Effectiveness of lingual retainers bonded to the canines in preventing mandibular incisor relapse

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Introduction: A retainer bonded to the lingual surfaces of the mandibular canines (3-3 retainer) is a widely used type of retention. Our aim in this study was to assess the effectiveness of the 3-3 mandibular lingual stainless steel retainer to prevent relapse of the orthodontic treatment in the mandibular anterior region.

Methods: The sample consisted of the dental casts of 235 consecutively treated patients (96 boys, 139 girls) from the archives of the Department of Orthodontics and Oral Biology, Radboud University Nijmegen Medical Center, The Netherlands, who received a 3-3 mandibular lingual stainless steel retainer at the end of active orthodontic treatment. The casts were studied before treatment (T5), immediately after treatment (T0), and 2 years (T2), and 5 years (T5) posttreatment. Results: The main irregularity index decreased significantly from 7.2 mm (SD, 4.0) at T5 to 0.3 mm (SD, 0.5) at T0; it increased significantly during the posttreatment period to 0.7 mm (SD, 0.8) at T2 and 0.9 mm (SD, 0.9) at T5. The irregularity index was stable during the 5-year posttreatment period (T0-T5) in 141 patients (60%) and increased by 0.4 mm (SD, 0.7) in 94 patients (40%). The intercanine distance increased 1.3 mm between T5 and T0 and remained stable during the posttreatment period. Conclusions: The 3-3 mandibular lingual stainless steel retainer (bonded to the canines only) is effective in preventing relapse in the mandibular anterior region in most patients, but a relatively high percentage will experience a small to moderate increase in mandibular incisor irregularity. (Am J Orthod Dentofacial Orthop 2008;134:179.e1-179.e8)
canines was 80%, much higher than in the other 2 groups. However, the average increase in irregularity was rather small (median, 0.4 mm), and the intercanine distance remained stable.

A stable intercanine distance was also reported by Lang et al., who retrospectively studied posttreatment stability in 132 patients for 6 years on average (± 1.2 years) after active orthodontic treatment. The 121 patients who received a bonded mandibular 3-3 retainer attached only to the canines experienced small post-treatment increases of the irregularity index (0.3 mm on average). This increase cannot be attributed to lack of control by the lingual retainer, since many patients discontinued their retention before the follow-up. Only 85 of the 132 patients still used a mandibular retainer at the follow-up control (it is not clear from the data whether a few had a removable retainer); this group had even smaller posttreatment increases of the irregularity index (0.2 mm on average).

From the above-mentioned studies, it is difficult to reach any definite conclusions about the posttreatment stability of the mandibular anterior teeth with a bonded lingual retainer as the retention device, since they are based on small patient groups or short observation periods. In the absence of evidence, we aimed to assess the effectiveness of the mandibular lingual stainless steel retainer (bonded to the canines only) in a large group of patients over a long period of time.

MATERIAL AND METHODS

Our material consisted of dental casts from the archives of the Department of Orthodontics and Oral Biology, Radboud University Nijmegen Medical Center, The Netherlands. We selected 235 patients according to the following criteria: (1) treated with full fixed appliances; (2) had lingual retainer bonded only to the mandibular canines with the same wire dimensions (0.0215 x 0.027-in stainless steel rounded rectangular wire) (Fig 1); (3) both mandibular permanent canines present before treatment; (4) no spacing in the mandibular anterior region before and after treatment; (5) no retreatment; and (6) dental casts were available before treatment (Ts), after treatment (T0), at least 2 years after treatment (T2), and at least 5 years after treatment (T5).

No interproximal enamel reduction or circumferential supracrestal fiberotomy was systematically performed.

The measurements for both the irregularity index and the intercanine distance were made with an electronic caliper (digital 6, Mauser, Winterthur, Switzerland) with an accuracy of 0.01 mm. The beaks of the electronic caliper were sharpened to a fine edge to permit access and make accurate measurements.

The intercanine distance was measured from the middle of the cusp of the mandibular left canine to the middle of the cusp of the mandibular right canine. In case of abrasion of a cusp, an estimation of the middle of the surface was made.

The irregularity index (Fig 2) was used to describe the contact point displacement of the mandibular anterior teeth. The irregularity index is the sum (in millimeters) of the 5 distances between the anatomic contact areas from the mesial aspect of the left canine through the mesial aspect of the right canine.

