

COMPARISON OF TWO TYPES OF BONDED NICKEL TITANIUM RETAINERS IN CHANGES OF LITTLE IRREGULARITY INDEX AND INTER CANINE WIDTH IN TWELVE MONTHS OF RETENTION PERIOD

СПОРЕДБА НА ДВА ТИПА НА НИКЕЛ ТИТАНИУМСКИ РЕТЕЈНЕРИ ВО ОДНОС НА ПРОМЕНИ НА ИНДЕКСОТ НА НЕПРАВИЛНОСТИ СПОРЕД LITTLE И ИНТЕРКАНИНТА ШИРИНА ВО ТЕК НА ДВАНАЕСЕТМЕСЕЧЕН ПЕРИОД НА РЕТЕНЦИЈА

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Abstract

Introduction: Fixed retainers bonded to the lingual surfaces of the mandibular canines (3-3 retainer) are commonly used type of retention after orthodontic treatment is finished. **Purpose** of this study is to assess two types of Nickel titanium fixed retainers, flat versus round shaped, for the effectiveness in maintaining the stability of the alignment of the mandibular anterior teeth after orthodontic treatment. **Material and methods:** the sample consisted of the dental casts of 60 consecutively treated subjects (18 male and 42 female) age 16-25, previously treated for mild crowding in Class I. 30 subjects received a flat Nickel-titanium Retainer, thickness .010" x .029" four-strand twisted in one, manufactured by Forestadent and 30 other patients had bonded multistrained round, co-axial retainer $\varnothing 0.44\text{mm}/17''$, manufactured by Dentaaurum. Retainers were bonded to all anterior teeth, at the end of active orthodontic treatment. The Little irregularity index and intercanine width were measured on dental casts immediately after treatment (T0), and 12 months (T1) post treatment. **Results:** The main Little irregularity index not significantly increased during the post treatment period from 0 mm to 0.18 mm (SD, 0.24) at (T1) in flat retainer group and 0.34 mm (SD, 0.47) in round retainer group. The intercanine distance increased from (T0) measured values in 0.34 (SD 0.31) in flat retainer group and 0.44 (SD 0.40) in round retainer group. In 4 patients (13.3%), of round group, unexpected post treatment complications (torque differences of the incisors) was recorded. **Conclusions:** Two types of fixed retainers, maintain the stability of teeth alignment after finished orthodontic treatment, during 12 months of retention phase. Round retainers have the tendency to incline the position of at least one incisor during 12 months of follow up. **Key words:** Fixed retainers, Little irregularity index, intercanine distance, retention

Апстракт

Вовед: По завршување на ортодонтичкиот третман со фиксни ортодонтички апарати за ретенција и стабилност на постигнатите резултати најчесто се употребува фиксен ретејнер бондиран на лингвалните површини на мандибуларните канини. **Цел:** Целта на оваа студија е да се процени ефикасноста во одржувањето на стабилноста на постигнатите тераписки резултати, споредувајќи го ефектот од примената на двата типа на фиксни никел титаниумски ретејнери, рамен наспроти округол ретејнер. **Материјал и методи:** примерокот се состоеше од 60 студио модели од пациенти со умерена форма на малоклузија збиеност класа I (18 машки и 42 женски) на возраст од 16-25 години, претходно третирани со фиксен ортодонтички третман. Кај првата група од 30 пациенти беше поставен рамен префабрикуван никел-титаниумски ретејнер (од 4 пати плетена жица во едно), со дебелина .010"x .029", произведен од Forestadent, додека кај втората група од 30 пациенти поставен беше округол, коаксијален ретејнер (од 6 пати плетена жица во едно), со дебелина 0.44mm/17" произведен од Dentaaurum. Анализата на индексот на неправилност според Little и интерканината ширина беше мерена на студио моделите веднаш по третманот (T0) и 12 месеци (T1) по третманот. **Резултати:** Индексот на неправилност според Little не се зголеми значително за време во периодот по третманот (T0), односно од 0 mm до 0,18 mm (SD, 0,24) кај испитаниците кај кои беше поставен рамен ретејнер, и за 0,34 mm (SD, 0,47) кај групата кај кои беше поставен округол ретејнер. Интерканинското растојание од измерените вредности на почетокот на третманот (T0) кај првата групата испитаници со бондиран рамен ретејнер беше незначително зголемена за 0,34 mm (SD 0,31), додека кај втората група со бондиран округол ретејнер зголемувањето изнесуваше 0,44 mm (SD 0,40). Кај 4 пациенти (13,3%), од втората група со поставен округол ретејнер, евидентирани се неочекувани компликации по

