research on effectiveness and, in addition, for studies concerning patients' experiences of different retention regimens.

The aim of this prospective study was therefore to evaluate stability after 6 months when using an Essix retainer full time for 3 months and thereafter during the night and to compare it with 1 week's full-time wear and then nightly thereafter. The hypothesis tested was that there would be no significant differences between the groups and consequently that night-time wear would be sufficient. Patients' experiences of wearing an Essix retainer were also evaluated. The hypothesis was that the Essix retainer was well tolerated.

Subjects and methods

The ethics committee of Örebro University, Sweden, which follows the guidelines of the Declaration of Helsinki, reviewed the study protocol. All patients were given oral and written information concerning the study and signed a written consent.

A sample size calculation was performed based on an alpha significance level of 0.05 and a beta of 0.1 to achieve 90 per cent power to detect a clinically meaningful difference of 1.0 mm [standard deviation (SD) 1.0] in relapse between the groups. The sample size calculation revealed that 22 jaws in each group were sufficient, but to compensate for possible dropouts, 30 jaws were enrolled in each group.

The patients were recruited from the Orthodontic Clinic at the Postgraduate Education Center in Örebro, Sweden. Subjects who were due to have their fixed orthodontic appliance removed were assessed by one author (SJ) for inclusion in the study according to the following criteria: maxillary or mandibular fixed appliance treatment or bimaxillary fixed appliance therapy who were willing to wear removable retainers. Patients with agenesis, a cleft lip and palate, or who had undergone surgical treatment were excluded.

A total of 69 patients, 53 girls and 16 boys (mean age 15.7 years, SD 1.96), were included. Since the inclusion criteria involved patients who had orthodontic treatment in both jaws and those who were treated only in one jaw, it was important to ensure that both groups included an equal number of maxillary and mandibular Essix retainers. The randomization procedure was therefore based on jaws and not patients and consequently, a patient could be randomized to different groups for the maxillary and mandibular retainer. Thus, group A who wore the Essix retainer full time for 3 months and thereafter only at night comprised 30 maxillary retainers and 18 mandibular retainers and group

B who wore the Essix retainer full time only during the first week and then only at night comprised 30 maxillary retainers and 18 mandibular retainers.

At debond, maxillary and mandibular alginate impressions were obtained and study models were cast. Standardized Essix retainers (thickness 1.0 mm; Raintree Essix, Los Angeles, California, USA) were fabricated by one experienced orthodontic technician. In the maxilla, the retainer covered all teeth and in the mandible from canine to canine (Figure 1). All patients were provided with standardized oral and written instructions on how to use the retainers by one dentist (SJ) who undertook the final evaluation after 6 months.

Registrations and measurements

Study casts were obtained at the start of the retention phase (T_1) and after 6 months (T_2). Little's irregularity index (LII; Little, 1975; Figure 2) was measured with a digital calliper

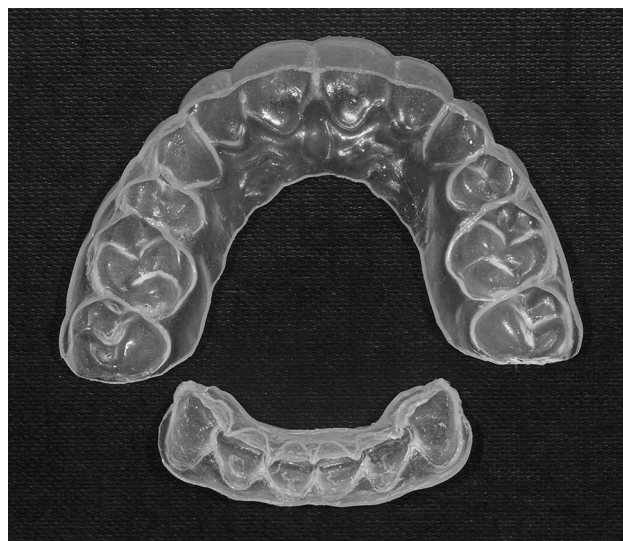


Figure 1 The Essix retainer covering all teeth in the maxilla and from canine to canine in the mandible.

