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A 3-year follow-up study of various types of orthodontic canine-to-canine retainers

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SUMMARY The present study was performed to test the tendency for plaque and calculus build-up along the wire of different types of bonded orthodontic canine-to-canine retainers, whether the presence of such retainers causes any damage to the teeth involved, the failure rate of the retainers, and any changes in incisor alignment during a 3-year period of retention. The four test groups received either retainers made of thick plain wire bonded only to the canines ($n = 11$); thick spiral wire bonded only to the canines ($n = 13$); thin, flexible spiral wire bonded to each tooth ($n = 11$); or removable retainers ($n = 14$). Accumulation of plaque and calculus along the gingival margin, gingival inflammation and probing attachment level were scored in lingual areas from canine to canine at the time of fixed appliance removal and again 3 years after retainer insertion. Incisor irregularity was measured on plaster models made at the same time periods. Accumulation of plaque and calculus and development of caries along the wire were scored at follow-up. Retainer failures were recorded whenever they occurred. The results revealed no intergroup differences in changes between baseline and follow-up examinations or status along the retainer wire for any of the variables. Gingival inflammation and plaque accumulation were scored less frequently after 3 years in retention than at the time of debonding. No signs of caries were seen adjacent to the wire. Failures were observed of one, four and three of the fixed retainer types, respectively. These patients showed a greater increase in incisor irregularity than the other patients.

Introduction

Orthodontic mandibular canine-to-canine retainers are frequently used to avoid relapse and secondary crowding of mandibular incisors. Such retainers may either be fixed or removable. Fixed retainers are typically made of a thick (0.032 inch) plain wire bonded only to the canines (Figure 1a), a thick (0.032 inch) spiral wire bonded only to the canines (Figure 1b), or a thin (0.0205 inch), flexible spiral wire bonded to each tooth (Figure 1c). Removable retainers are typically made of acrylic with wire reinforcement, and may be shaped to cover the labial and lingual surfaces of the teeth (Figure 1d).

The major advantage of bonded canine-to-canine retainers relative to removables is that they are compliance free, except possibly with regard to oral hygiene procedures. However, despite a perfect fit between the thick wire segment and the lingual surfaces of the incisors, slight incisor irregularity may not be completely prevented. Also, any wire distortion during function, either of the intercanine segment using the thick wire types, or of any of the interdental segments using the thin wire type, may be associated with unwanted tooth movements.

One major disadvantage of bonded retainers relative to removables is that the placement procedure is time consuming and technique sensitive (Zachrisson, 1977; Becker, 1987; Dahl and Zachrisson, 1991). If the retainer wire is not passive at the time of bonding, the teeth may move. Another technique-related problem is frequent bond failure, either in the wire/composite interface if too little composite is added, or in the adhesive/enamel interface in situations with moisture contamination or retainer movement during the bonding procedure (Zachrisson, 1977). However, retainer failures may occur despite meticulous place-