третманот (разлики во торкот на корените на инцизивите). **Заклучоци:** Обата модели на фиксен ретејнер, ја одржуваат стабилноста на положбата на забите по завршен ортодонтски третман, во текот на 12 месеци постретенционен период. Резултатите сугерираат дека округлиот ретејнер покажува минимално влијание на инклинацијата на мандибуларните инцизиви во текот на 12-месечното следење. **Клучни зборови:** фиксен ретејнер, индекс на неправилности според Little, интерканинско растојание, ретенција

Introduction

Orthodontic retention is commonly defined as maintaining teeth in optimal aesthetic and functional position after orthodontic treatment is finished. Ideally, the correction should remain stable but there is often a tendency for teeth to relapse or to return to their primary position. Therefore, post treatment corrected tooth position generally requires maintenance for a period in order to prevent relapse¹.

For this purpose fixed retainers are recommended. Retention is one of the most important final stages of treatment phase in which orthodontists have not come to a common agreement and also decided of which shapes and materials are more superior for this purpose². Post treatment stability is unpredictable at the individual level and there are various factors that contribute to relapse; therefore, most patients are provided with a bonded lingual retainer in anterior teeth when the orthodontic appliance is removed in order to try minimize the chances of relapse³. After finishing orthodontic treatment the retention phase is very challenging both for orthodontists and patients. Pandis et al. concluded that at least 232 days of retention is needed to insure stability after an orthodontic treatment, furthermore several longitudinal studies evaluated post-treatment records and stated tremendous relapses in some occlusal relations, especially in the alignment of the mandibular anterior teeth⁴⁻⁷.

In majority studies related to fixed retainers, orthodontist researches believe that the only way to maintain the ideal alignment after orthodontic treatment would be a form of permanent retention. This can be a fixed retainer bonded in lingual area of anterior teeth, left in the mouth for a long period of time.

But some of the influencing factors that are associated with a relapse that are seen as occlusal factors, soft tissue pressures and further growth, while the biggest importance is given to the supragingival and transseptal fibers⁸⁻⁹

There are different types of methods that have been used for the retention of post treatment tooth position. Most of them have their advantages and disadvantages. The first appliances proposed were based on banded fixed appliances, then various removable retainers were advocated and most often the use of bonded fixed retainers have been suggested.

In this sense, bonded retainers consist of a various size and wire material bonded to the teeth with acid-etch retained composite. The main idea was to help prevent relapse in the lower incisor area¹⁰.

Retention is not a separate problem or phase in orthodontics, and the type of retention and retainers planned to be used should be considered during treatment planning.

Little's Irregularity Index (LII) is a commonly used Index to measure mandibular incisor crowding used in epidemiological studies by providing a guide to quantify mandibular anterior crowding¹¹.

However, still there is no concrete conclusions about the post treatment stability of the mandibular anterior teeth with a bonded lingual retainer, since literature shows quite controversy results.

In recent years, flat easy banded nickel-titanium wire of thickness .010"x.029" for retention purpose has been introduced. Searching for stable and comfortable solution for patients, **the aim** of this study was to assess two types of Nickel titanium fixed retainers, flat and round, for the effectiveness in maintaining the stability of the alignment of the mandibular anterior teeth after orthodontic treatment is finished.