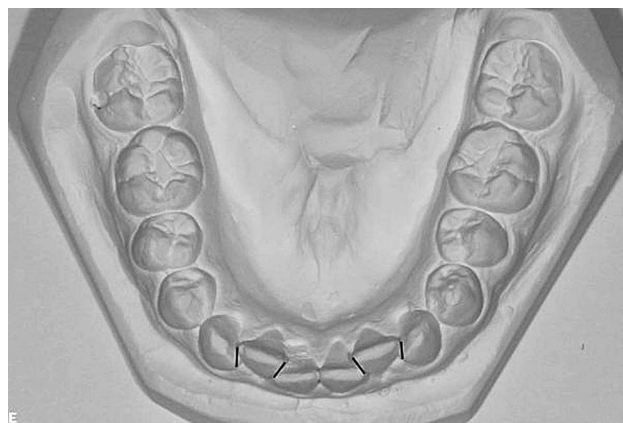


Figure 2 Measurement of the irregularity index (according to Little) by adding the sum of the contact point displacements.

(Digital 6; Mauser, Winterthur, Switzerland) to the nearest 0.01 mm. The casts were examined by one author (SJ) who was blind to group allocation.

Overjet and overbite measurements were performed with a vernier calliper (Series 531; Mitutoyo, Kawasaki, Japan) to the nearest 0.1 mm. Groups A and B were compared for changes in overjet and overbite between T_1 and T_2 . Changes in overjet and overbite were also compared between those who had Essix retainers in both jaws and those who only had an Essix retainer in one jaw.

In order to check standardization, the thickness of the retainers was measured at the buccal and lingual surfaces of the first molars, canines, and central incisors for the maxillary retainers and at the canines and central incisors for the mandibular retainers. All measurements were made with an Iwanson's calliper to the nearest 0.1 mm.

At T_2 , all patients completed a questionnaire in order to evaluate their experience of wearing an Essix retainer and how they succeeded in complying with the given instructions.

Statistical analysis

The arithmetic mean and SD were calculated for age and treatment time. Since data concerning LII, overjet, overbite, and thickness of the retainers were considerably skewed and did not follow a normal distribution, the median and interquartile range were calculated for these variables.

The amount of relapse for LII, overjet, and overbite was determined by comparing the differences between measurements at T_1 and T_2 . Absolute values for the outcome measurements for LII were calculated since any change in either a positive or a negative direction could be considered as relapse. Differences within and between groups were analysed with a Mann-Whitney test. Differences of $P < 0.05$ were considered statistically significant.

Error of method

Ten randomly selected maxillary and mandibular study models were assessed on two separate occasions, with an interval of 3 weeks. The error of the method regarding LII was measured according to the equation $(Se = \sqrt{\sum d^2 / 2N})$, where d is the difference between two measurements and N is the number of double measurements (Dahlberg, 1940). The error of method for the maxillary and mandibular arches was 0.38 and 0.25 mm, respectively.

Results

Nine of the 69 patients were excluded from the analysis for the following reasons: three patients did not attend for final evaluation, one could not wear the Essix retainer and this was replaced with a bonded retainer before the end of the observation period, and five did not follow the instructions

Table 1 Values for Little's irregularity index (LII) at debond (T_1) and changes after 6 months (T_2).

	Group A		Group B		Group differences
	Median	Interquartile range	Median	Interquartile range	
LII (T_1 ; mm)					
Maxilla + mandible	0.81	0.35–1.25	1.11	0.63–1.57	ns
Maxilla	0.89	0.46–1.48	1.17	0.80–1.86	ns
Mandible	0.81	0.46–1.19	0.90	0.54–1.26	ns
LII changes (T_1 – T_2 ; mm)					
Maxilla + mandible	0.44	0.04–0.84	0.49	0.22–0.76	ns
Maxilla	0.71	0.16–1.26	0.51	0.15–0.80	ns
Mandible	0.35	0.07–0.63	0.36	0.02–0.70	ns

ns = not significant. Group A wore the Essix retainer 3 months full time and thereafter at night and group B wore the Essix retainer 1 week full time and thereafter at night.

due to misunderstandings about wear regimens and/or lost retainers. Group A therefore consisted of 26 retainers in the upper and 16 in the lower jaw and group B 29 retainers in the upper and 14 in the lower jaw.