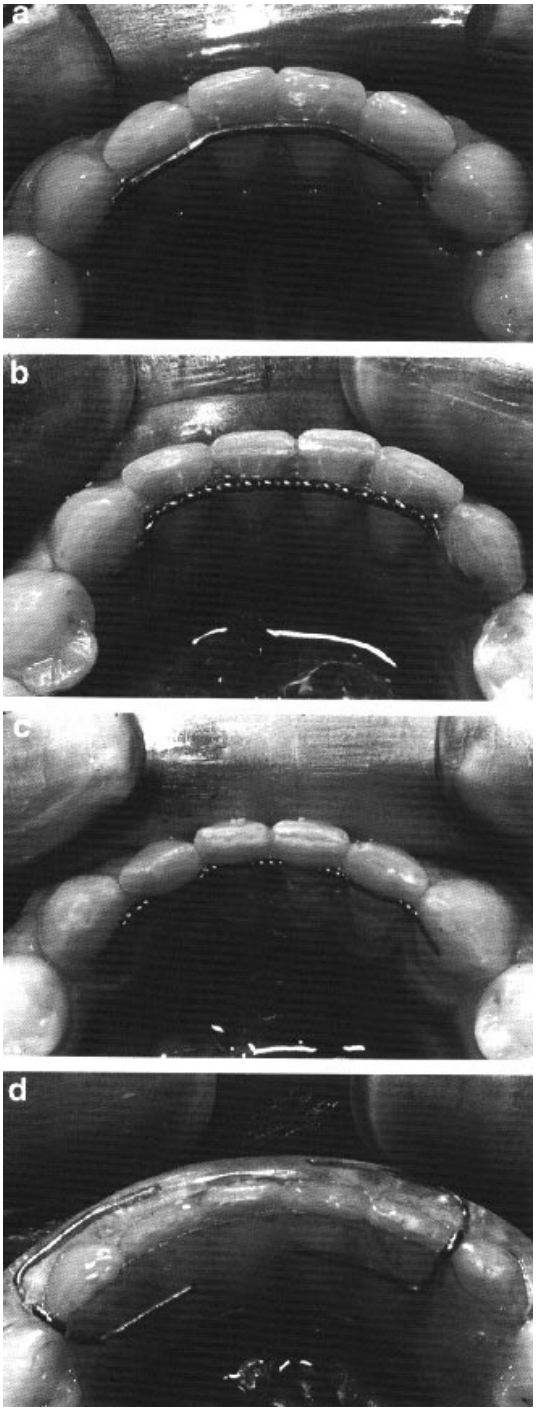

Figure 1 The different canine-to-canine retainers used in the present study: (a) 0.032 inch plain wire, bonded only to the canines; (b) 0.032 inch spiral wire, bonded only to the canines; (c) 0.0205 inch spiral wire, bonded to each tooth; (d) removable retainer.

ment techniques (Zachrisson, 1977; Becker, 1987; Dahl and Zachrisson, 1991), and have been analysed following use of thin, flexible spiral wires bonded to each tooth in maxillary and mandibular anterior segments (Dahl and Zachrisson, 1991). In addition to bond failure, stress fracture of the interdental wire segments was reported. However, few studies have compared failure rates of the different types of mandibular canine-to-canine retainers.

Another major disadvantage of bonded retainers is the tendency for plaque and calculus to accumulate along the retainer wire over time (Gorelick *et al.*, 1982; Årtun, 1984). This might be expected to be more pronounced along retainers made of spiral wire, due to retention areas in the undercuts of the spiral wire. However, a cross-sectional follow-up study suggested that the period of orthodontic retention was more important than the configuration of the wire (Årtun, 1984). The presence of the retainer did not seem to have a negative effect on the periodontal tissues, regardless of accumulation of plaque and calculus along the wire (Årtun, 1984). In addition, few signs of caries have been found on lingual enamel surfaces adjacent to the wire, despite plaque and calculus build-up (Gorelick *et al.*, 1982; Årtun, 1984).

Since the observation periods of the experimental groups were different in the follow-up study mentioned above (Årtun, 1984) and since the patients in the experimental groups were collected from two different practices, a clinical trial was designed to eliminate those variables. Any adverse effects of the three types of fixed, orthodontic canine-to-canine retainers (Figure 1a–c) and removable spring retainers (Figure 1d) were compared in groups of matched patients. Short-term results failed to detect any differences in plaque and calculus accumulation along the retainer wires of the different types, or any difference in gingival inflammation among patients with bonded and removable retainers (Årtun *et al.*, 1987). The purpose of this study was to analyse any differences after a retention period of 3 years, and also to analyse failure rate and the ability to maintain incisor alignment of the different retainer types.

Subjects and methods

Experimental groups

A total of 49 patients in the finishing phase of orthodontic treatment for various types of malocclusion were selected from the files of two orthodontists sharing one practice. The patients had been treated with an edgewise light-wire technique with bonded brackets anterior to the first molars. On the basis of age (adults versus adolescents), gender, and gingival condition at the lingual aspect of the mandibular anterior teeth at the time of appliance removal (gingival bleeding versus no gingival bleeding), the experimental subjects were classified in eight strata. From each stratum the patients were randomly assigned to four test groups.

Experimental design

Routine adhesive removal and polishing were performed (Zachrisson and Årtun, 1979) before different types of orthodontic canine-to-canine retainers were inserted in the four test groups. One group received retainers of thick plain wire bonded only to the canines (n = 11, Figure 1a). The second group received retainers made of thick spiral wire bonded only to the canines (n = 13, Figure 1b), and the third group received a thin flexible spiral wire bonded to each tooth in the segment (n = 11, Figure 1c). The fourth group received removable retainers (n = 14, Figure 1d). These patients had previously participated in a short-term clinical trial, in which one young and one adult male without gingival bleeding were eliminated from the group with thick spiral wire bonded only to the canines, as well as one young and one adult male without gingival bleeding and one young female with gingival bleeding from the group with removable retainers. The elimination was undertaken to secure equal number of patients from each stratum in each experimental group. In this study all the patients were included.