Materials and methods

Our material consisted of the dental casts of 60 consecutively treated patients (18 male and 42 female) age 16-25, previously treated for mild crowding in Class I according to Cannut A, in Private Dental Practice Confident in Prishtina. A non-extraction treatment protocol was approved for all patients with straight wire appliances (0.022-in slot, Roth prescription). All subjects had previous Bolton Analyze within a standard range of values. After the orthodontic treatment finished for selected subjects; they were divided in two groups of 30 each. Also the groups were divided in subgroups of growing subjects (age 16-19) and adults subjects (age 20-25). The reason behind this subgroup division was to evaluate, if changes in growing patients, are being recorded with more significance. Subjects received a bonding mandibular lingual nickel titanium retainer from canine to canine in all anterior segment, at the end of active orthodontic treatment. They were randomly selected upon finishing orthodontic treatment. To 30 patients were bonded flat Nickel-titanium Retainer, thickness

.010" x .029" four-strand twisted in one, manufactured by Forestadent and 30 other patients had bonded multi-strained round, co-axial retainer $\varnothing 0.44\text{mm}/17''$, manufactured by Dentaaurum. Figure 1.

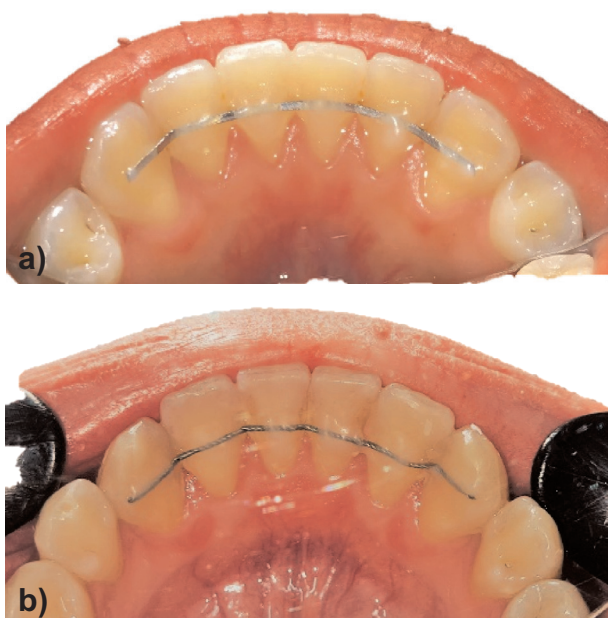


Figure 1. (a) Bonded Flat Retainer, (b) Bonded Round Retainer

First impressions are taken one week after fixed retainer is bonded marked with (T0) and initial measurements are conducted in study model. Second impression marked with (T1) is taken after 12 months of observatory period and final measurements were conducted at that point. Figure 2.

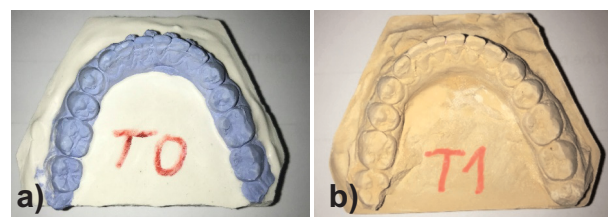


Figure 2. (a) dental cast in beginning of retention phase (T0); (b) dental cast in the end of observatory period 12 months of retention (T1)

Subject inclusion criteria were as follows: (1) treated with full fixed appliances; (2) all had been treated for mild crowding at the beginning of the treatment in class I; (3) treated without extraction of any of lower teeth; (4) no caries, restorations, crown or bridges presented. (4) absence of habits and occlusal interference (5) canine

guidance bilaterally, (6) No interproximal enamel reduction or circumferential supracrestal fiberotomy that was systematically performed, (7) no presence of any syndrome.

Excluded subjects were: (1) The ones that failed to be present at requested follow up periods, (2) subjects that during follow up period did any kind of prosthetic restoration, (3) smokers.

Subjects got information letter with clear aim and purpose of the study and signed the consent letter to participate in the study. Ethical Committee of Kosova Dental Chamber approved the study.