When anatomic contact points of adjacent teeth are touching, the measurement was zero. With increased irregularity, greater displacement leads to an increased index score. Before measurement, the anatomic contact areas of the mandibular incisors and the mesial anatomic contact areas of the canines were marked on the dental casts. The linear distance between the markings was then measured, and the 5 values were added. Because the beaks of the caliper were sharpened, it was possible to measure very small distances, often resulting in irregularity index values just marginally larger than 0 mm. The irregularity index was not rounded, but it was decided to consider all patients with scores smaller than 0.25 mm to have a perfect irregularity.
index. These measurements were made at Ts, T0, T2, and T5.

Sex, age, treatment duration, and failures were obtained from the patient files. Angle classification was determined on the right side of the plaster models. Sagittal contact of the incisors after treatment was determined from the plaster models in occlusion. Regarding extractions, patients were divided into 4 categories: nonextraction, extraction of 1 premolar in every quadrant, no extraction in the mandibular arch and extraction of 1 premolar or first molar in both maxillary quadrants, and without extraction in the mandibular arch and extraction of the second molars in both maxillary quadrants. In patients with an increase of the irregularity index from T0 to T5, the direction of the displacement of the teeth was assessed. When the displacement was in the direction of the initial situation, it was judged to be relapse. Retainer failures were obtained from the patient files. If the retainer was completely loose, the number of failures was counted as 2.

One observer (A-M.R.) made all measurements. To determine the measurement error and assess the intraobserver and interobserver agreement of both the intercanine distance and the irregularity index, a random sample of the 76 dental casts of 19 patients was, after calibration, evaluated by the main observer (A-M.R.) and by a second observer (S.A-A.). The 2 observers measured the 76 dental casts twice, with 3 months between the first and second measurements. The Angle classification, sagittal contact of the incisors, failures, and relapse were assessed twice by 1 observer (A-M.R.).

**Statistical analysis**

Descriptive statistics with means and standard deviations were used to report the findings at Ts, T0, T2, and T5. Box plots were made for visual representations of distributions of the values measured.

For our analysis, the following factors that could have influenced the posttreatment changes in intercanine distances were taken into account: age at the start of treatment, treatment duration, extractions, posttreatment sagittal contact of the incisors, posttreatment intercanine distance (at T0), and number of failures. From T0 to T2, and from T0 to T5, 2 backward linear regression models were built to analyze the relationship between these potential explanatory variables and the changes in intercanine distance. The threshold for a variable to stay in the model during the backward elimination process was set at $P = 0.10$.

For the factors potentially influencing changes in irregularity index, a similar procedure was applied, with 1 important difference. The distribution of the irregularity index did not allow for the use of a linear regression model. Therefore, the increment of the irregularity index was dichotomized (0 for values smaller than 0.25 mm, 1 for larger values), and logistic linear regression models were used. The following factors were considered: age at the start of treatment, treatment duration, extractions, posttreatment sagittal contact of the incisors, changes in intercanine distance, pretreatment and posttreatment irregularity index values, and number of failures.

**RESULTS**

With regard to the intercanine distance, the duplicate measurement errors were 0.18 mm for observer 1 (A-M.R.) and 0.24 mm for observer 2 (S.A-A.). The reliability coefficients were 0.991 for observer 1 and 0.985 for observer 2 (S.A-S.). The mean interobserver difference was 0.01. This difference was not statistically significant ($P = 0.723$; confidence interval of the difference: $-0.059-0.090$ mm). For the irregularity index, the duplicate measurement errors were 0.12 and 0.20 mm, respectively. The reliability coefficients were 0.998 and 0.997. The mean difference between the 2 observers was 0.07 mm. This difference was statistically significant ($P = 0.032$; 95% confidence interval of the difference: 0.006-0.133 mm).

For Angle classification, failure, and relapse, the level of reliability was high ($\kappa = 1$); it was also high ($\kappa = 0.89$) for sagittal contact.

In the total sample, 96 patients (41%) were boys, and 139 (59%) were girls. The distribution of the Angle classifications at Ts was 40 Class I, 191 Class II, and 4 Class III patients. The mean ages were 12.8 years (SD, 2.7) at the beginning of the orthodontic treatment and 15.6 years (SD, 2.7) at the end of treatment. The mean treatment duration was 2.8 years (SD, 1.0). The distribution of the extraction categories was 63 subjects (26.8%) with extraction of 4 premolars, 39 (16.6%) without extraction in the mandibular arch and extraction of 1 premolar or first molar in both maxillary quadrants, 9 (3.8%) without extraction in the mandibular arch and extraction of the second molar in both maxillary quadrants, and 124 nonextraction subjects (52.8%).