The fixed retainers were bent indirectly on plaster models made just prior to removal of the orthodontic appliances. The wires were fitted to the incisal portion of the teeth to avoid contact with the gingival papillae. The retainers were bonded with Concise (3M Dental Products Division, St Paul, MN 55144) by the primary investigator according to the procedures described earlier (Årtun and Zachrisson, 1982). The removable retainers were made at a dental laboratory.

At the time of appliance removal and insertion of the retainers, all patients were taught correct oral hygiene procedures with toothbrush and dental floss. The patients with bonded retainers were shown how to use floss-threaders.

Clinical evaluations

Prior to appliance removal and 3 years after insertion of the retainers, the subjects were scored for their accumulation of plaque and calculus and gingival inflammation along the gingival margin of the mandibular incisors and canines according to the Plaque Index (Pl I) system (Löe, 1967), Calculus Index (Calc I) component of the Periodontal Disease Index system (Ramfjord, 1959) and Gingival Index (G I) system (Löe, 1967), respectively. Probing attachment level or the distance from the cemento–enamel junction to the bottom of the gingival pocket was also recorded, using a University of Michigan No. 0 probe with Williams markings at a non-standardized light force. The measurement was made to the nearest whole millimetre, with the exception that measurements close to 0.5 mm were always rounded to the lower whole number (Ramfjord, 1959). At the 3-year post-insertion check, the patients were also scored for their oral hygiene condition along the retainer wire using a modification of the Plaque Index system of Löe (1967) and the Calculus Index component of the Periodontal Disease Index system of Ramfjord (Årtun, 1984). The scorings were carried out by the dental hygienist who participated in the short-term follow-up examination (Årtun *et al.*, 1987).

Plaque and calculus were scored both incisally and gingivally along the retainer wire in areas corresponding to the interproximal sites from the distal of one canine to the distal of the other canine, and at all midlingual sites from canine to canine. At the bonding sites, scorings were performed at the transitions between the composite and the enamel. Pl I, G I and Calc I were scored in all interproximal and midlingual areas from canine to canine. As recommended by

Löe (1967), the assessments of Pl I always preceded those of G I. Probing attachment level was scored only at the midlingual aspects of canines and incisors. Calculus found at baseline and follow-up examinations was removed.

Retainer failures were recorded whenever they occurred. Failed bonded retainers were substituted with removable retainers, following removal of wire and composite remnants from the teeth. Lost or broken removable retainers were replaced.

Measurements on study models

Incisor irregularity was evaluated by the senior author according to the Irregularity Index (Little, 1975). The index is the sum of the linear displacements of the anatomic contact points of each mandibular incisor from the adjacent tooth anatomic point. Measurements were made to the nearest tenth of a millimetre using a digital caliper (Fred V. Fowler Co., Inc., Newton, MA) on study models made at the time of appliance removal and again at the 3-year follow-up check.

Error of the method

The reproducibility of the hygienist's measurements for plaque along the wire, Pl I, and G I have been reported earlier (Årtun *et al.*, 1987). The reproducibility of the measurement for the Irregularity Index was assessed by analysing statistically the difference between double measurements taken at least 1 week apart on 20 study models selected at random. The error of the method was calculated from the equation

$$S_x = \sqrt{\frac{\sum D^2}{2N}}$$

where D is the difference between duplicated measurements and N is the number of double measurements (Dahlberg, 1940). The error was 0.16 mm.

Data analysis

The mean score per patient was calculated for Pl I and G I. The scores for plaque and calculus along the retainer wire and Calc I were dichotomized into scores 0 and scores 1+2. Repeated measurements for analysis of variance were conducted to determine any statistically significant differences in scores among types of retainers with time, eliminating patients with retainer failures from the analysis. The same analysis was used to determine any statistically significant differences in the Irregularity Index with time among the groups of patients with the presence of the different types of retainers and the patients with failures. A Kruskal–Wallis analysis was used to determine any differences in probing attachment loss between the patients in the different retainer groups, eliminating patients with retainer failures from the analysis.