The measurements for the Little irregularity index and intercanine width were made with an electronic caliper (digital 6, Mauser, Winterthur, Switzerland) with an accuracy of 0.01 mm. Figure 3



Figure 3. Digital Vernier Caliper 6 Inch 150mm Stainless Steel

Since in the stage T(0) all the casts were at 0 mm irregularity values it was easy to assess the difference in 12 months. At the point where anatomic contact points of adjacent teeth are touching, the measurement is considered zero. If there was increased measured irregularity or greater displacement it led to an increased index score. At the dental casts, the anatomic contact areas of the mandibular incisors were marked and the mesial anatomic contact areas of the canines. The linear distance between the markings was measured and the 5 values were added. The measurements were made at (T0) and (T1). Patients with scores less than 0.25 mm were considered to have good alignment. The intercanine distance was measured from the middle of the cusp of the mandibular right canine to the middle of the cusp of the mandibular left canine. All retainers were bonded directly by the same investigator. The same etching agent (Etch-Royale.), adhesive primer (Transbond XT primer, 3M Unitek) and flow composite (Transbond LR, 3M Unitek) were used to bond all retainers.

Statistical analyses

The data obtained with the research were processed in SPSS software package, version 22.0 for Windows, and presented in tables and graphs.

- The qualitative series were processed by determining the coefficient of relations, proportions, and rates, and were shown as absolute and relative numbers.
- Quantitative series were analyzed with measures of central tendency (mean, median, minimum /maximum values), as well as by dispersion measures (standard deviation). -The Shapiro-Wilk W test was used to determine the normality of frequency distribution of investigated variables.
- Pearson Chi square test was used to determine the association between certain variables in the groups of subjects.
- Two independent samples were compared with the Mann Whitney U test. A two-sided analysis with a significance level of $p < 0,05$ was used to determine the statistical significance.

Results

In our investigation of the total sample of 60 cast models of 30 subjects with bonded flat Retainer (FR), gender

distribution was 11 (36.7%) Male and 19 (63.3%) Female, whereas in Round retainer group (RR) 7(23.3%) were Male and 23 (76.7%) female. The results of Chi-Square=1,269 and the $df=1$; $p=0,259$. Table 1.

Observatory period was 12 months post retention. None of the indices revealed any significant differences between the two groups of study at the baseline in the mandibular arch, which implements similar optimal good alignment of mandibular dental arch in all individuals at the beginning of the trial according to the cast models.

At the beginning of retention phase (T0), there were all 60 patients with an irregularity index value of zero. 12 months after the treatment, the average LII in FR group was 0.18 ± 0.24 with 50% patients with lower value than 0.01. In RR group the average LII value was 0.34 ± 0.47 with 50% patients who had value 0.00. In FR/RR subgroup the average LII was 0.26 ± 0.26 vs. 0.41 ± 0.58 respectively with 50% patients with lower value than 0.02 in FR subgroup and 0.00 value in RR subgroup. Table 2.

The Little irregularity index rebounded slightly from the beginning of retention period to the follow-up phase in both groups, but the patients with bonded round multi-strained retainer showed slightly more incisor irregularity in lower arches than those having flat retainers at the 12 month follow-up stage; however, this difference was not statistically significant ($p > 0.05$).

Table 1. Demographic data of the study patients by Group Flat Retainers (FR) and Round Retainers (RR).

Parameters	FR	RR	P-value
Gender			
Male	11 (36,7%)	7 (23,3%)	Chi-Square=1,269; df=1; p=0,259
Female	19 (63,3%)	23 (76,7%)	
Age			
Mean \pm SD	20.09 \pm 3.36	20.52 \pm 3.38	Z=-0.658; p=0.510
Min/Max	16,1/25	16,1/225	
Median (IQR)	19,7 (16,8-23,4)	20,7 (17,2-23,5)	
Z=Mann-Whitney U Test X ² = Chi-Square *significant for $p < 0,05$ Flat Retainers - FR; Round Retainers - RR			

Table 2. Analysis of Little Irregularity Index (LII) by FR / RR groups and subgroups