There were no significant differences between the two groups concerning mean age [15.9 years, SD 2.30 (group A) and 15.7 years SD 1.91 (group B)], gender, and treatment time (19 months, SD 8.68 and 21.3 months, SD 6.54, respectively). There were also no differences between groups concerning LII at T_1 (Table 1).

Differences in the median LII between T_1 and T_2 were for group A 0.44 mm (0.04–0.84 mm) and for group B 0.49 mm (0.22–0.76 mm). There was no significant difference between the groups (Table 1). The median LII changes in group A was maxilla 0.71 mm and mandible 0.35 mm and for group B 0.51 and 0.35 mm, respectively. There was no significant difference in LII between the maxilla and mandible between groups, and although there was a tendency for LII changes to be larger in the maxilla compared with the mandible within each group, this was not statistically significant. Changes in LII during T_1 – T_2 exceeded 1 mm only in a few subjects and with an equal distribution in both groups. Of note was that in a few patients, there was a small but continued alignment during the observation period.

There were no significant differences within or between groups concerning median changes in overjet and overbite during T_1 – T_2 but as nine patients were allocated to different groups for their maxillary and mandibular retainers, and these measurements contained nine duplicates, the findings are less relevant. The median overjet for all patients (groups A + B) was at T_1 2.8 mm (2.2–3.4 mm) and at T_2 2.7 mm (2.0–3.5 mm). The median overbite for all patients (groups A + B) was at T_1 3.3 mm (2.6–4.0 mm) and at T_2 3.5 mm (2.0–4.0 mm). No significant differences in overjet and overbite were observed during the observation period. The

median overjet changes for patients with retainers in both jaws was -0.1 mm (-0.33 to 0.23 mm) and for those who had a retainer in only one jaw 0.0 mm (-0.48 to 0.4 mm). The median overbite changes for patients with retainers in both jaws was -0.1 mm (-0.42 to 0.35 mm) and for those who had a retainer in only one jaw 0.0 mm (-0.27 to 0.60 mm). Changes in overjet and overbite were thus not significant concerning Essix retention in one or both jaws. No gender differences were found.

Measurements of the thickness of the Essix retainers demonstrated a significant difference ($P < 0.001$) between the buccal, median 0.43 mm (0.36 – 0.56 mm), and lingual side, median 0.68 mm (0.63 – 0.73 mm) but with no difference between tooth regions or between the maxillary and mandibular retainers. Nine retainers with a mean thickness below 0.35 mm on the buccal surface were selected for further examination. The difference in LII between T_1 and T_2 did not exceed 1 mm for any of the nine cases. No association was found between retainer thickness and the changes in LII.

All patients who participated in this study completed a questionnaire (Table 2) at T_2 . Overall, the Essix retainers were well tolerated, easy to get used to, and most patients had no difficulties in remembering to wear the retainer when using them only part time. Although, for Question 2, all patients answered that the information before the stabilization phase had been sufficient, when compared with Question 3 every fifth patient answered that they did not know what would

happen if they did not use the retainer. The retainers caused soreness in 13 per cent, and 22 per cent had problems with speech.

Discussion

The most important finding of this study was that there were no differences regarding changes in LII over the 6 month observation period between group A who wore the Essix retainer full time for 3 months and thereafter during the night group B who wore the retainer 1 week full time and thereafter at night. The hypothesis that the night only retainer wear will maintain alignment of teeth after orthodontic treatment was therefore confirmed. These results are also in agreement with Lindauer and Shoff (1998), Rowland *et al.* (2007), and Gill *et al.* (2007). In addition, the findings are in agreement with a recently published study concerning different wear regimens for Essix retainers (Thickett and Power, 2010).

No significant difference in overjet and overbite was seen during the observation phase in this study, which is in agreement with Lindauer and Shoff (1998). Sheridan *et al.* (1993), however, reported that a slight bite opening was noticed by clinicians in 2.3 per cent of their study patients, but this was so small that the patients were unaware of the change. In the present study, there were also no significant changes in overbite between patients who had retainers in both jaws and those who had retainers only in one jaw. This is important since there is a theoretical risk of bite opening, due to over eruption of posterior teeth when Essix retainers cover only the canine to canine.