The intercanine distances at Ts, T0, T2, and T5 are shown in Figure 3. As a result of the orthodontic treatment, the mean intercanine distance increased by 1.3 mm, from 25.8 mm at Ts to 27.1 mm at T0. The mean values of the intercanine distance remained stable—27.3 mm at T2 and 27.2 mm at T5.

The irregularity index values at all stages are shown in Figure 4. The mean irregularity index for the whole
At T0, there were 154 patients with an irregularity index value of zero, and 81 with values of 0.25 to 1.80 mm (Fig 5). Since at T0 not all patients had an irregularity index value of zero, the sample was split into 2 groups. If we follow the development in the first group, we can see that, because of the increase of the irregularity index value, the numbers of patients with a score of 0 mm were reduced to 104 at T2 and to 97 at T5. In other words, 67.5% of these patients remained stable from T0 to T2, and 63.0% remained stable from T0 to T5. In the second group, the numbers of patients with no change in the irregularity index were 51 at T2 and 44 at T5. In this group, 63.0% of the patients were stable from T0 to T2, and 54.3% were stable from T0 to T5. For the whole sample, we can state that, in 66.0% of the subjects (n = 155), the irregularity index was stable at T2, and, in 60.0% (n = 141), it was stable at T5 (Fig 5).

An alternative way to judge the development of irregularity is not to look at the irregularity index at the different stages but to look at its increments between T2 and T0, and between T5 and T0 (Fig 6). An increment of ≤ 1.00 mm was measured in 201 subjects from T2 to T0, and in 186 from T5 to T0. Assuming that an increment of ≤ 1.00 mm is clinically irrelevant, we can characterize the alignment of the mandibular front teeth as stable in 85.5% of the patients at T2 and in 79.1% at T5. The largest increments were 3.92 mm from T2 to T0 and 4.32 mm from T5 to T0.

In the group of patients whose irregularity index increased from T0 to T5 (n = 94), in 49 patients (52.1%) this irregularity was not in the direction of the initial condition, but, in 45 patients (47.9%), the irregularity was in the direction of the initial irregularity. In the latter group, relapse occurred, for a relapse rate of 19.1% for the total sample.

The distribution of failures for the time periods is shown in the Table 1. At T5, 187 patients (79.6%) had never had a failure of their bonded retainer, whereas 48 patients (20.4%) had at least 1 failure of their bonded retainer. The failure rates (ie, failures per year) were 12.1% from T0 to T2 and 6.4% from T0 to T5. These rates were calculated by comparing the number of failures (57 and 75) with the number of patients (235) divided by the time period in years (2 and 5).

Two backward linear regression models were built with changes in the intercanine distance as the dependent variables and potential explanatory variables as the independent variables: the first for changes at T2, and the second for changes at T5. In the first model, no explanatory variable remained. For the model covering the 5-year interval, only the number of retainer failures remained. The effect of a failure was estimated to be a
decrease of the intercanine distance by 0.033 mm for each failure in the 5-year interval (95% CI: –0.069-0.03), with a $P$ value of 0.075.

For changes in the irregularity index, again 2 backward logistic models were built. The first had an increment of the irregularity index from T2 to T0 as the dependent variable. The second model analyzed the period from T5 to T0. For the 2-year interval, only the number of retainer failures in the first 2 years remained in the model. The effect of this variable, expressed by odds ratio, was 1.76 (96% CI: 1.13-2.76) with a $P$ value of 0.013. For the 5-year interval, again the number of retainer failures in this period was the only variable remaining in the model. The odds ratio was 1.80 (95% CI: 1.21-2.66), with a $P$ value of 0.004.

**DISCUSSION**

The material in this retrospective study was obtained from patients treated at the Department of Orthodontics and Oral Biology, Radboud University...
After retention, the mandibular intercanine distance of intercanine distance after orthodontic treatment. Other researchers found more or less increase with the results of Kaplan and Gardner and Chaconas. In our study, with a bonded lingual retainer, the mean values of the intercanine distance were stable 2 and 5 years after treatment. The differences between the values of the intercanine distance at T0, T2, and T5 are within the measurement error. This demonstrates that the lingual retainer bonded only to the mandibular canines is effective in maintaining the intercanine distance, as was found in earlier studies. In patients with failure of the bonded retainer, we found a small decrease in the intercanine distance. This agrees with the development of the intercanine distance in patients whose retention was discontinued.