LII	N	Mean ± SD	Min/Max	Median (IQR)	P-value
Groups					
FR	30	0.18 ± 0.24	0.0/0.8	0.01 (0.0-0.4)	Z=-0.680; p=0.496
RR	15	0.34 ± 0.47	0.0/0.8	0.00 (0.0-0.5)	
Subgroup: 16-19 years					
FR	30	0.26 ± 0.26	0.0/0.8	0.02 (0.0-0.5)	Z=0.124; p=0.901
RR	15	0.41 ± 0.58	0.0/0.2	0.00 (0.0-0.8)	
Z=Mann-Whitney U Test Flat Retainers - FR ; Round Retainers - RR					*significant for p<0,05

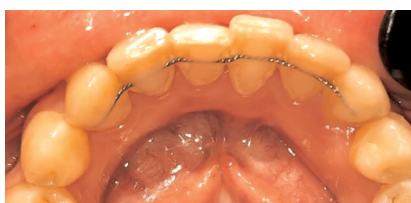


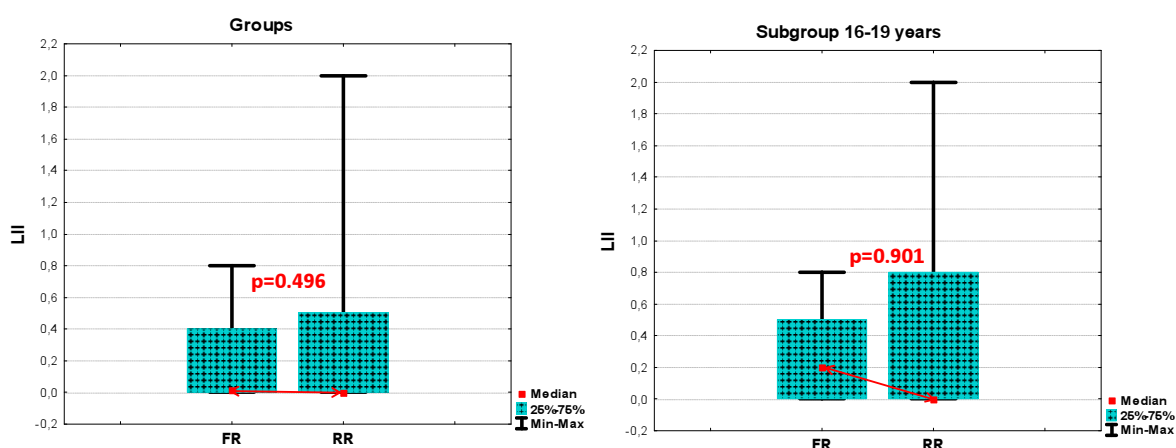
Figure 3. Proinclined d.41



Figure 4. Proinclined d.41



Figure 5. Torque change in d.42



Graph 1. Little Irregularity Index (LII) by FR / RR groups and subgroups

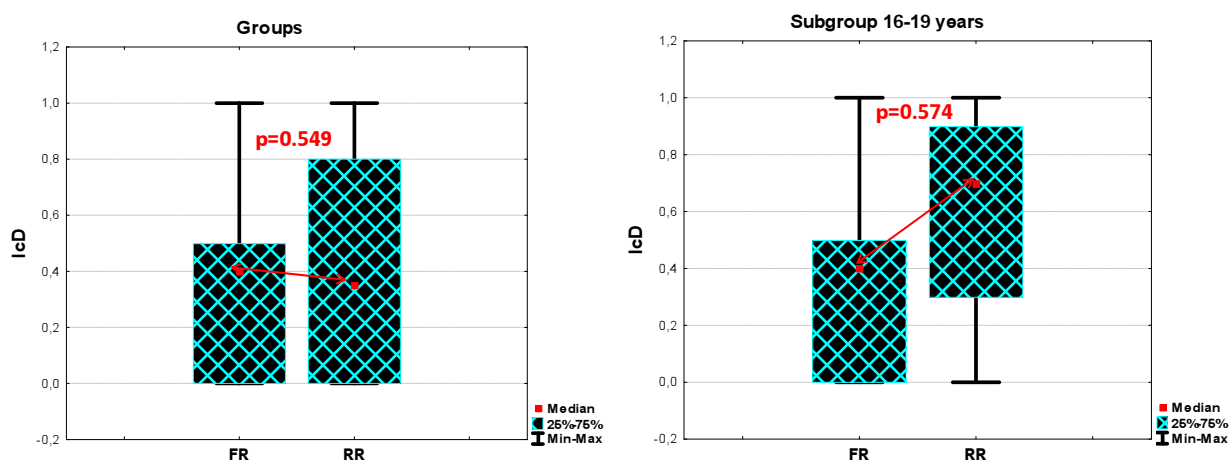
The minimum one lower incisor in three cases had torque difference (X effect). Figure 3. 4. 5.