Since a large number of the allocated patients had only treatment in the maxilla, it was decided to randomize on jaws and not on patients in order to obtain an equal number of maxillary and mandibular retainers in both groups. After allocation, the two groups were favourably matched for the number of maxillary and mandibular retainers and pre-observation characteristics, such as age, gender distribution, treatment time, LII, overjet, and overbite confirming the appropriateness of the randomization process. However, this also led to an increase in the number of dropouts due to misunderstandings concerning retainer wear.

In total, there more females were included in this study, which is not uncommon when consecutive orthodontic patients are recruited. While this skewed distribution had no effect on tooth movement, it might have influenced compliance since other investigations have demonstrated that females comply better with removable appliances, i.e. headgear (Clemmer and Hayes, 1979; Cucalon and Smith, 1990). However, no gender differences were seen in this study.

Absolute values were used for changes in LII in order to avoid positive and negative changes cancelling each other out, i.e. any changes in either a positive or a negative direction were considered as relapse. Probable reasons for negative values were overcorrection of crowded and rotated teeth, and, in some

Table 2 Self-reported questionnaire concerning experiences of wearing Essix retainers as retention for all patients ($N = 60$).

Questions	Alternatives	<i>N</i>
1. I have used the Essix retainer/retainers	a. According to prescription b. Missed 1–2 days, nights/week c. Almost never	42 17 1
2. The information I have received	a. Was sufficient b. Verbal would have been enough c. Was not sufficient	56 4 0
3. If I do not use the retainer/retainers	a. The retainer changes due to shrinkage b. The teeth can move c. Don't know	1 48 11
4. It was easy to get used to the retainer/retainers	a. Yes b. No c. Don't know	58 2 0
5. The retainer causes soreness	a. Yes b. No c. Don't know	8 50 2
6. I speak without problems when I wear the retainer	a. Yes b. No c. Don't know	41 13 6
7. The retainer tastes bad.	a. Yes b. No c. Don't know	6 53 1
8. The retainer is easy to clean	a. Yes b. No c. Don't know	52 6 2
9. It is difficult to remember to wear the retainer when I don't use them full time	a. Yes b. Not at all c. Don't know	8 48 4

cases, the small changes over time were comparable with the method error. The method error for LII was 0.38 mm in the maxilla and 0.25 mm in the mandible, which is similar to other studies using this method (de Freitas *et al.*, 2007; Edman Tynelius *et al.*, 2010). Power analysis revealed that 22 cases/jaws were needed in order to detect a clinically significant difference in LII of 1 mm between groups. This value was chosen because 1 mm of displacement in one contact point in the anterior segment is noticeable by the patient although 1 mm divided on five displaced contact points can be ignored.

This study contained 16 and 14 mandibular retainers meaning that the sample size was to some extent small concerning the mandibular arch. However, most changes in LII during the observation period were less than 1.0 mm and therefore not clinically significant. Values that exceeded 1.0 mm were few and equally distributed in both groups and in the maxilla and mandible. Correlation between LII at T₁ and the amount of relapse during T₁–T₂ was not supported in this study, in contrast to the findings of de Freitas *et al.* (2007). Lack of compliance was therefore considered the most probable cause for differences greater than 1 mm.

A large variation in thickness among the Essix retainers used in the study was found. The retainers were generally thicker lingually than buccally. The reason for this variation was probably due to the fabrication process. However, even very thin Essix retainers (less than 0.35 mm) have the capability to maintain the treatment result. Thus, the thickness of the retainer does not seem to be a determining factor in maintaining the orthodontic treatment result.

The findings of the questionnaire demonstrated that individuals are interested in complying and maintaining the teeth in their positions. The subjects completed the questionnaire anonymously at T₂ and the results indicated that the Essix retainer was well tolerated.

Six months is a short observation period when studying stability after orthodontic treatment but as it coincides with the initial critical phase of retention and the reorganization period (approximately 200 days), it is of value. It would be interesting to see if the results from this first phase can be an indicator of further development. Longitudinal studies with a follow-up period of 1–5 years and preferably longer are necessary.

Conclusions

1. The Essix retainer proved to be sufficient for maintaining orthodontic treatment results.
2. Night-time wear appeared to be sufficient for stabilization after orthodontic treatment.
3. The Essix retainer was well tolerated by the patients.