Results

Retainer failures

A total of eight of the 35 bonded retainers (22.9 per cent) failed, one during the first year, one during the second year, and six during the third year. Failures occurred in four of the 13 retainers made of thick spiral wire bonded only to the canines (30.8 per cent), one of the 11 made of thick plain wire bonded only to the canines (9.1 per cent), and three of the 11 made of thin, flexible spiral wire bonded to each tooth (27.3 per cent). Two of the 14 removable retainers (14.3 per cent) were lost during the course of the study.

Scores along the retainer wire

Accumulation of plaque. Visible plaque was not observed along any retainer wire. Plaque was recorded more frequently gingivally than incisally relative to the wire ($P < 0.001$, Table 1). Analysis of the interaction between retainer group and surface of wire indicated no significant difference between the retainer wires in terms of the presence of plaque along either surface (Table 1).

Accumulation of calculus. Moderate accumulation of calculus was seen gingival to the wire at five, six and 11 sites, respectively, in three of the 11 patients with retainers of thick plain wire; at two sites in one of the 13 patients with retainer of thick spiral wire; and at 11 sites in one of the 11 patients with retainers of thin, flexible spiral wire. The latter patient presented with calculus along the gingival margin both at the baseline

Table 1 Mean percentage area with presence of plaque (score 1 + 2) incisally and gingivally along the different retainer wire types at 3 years in retention in the different retainer groups. (Standard error given in parentheses.)

	All retainers	Thick plain wire bonded only to canines	Thick spiral wire bonded only to canines*	Thin spiral wire bonded to incisors and canines
Incisally	3.70 (1.39)	2.22 (2.14)	8.02 (2.25)	0.69 (2.39)
Gingivally	18.72 (3.97)	19.44 (6.69)	22.22 (7.06)	13.89 (7.48)

Repeated measures of analysis of variance: main effect of surface (incisal versus gingival): $F = 16.6$; d.f. = 1/24; $P = 0.0004$; interaction of retainer type by surface: $F = 0.1$, d.f. = 2/24, $P = 0.89$.

Table 2 Mean scores for accumulation of plaque (Pl I) along the gingival margin at the time of appliance removal (baseline) and at 3 years in retention in the different retainer groups. (Standard error given in parentheses.)

	All retainers*	Thick plain wire bonded only to canines*	Thick spiral wire bonded only to canines*	Thin spiral wire bonded to incisors and canines*	Removable retainers
Baseline	0.27 (0.07)	0.32 (0.20)	0.17 (0.08)	0.26 (0.20)	0.31 (0.11)
At 3 years	0.11 (0.02)	0.06 (0.02)	0.10 (0.03)	0.13 (0.07)	0.13 (0.06)

Repeated measures of analysis of variance: main effect of time (baseline versus 3 years): $F = 4.89$; d.f. = 1/37; $P = 0.033$; interaction of retainer type by time: $F = 0.31$; d.f. = 3/37; $P = 0.82$.
*Does not include failures.

and follow-up examinations, as opposed to the other four patients.

Formation of caries. Signs of carious white spot lesions were not found in any patient.

Scores along the gingival margin

Accumulation of plaque. Pl I score 3 was not recorded in any area. Based upon mean scores, less accumulation of plaque was found at the 3-year follow-up examination than at the time of debonding ($P < 0.05$, Table 2). Analysis of the interaction between retainer groups and time of registration indicated no differences between the groups at either registration, and that the difference between the two examinations was significant within the groups (Table 2).

Accumulation of calculus. Subgingival calculus was not recorded in any area. No significant difference was found in accumulation of calculus between the baseline and follow-up examinations (Table 3). The interaction between retainer groups and time of examination was not significant (Table 3), indicating no intergroup differences in accumulation of calculus at either examination.

Gingival inflammation. Spontaneous bleeding was not recorded in any area. Based upon mean scores, gingival health was significantly better at the 3-year follow-up examination than at the time of appliance removal ($P < 0.0001$, Table 4). Analysis of the interaction between retainer groups and time of registration indicated no differences between the groups at either registration, and that the difference between the two examinations was significant within the groups.