In our study we recorded 4 subjects in a RR group

with one incisor minor inclination and recorded it only as clinically significant, but not statistically significant. Graph 1.

Table 2. Analysis of Little Irregularity Index (LII) by FR / RR groups and subgroups

IcD	N	Mean ± SD	Min/Max	Median (IQR)	P-value
Groups					
FR	30	0.34 ± 0.31	0.0/1.0	0.4 (0.0-0.5)	Z=-0,599; p=0.549
RR	30	0.44 ± 0.40	0.0/1.0	0.3 (0.0-0.8)	
Subgroup: 16-19 years					
FR	15	0.34 ± 0.31	0.0/1.0	0.4 (0.0-0.5)	Z=-1.783; p=0.074
RR	15	0.59 ± 0.36	0.0/1.0	0.7 (0.3-0.9)	
Z=Mann-Whitney U Test Flat Retainers - FR; Round Retainers - RR					*significant for p<0,05



Graph 2. Analysis of Intercanine distance (IcD) by FR / RR groups and subgroups.

In this study, Intercanine distance (IcD) remained stable during 12 months of retention period. 12 months after the treatment, the average IcD values in FR and RR groups, were 0.34 ± 0.31 vs. 0.44 ± 0.40 respectively. About 50% of the patients in this groups had IcD value lower than 0.4 vs. 0.3. The average IcD value in the FR/RR subgroup of 16-19 years old was 0.34 ± 0.31 vs. 0.59 ± 0.36 respectively with 50% patients with lower value than 0.4 in FR subgroup and 0.7 value in RR sub-

group. The mean values of the Intercanine distance showed stability from (T0) throughout follow up 12 months (T1) in both groups. Table 2.

As this study uses cast models of subjects treated for mild crowding in Class I, Intercanine distance was preserved and very slightly decreased therefore we assume that it was a favorable factor in maintaining stability of the Intercanine distance during 12 months of follow up. Graph 2.

Discussion

While patients are exclusively perceptive to the alignment of their incisors and canines, orthodontists are also sensitive to changes in tooth positions, from an aesthetic point of view, but also the relapse of the anterior teeth alone prey on any assessment for the stability of a treatment result.

Zachrisson made a longitudinal study during follow up period of 20 years and concluded that 0.0215 inch 5-stranded wires show better results based on failure rates and serve better to stability observed in follow-up sessions¹².

Scribante et al. in a longitudinal prospective randomized study, made clinical comparison between Multi-stranded Wires and Direct-Bond Glass Fiber-Reinforced Composite Splints. They found no statistically significant difference between the two types of bonded retainers concerning the stability¹³.

Retention phase and possible relapse of previously stable results after orthodontic treatment has been issue of concern for orthodontists.

Different studies have investigated different modules of retention in comparison to standard wires with different properties¹⁴⁻¹⁷. In our study, anterior crowding was evaluated with Little's irregularity index and Intercanine distance and also these two parameters were used to evaluate the stability of lower anterior teeth in cast models taken after orthodontic treatment is finished.

Some studies show that greater increase in incisor irregularity was noted in the growing subjects compared with the adult group in both different wire groups, which could also be explained by influence of growth in young subjects⁵. In this study our results reveal no significant value among two groups with different type of retainers.

Similar result was described in the study of Kucera et al. where they found out 0.1% to 5% of patients experienced unexpected complication as X effect of lower incisors¹⁸.

In our study a mean Little Irregularity Index score in FR group was 0.18 ± 0.24 and in RR group was 0.34 ± 0.47 for 12 months post retention is regarded satisfactory, as we deliberately corrected Intercanine region in the tolerated dimension.