Acknowledgement

We wish to thank all colleagues at the Orthodontic Clinic, Centre for Postgraduate Education, Örebro, Sweden, for valuable participation in the clinical procedures.

References

- Bennett M E, Tulloch J F, Vig K W, Phillips C L 2001 Measuring orthodontic treatment satisfaction: questionnaire development and preliminary validation. *Journal of Public Health Dentistry* 61: 155–160
- Clemmer E J, Hayes E W 1979 Patient cooperation in wearing orthodontic headgear. *American Journal of Orthodontics* 75: 517–524
- Colett T 1998 A rationale for removable retainers. *Journal of Clinical Orthodontics* 32: 667–669
- Cucalon A III, Smith R J 1990 Relationship between compliance by adolescent orthodontic patients and performance on psychological tests. *Angle Orthodontist* 60: 107–114
- Dahl E H, Zachrisson B U 1991 Long-term experience with direct-bonded lingual retainers. *Journal of Clinical Orthodontics* 25: 619–630
- Dahlberg G 1940 Statistical methods for medical and biological students. Allen and Unwin, London, pp. 122–132
- de Freitas K M, Janson G M R, de Freitas Pinzan A, Henriques J F, Pinzan-Vercelino C R 2007 Influence of the quality of the finished occlusion on postretention occlusal relapse. *American Journal of Orthodontics and Dentofacial Orthopedics* 132: 428. e9–e14
- Edman Tynelius G, Bondemark L, Lilja-Karlander E 2010 Evaluation of orthodontic treatment after 1 year of retention—a randomized controlled trial. *European Journal of Orthodontics* 32: 542–547
- Gill D S, Naini F B, Jones A, Tredwin C J 2007 Part-time versus full-time retainer wear following fixed appliance therapy: a randomized prospective controlled trial. *World Journal of Orthodontics* 8: 300–306
- Heier E E, De Smit A A, Wijgaerts I A, Adriaens P A 1997 Periodontal implications of bonded versus removable retainers. *American Journal of Orthodontics and Dentofacial Orthopedics* 112: 607–616
- Lee R T 1981 The lower incisor bonded retainer in clinical practice: a three year study. *British Journal of Orthodontics* 8: 15–18
- Lindauer S J, Shoff R C 1998 Comparison of Essix and Hawley retainers. *Journal of Clinical Orthodontics* 32: 95–97
- Little R M 1975 The irregularity index: a quantitative score of mandibular anterior alignment. *American Journal of Orthodontics* 68: 554–563
- Littlewood S J, Millett D T, Doubleday B, Bearn D R, Worthington H V 2006 Orthodontic retention: a systematic review. *Journal of Orthodontics* 33: 205–212
- Parker W S 1989 Retention-retainers may be forever. *American Journal of Orthodontics and Dentofacial Orthopedics* 95: 505–513
- Proffit W R, Fields H W 2007 Reorganisation of the periodontal and gingival tissues. In: Proffit W R, Fields H W, Sarver D M (eds.). *Contemporary orthodontics*. Mosby, St. Louis, pp. 618–619
- Reitan K 1967 Clinical and histologic observations on tooth movement during and after orthodontic treatment. *American Journal of Orthodontics* 53: 721–745
- Rowland H *et al.* 2007 The effectiveness of Hawley and vacuum-formed retainers: a single-center randomized controlled trial. *American Journal of Orthodontics and Dentofacial Orthopedics* 132: 730–737
- Sheridan J J 1991 The three keys of retention. *Journal of Clinical Orthodontics* 25: 717–718
- Sheridan J J, LeDoux W, McMinn R 1993 Essix retainers: fabrication and supervision for permanent retention. *Journal of Clinical Orthodontics* 27: 37–45
- Thickett E, Power S 2010 A randomized clinical trial of thermoplastic retainer wear. *European Journal of Orthodontics* 32: 1–5
- Wang F 1997 A new thermoplastic retainer. *Journal of Clinical Orthodontics* 31: 754–757
- Zachrisson B U 1977 Clinical experience with direct-bonded orthodontic retainers. *American Journal of Orthodontics* 71: 440–448