Loss of attachment. No areas with 3 mm attachment loss were found. Mean attachment loss was 0.85 mm (SD = 0.55) for the patients with retainers of thick plain wire bonded only to the canines, 0.63 mm (SD = 0.20) for the patients with retainers of thick spiral wire bonded only to the canines, 0.62 mm (SD = 0.25) for the patients with retainers of thin, flexible spiral wire bonded to each tooth, and 0.72 mm (SD = 0.33) for the

Table 3 Mean percentage area with presence of calculus (Calc I score 1) along the gingival margin at the time of appliance removal (baseline) and at 3 years in retention in the different retainer groups. (Standard error given in parentheses.)

	All retainers*	Thick plain wire bonded only to canines*	Thick spiral wire bonded only to canines*	Thin spiral wire bonded to incisors and canines*	Removable retainers
Baseline	12.60 (3.11)	16.67 (8.03)	8.64 (4.45)	17.36 (6.84)	9.52 (5.45)
At 3 years	7.72 (2.57)	3.33 (2.22)	3.09 (3.09)	17.36 (8.87)	8.33 (5.61)

Repeated measures of analysis of variance: main effect of time (baseline versus 3 years): $F = 1.61$; d.f. = 1/37; $P = 0.21$; interaction of retainer type by time: $F = 0.60$; d.f. = 3/37; $P = 0.62$.
*Does not include failures.

Table 4 Mean scores for gingival inflammation (G I) at the time of appliance removal (baseline) and at 3 years in retention in the different retainer groups. (Standard error given in parentheses.)

	All retainers*	Thick plain wire bonded only to canines*	Thick spiral wire bonded only to canines*	Thin spiral wire bonded to incisors and canines*	Removable retainers
Baseline	1.05 (0.04)	1.01 (0.10)	0.95 (0.07)	1.14 (0.07)	1.08 (0.07)
At 3 years	0.61 (0.07)	0.66 (0.14)	0.49 (0.13)	0.39 (0.15)	0.77 (0.11)

Repeated measures of analysis of variance: main effect of time (baseline versus 3 years): $F = 42.10$; d.f. = 1/37; $P < 0.0001$; interaction of retainer type by time: $F = 1.70$; d.f. = 3/37; $P = 0.18$.
*Does not include failures.

patients with removable retainers. No differences in probing attachment loss were found between the groups.

Incisor irregularity. Based upon mean scores, the Irregularity Index was higher at the 3-year follow-up examination than at the time of appliance removal ($P < 0.01$, Table 5). Analysis of the interaction between retainer groups and time of registration indicated that the patients with retainer failure experienced a different change than the patients with retainers in place.

Discussion

The patients who participated in this prospective, clinical study were treated in a relatively large orthodontic practice, in which several routine procedures were performed by various staff members. Despite instructions to the staff not to perform any professional cleaning procedures on these patients, occasional scaling cannot be ruled out. Another uncontrolled variable is any cleaning performed during recalls to the respective general dentists. Under such circumstances, our findings suggest only a minor tendency for plaque and calculus to accumulate along the wire of bonded mandibular canine-to-canine retainers over a 3-year period. Visible plaque was not observed in any area, and eight of the 27 patients with intact bonded retainers presented without scorable plaque along the retainer wire. These results also support previous studies (Årtun, 1984; Årtun *et al.*, 1987) and indicate that bonded retainers made of spiral wire do not accumulate more plaque and calculus than those made of plain wire. Furthermore, our observations confirm that despite occasional accumulation of plaque and calculus along such retainers, formation of caries is not a problem. These data support other studies (Gorelick *et al.*, 1982; Årtun, 1984) and may suggest that

Table 5 Mean scores for the irregularity index at the time of appliance removal (baseline) and at 3 years in retention in the different retainer groups. (Standard error given in parentheses.)

	All retainers*	Thick plain wire bonded only to canines*	Thick spiral wire bonded only to canines*	Thin spiral wire bonded to incisors and canines*	Removable retainers	All failures
Baseline	0.40 (0.08)	0.65 (0.24)	0.20 (0.08)	0.30 (0.16)	0.36 (0.13)	0.49 (0.31)
At 3 years	0.83 (0.15)	1.19 (0.27)	0.36 (0.12)	0.30 (0.16)	0.66 (0.25)	1.74 (0.65)

Repeated measures of analysis of variance: main effect of time (baseline versus 3 years): $F = 12.26$; d.f. = 1/44; $P = 0.0011$; interaction of retainer type by time: $F = 2.53$; d.f. = 4/44; $P = 0.054$.
*Does not include failures.