Renkema et al. in their study concluded that it is very important to avoid over expansion of the Intercanine area of lower arch during treatment, which would help maintain stability with fixed retainers during retention. [19] We preserved intercanine distance in all subjects during treatment, however in 4 subjects in a RR group was noticed minor inclination of one lower incisor. We stated it as clinically significant but not statistically. Early studies presented the advantages of using multi-stranded wires as

bonded retainers to avoid post treatment inclination of incisors, but also there were few reported cases with stability issues²⁰. Later several studies, introduced the technique of bonding multi-stranded wires to canines only^{16-18, 20, 21}. Al Nimri et al. reported in follow up observatory period of one year significant incisor irregularity with round SS retainer as compared to multistranded SS retainer bonded to lower anterior teeth¹⁵. Therefore, studies suggest that any over expansion beyond the original pre-treatment status will have the potential to increase the chances for relapse during post-treatment phase²².

Forde et al. in bonded 3-strand stainless steel wire 0.0195 for retention found an increase in irregularity (0.77 mm). They assumed that it is related to higher rate of failure observed (50%)²³. The study conducted by Zachrisson, reported that thinner wires demonstrated more distortion, and 0.0215-in multistrand dead-soft or heat-treated wires were considered more week for maintaining stability of anterior teeth²⁰.

However, Renkema et al. evaluated the long-term effectiveness of a 0.0195-in 3-strand wire and found stable outcomes in mandibular anterior alignment in most patients⁵.

In our study, Intercanine distance (IcD) remained stable during 12 months of retention period, in agreement with previous studies^{5, 24-26}.

The study conducted by Shapiro yielded interesting results. In a sample of 80 subjects of 10 years after retention of mixed malocclusions, the mandibular intercanine width has a high propensity to return to its pretreatment dimension²⁷. On the other hand, a lot of studies have showed that multiple factors influence the stability of teeth after orthodontic treatment. Those factors as periodontal and gingival, soft tissue, occlusal, and growth factors cause teeth to revert to their pre-treatment positions. Changes may occur also as a result of normal dentofacial aging and are highly variable²⁸⁻³⁰. Burke et al. suggests that regardless of pretreatment classification or whether treatment was extraction or non-extraction, mandibular intercanine width tends to exhibit a net shift in post retention on the order of 0.5 mm expansion to 0.6 mm constriction. Their study strongly supports the concept of maintaining original intercanine width in orthodontic treatment because the net change in mandibular intercanine width was determined to be about zero in a total of 1,233 participants in their study, which is in agreement with our study³¹.

Conclusion

Two types of fixed retainers maintain the stability of teeth alignment after finished orthodontic treatment during 12 months of retention phase.

Post treatment stability is not only dependent from the retention choice but also from the careful treatment planning, mechanics, periodontal and biomechanical considerations.

Retention phase should be monitored for extended period of time.

As this is a randomized clinical trial, bias is minimized. The prospective character of the study allows for a trustworthy and precise evaluation of the results. However, there are certain drawbacks, such as a small sample size and also because the study was conducted on limited post-orthodontic patients treated only for mild crowding, while other malocclusions such as Class II or III and also extraction protocol was excluded.

Furthermore, the duration of follow-up was limited to one year. Similar research with a larger sample size and longer follow up should be conducted in the future.