At T2, the irregularity index was stable in 66% of the patients; at T5, it was stable in 60% of the patients. In his article about the irregularity index, Little used a subjectively ranked scale with the following criteria: 0 mm, perfect alignment; 1-3 mm, minimal irregularity; 4-6 mm, moderate irregularity; 7-9 mm, severe irregularity; and 10 mm, very severe irregularity. This implies that an increment of ≤ 1.00 mm is clinically irrelevant. With this assumption in mind, the alignment of the mandibular front teeth in our sample can be characterized as stable in 88.5% of the patients at T2 and in 79.1% of the patients at T5. In 6.0% of the patients (n = 14), the increment of the irregularity index from T0 to T5 was more than 2.00 mm, and the largest increment during that time was 4.32 mm, which is unacceptable. The increase of the irregularity from T0 to T5 was irrespective of pretreatment irregularity, age at the start of treatment, treatment duration, extractions, posttreatment sagittal contact between incisors, changes in the intercanine distance, and posttreatment irregularity (at T0). The only responsible factor that could be determined was the number of failures. The obvious reason for the increased irregularity among the patients with retainer failures might be the changes that occurred during the time lapse between the actual and reported failures.

Ártun et al found in their prospective study minor changes in alignment in the patients with retainers bonded only to the canines; in patients with failures of the retainer, the changes were larger. These findings are comparable with our results. It was suggested that less change in alignment might be expected when retention with the bonded 3-3 retainer is combined with interproximal enamel reduction and circumferential supracrestal fiberotomy, but this was not systematically performed in our sample. There is some evidence that circumferential supracrestal fiberotomy leads to an...
increase in stability in both the maxillary and mandibular anterior segments, but this evidence was judged by the Cochrane systematic review as weak and unreliable because of flaws in the study design.

In only 47.9% of the patients, the development of irregularity was in the direction of the initial irregularity. This finding agrees with the study of Little et al., who found that as many as half of the rotations or displacements returned in a pattern different from the original condition. This fact confirms that we cannot automatically claim relapse for postretention displacement of the anatomic contact points of the mandibular anterior teeth.

In this study, 20.4% of our patients experienced retainer failures. The failure rates (failures per year) were 12.1% from T0 to T2 and 6.4% from T0 to T5. Our failure rate might be higher because we cannot rule out that, in some subjects, the patient’s dentist rebonded the retainer. Reported failures of 3-3 bonded retainers vary widely from 0.1% to 30.8% of the patients. Because of the wide variety of observation periods and materials, it is difficult to compare these findings with ours.

Failures can be inherent, as a result of poor chairside technique, or acquired, from wear or direct trauma to the retainer. The difference in failure rates can also be attributed to various bonding techniques and bonding materials. The patients in our study received their retainers between 1985 and 1993. Bonding materials have improved over the years, increasing the durability and effectiveness of bonded appliances and decreasing the numbers of failures. Because failures of the 3-3 mandibular retainer led to an increase of the irregularity index values after treatment, this is 1 reason to aim for a failure rate as low as possible and adhere to a meticulous bonding technique for the long-term success of bonded retainers.

CONCLUSIONS

Regarding the maintenance of the achieved alignment of the mandibular anterior region, we can conclude that the 3-3 mandibular lingual stainless steel retainer (bonded only to the canines) is effective in stabilizing the orthodontic treatment results in most patients. However, in a relatively high percentage of patients, a small to moderate increase in mandibular irregularity might occur.

Because the stability of the alignment was negatively influenced by failures of the bonded retainer, the incidence of failures should be minimized as much as possible by paying attention to bonding procedures. It is also important to ask the patient to report a failure immediately so that a repair can be made as soon as possible.

The results of this study should enable clinicians to inform their patients about the limitations of retention of the mandibular front region with a lingual retainer bonded only to the canines and give them realistic expectations.

REFERENCES

9. Sadowsky C, Schneider BJ, BeGole EA, Tahir E. Long-term stability after orthodontic treatment: nonextraction with pro-

Table. Distribution of failures in the periods T0-T2, T2-T5, and T0-T5

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