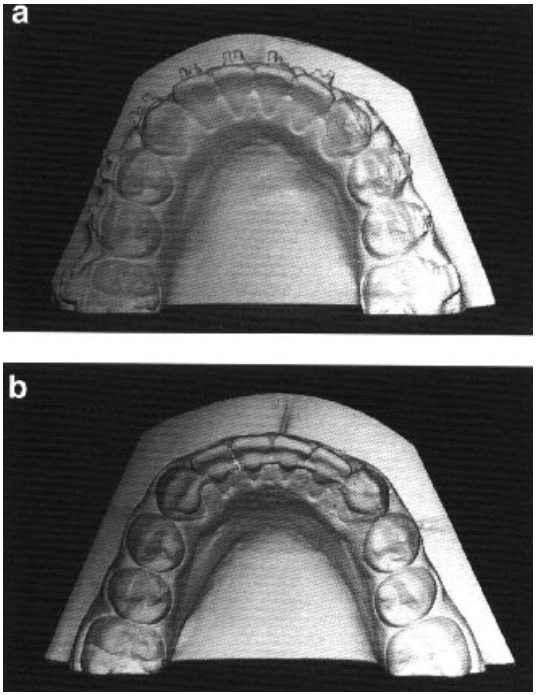

Figure 2 Study models made at the time of appliance removal (a) and 3 years later (b) of a patient with a mandibular canine-to-canine retainer made of thin, flexible spiral wire bonded to each tooth. Note no changes in incisor alignment.

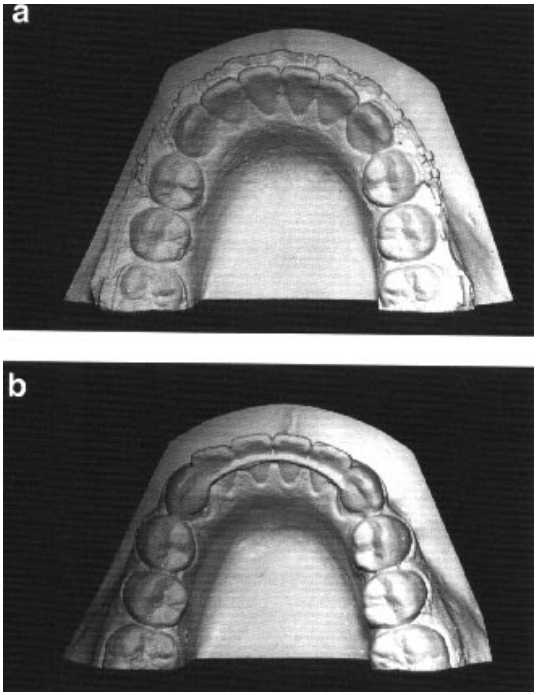

Figure 3 Study models made at the time of appliance removal (a) and 3 years later (b) of a patient with a mandibular canine-to-canine retainer made of thick plain wire bonded only to the canines. Note slight rotations of the lateral incisors during the period of retention.

accessibility to free flow of saliva is a major factor precluding enamel decalcification.

In keeping with previous studies (Årtun, 1984; Årtun *et al.*, 1987), the presence of a bonded retainer did not seem to have any negative effect upon the patient´s ability to achieve satisfactory hygiene along the gingival margin. In fact, accumulation of plaque and gingival inflammation was scored less frequently at 3 years in retention than at the time of debonding. One possible explanation for this is that the presence of orthodontic appliances influenced the base-

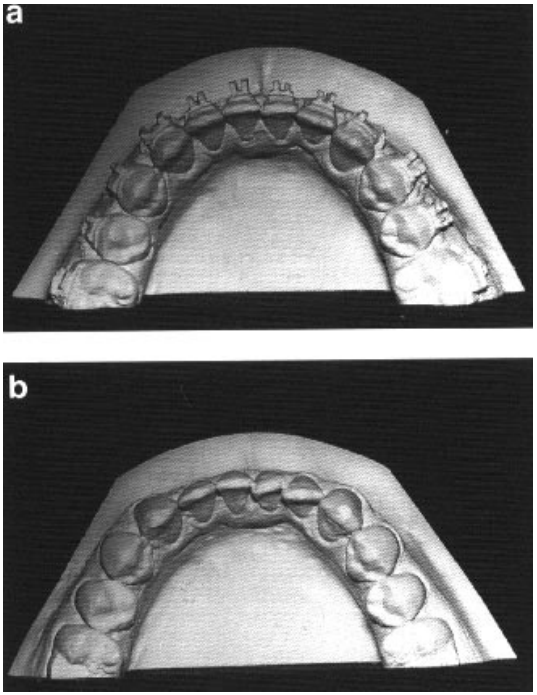

Figure 4 Study models made at the time of appliance removal (a) and 3 years later (b) of a patient with failure of a mandibular canine-to-canine retainer after 5 months, and subsequent loss of the substituted removable retainer. Note gross relapse of the mandibular incisors.

line examination. Inflammatory response in the gingival tissues to fixed orthodontic appliances is well documented (Zachrisson and Zachrisson, 1972; Alstad and Zachrisson, 1979). However, all the patients in the present study were treated with multibonded appliances, which are less likely to affect the gingival tissues in lingual areas than appliances employing orthodontic bands. The most likely explanation for the enhancement in gingival health is the generally higher oral hygiene level associated with improvement in toothbrushing accessibility after appliance removal.

The primary investigator was not available for retainer maintenance, and the routine in the practice from which the patients were recruited was to utilize removable retainers. For those reasons, removable retainers were substituted for any lost or broken bonded retainer during the course of the experiment. It should be stressed that the drop-out rate due to retainer failures, and inclusion of all the subjects with available baseline data in the study, caused a slightly uneven distribution of gender, age and gingival status at baseline among the subjects in the experimental groups. Another problem may be the risk of emphasizing the influence of single results due to the relatively small group sizes used. Regardless of this, the results may be considered valid since no significant intergroup differences existed in baseline observations of oral hygiene level and gingival status, and since the variation of the observations was similar at follow-up (Tables 2–4).

Failure of five of the 24 retainers (20.8 per cent) made of thick wire bonded only to the canines was observed. This failure rate is higher than the 11.6 per cent reported by Zachrisson (1977). The discrepancy may be explained by the relatively shorter observation time of from 12 to 30 months in Zachrisson´s study and the fact that the majority of the failures in this study occurred during the third year of observation. Failure of three of the 11 retainers (27.2 per cent) made of thin, flexible spiral wire was also observed. Respective comparable findings of Becker (1987) and Dahl and Zachrisson (1991) are failures of one of 11 (9.1 per cent) and six of 29 (20.7 per cent) of such retainers. Using flexible spiral wire retainers bonded to each tooth, failures may occur both at the bonding sites and as stress fracture of interdental wire segments (Dahl and Zachrisson, 1991). There are indications that the use of a wire with five strands rather than three, as in our study, may increase the success rate because the tendency for stress fracture reduces using multistranded wire (Dahl and Zachrisson, 1991). The results of this study suggest that despite appropriate bonding techniques, failures may be observed in approximately 20 per cent of various designs of bonded, mandibular canine-to-canine retainers. However, in keeping with Becker (1987), the experience of the primary investigator in this study is that in most cases of failure, the repair procedures are easy and require a minimum of chairtime. It should also be stressed that patients may lose or break removable retainers. In this study, two of the 14 patients (14.3 per cent) who were given removable retainers lost the original.

Our results suggest that the different retainer designs were equally efficient in maintaining incisor alignment. However, careful observation of individual cases revealed no change in incisor irregularity among the patients with retainers bonded to each tooth (Figure 2) and occasional cases of minor change in alignment among the patients with retainers bonded only to the canines (Figure 3). Gross changes due to wire distortions were not observed. The obvious reasons for the increased irregularity among the patients with retainer failures may be due to the changes that occurred during the time lapse between actual and reported failure or lack of retainer substitution (Figure 4). Contrary to intentions, two of the eight patients with failures were not given a removable retainer, and another two lost the removable retainers they were given.

It may be concluded that bonded, orthodontic canine-to-canine retainers effectively maintain incisor alignment following orthodontic treatment. However, a failure rate of approximately 20 per cent may be expected during a period of 3 years. Occasional cases of slight incisor relapse may occur using retainers bonded only to the canines, but gross malalignment due to wire distortion is rare. There seems to be no basis for claiming that canine-to-canine retainers made of spiral wire tend to accumulate more plaque and calculus than retainers made of plain wire. The presence of a retainer and the occasional accumulation of plaque and calculus along the wire cause no apparent damage to the hard and soft tissues adjacent to the wire.

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