Reference

1. Bearn DR. Bonded orthodontic retainers: a review. *Am J Orthod Dentofac Orthop* 1995; 108: 207-13.
2. Sonia M, Dosanjh K. Efficacy of Different Retention Types Post-Orthodontic Treatment. 2011.
3. Andrén A, Asplund J. A clinical evaluation of long term retention with bonded retainers made from multi-strand wires. *Swed Dent J*. 1998; 22(3):123-31.
4. Pandis N, Vlahopoulos K, Madianos P, Eliades T. Long-term periodontal status of patients with mandibular lingual fixed retention. *Eur J Orthod* 2007; 29: 471-6.
5. Renkema AM, Renkema A, Bronkhorst E, Katsaros C. Long-term effectiveness of canine-to-canine bonded flexible spiral wire lingual retainers. *Am J Orthod Dentofac Orthop* 2011; 139: 614-621.
6. Renkema AM, Sips ET, Bronkhorst E, Kuijpers-Jagtman AM. A survey on orthodontic retention procedures in the Netherlands. *Eur J Orthod* 2009; 31: 432-7.
7. Keim RG, Gottlieb EL, Nelson AH VD. JCO study of orthodontic diagnosis and treatment procedures. Part 1. Results and trends. *J Clin Orthod* 2002; 36: 553-68.
8. Pratt MC, Kluemper GT, Hartsfield Jr. JK, Fardo D, Nash DA. Evaluation of retention protocols among members of the American Association of Orthodontists in the United States. *Am J Orthod Dentofac Orthop* 2011; 140: 520-6.
9. Andriekute A, Vasiliauskas A, Sidlauskas A. A survey of protocols and trends in orthodontic retention. *Prog Orthod*. 2017 Oct 9;18(1):31.
10. Degirmenci Z, Ozsoy OP. Retention after fixed orthodontic treatment. *Cumhuriyet Dent J* 2009; 12: 83-90.
11. Little RM. The irregularity index: a quantitative score of mandibular anterior alignment. *Am J Orthod*. 1975; 68:554-63.
12. Zachrisson BU. Multistranded wire bonded retainers: From start to success. *Am J Orthod Dentofac Orthop* 2015; 148: 724-7.
13. Scribante A, Sfondrini M, Broggin S. Efficacy of Esthetic Retainers: Clinical Comparison between Multistranded Wires and Direct-Bond Glass Fiber-Reinforced Composite Splints. *International Journal of Dentistry* Volume 2011, Article ID 548356.
14. Lang G, Alfter G, Göz, Lang GH. Retention and stability— taking various treatment parameters into account. *J Orofac Orthop/Fortschr Kieferorthop* 2002; 63:26-41.
15. Booth FA, Edelman JM, Proffit WR. Twenty-year follow-up of patients with permanently bonded mandibular canine-to-canine retainers. *Am J Orthod Dentofac Orthop*. 2008; 133:70–6.
16. Al-Nimri K, Al Habashneh R, Obeidat M. Gingival health and relapse tendency: a prospective study of two types of lower fixed retainers. *Aust Orthod J*. 2009; 25:142.
17. Cerny R. The reliability of bonded lingual retainers. *Aust Orthod J*. 2007; 23:24.
18. Kučera J, Marek I. Unexpected complications associated with mandibular fixed retainers: A retrospective study, *American Journal of Orthodontics and Dentofacial Orthopedics*, 2016. Volume 149, Issue 2, Pages 202-211.
19. Renkema AM, Al-Assad S, Bronkhorst E, Weindel S, Katsaros C, Lisson JA. Effectiveness of lingual retainers bonded to the canines in preventing mandibular incisor relapse. *Am J Orthod Dentofac Orthop*. 2008 Aug;134(2):179e1-8.
20. Zachrisson BU. Clinical experience with direct-bonded orthodontic retainers. *Am J Orthod*. 1977;71:440–8.
21. Årtun J, Zachrisson B. Improving the handling properties of a composite resin for direct bonding. *Am J Orthod Dentofac Orthop*. 1982; 81:269–76.
22. Carter GA, McNamara JA Jr. Longitudinal dental arch changes in adults. *Am J Orthod Dentofacial Orthop*. 1998; 114: 88– 99.
23. Forde K, Storey M, Littlewood SJ, Scott P, Luther F, Kang J. Bonded versus vacuum-formed retainers: a randomized controlled trial. Part 1: stability, retainer survival, and patient satisfaction outcomes after 12 months. *European Journal of Orthodontics*. 2018 Jul 27;40(4):387-98.
24. Gunay F, Oz AA. Clinical effectiveness of 2 orthodontic retainer wires on mandibular arch retention. *American Journal of Orthodontics and Dentofacial Orthopedics*. 2018 Feb 1;153(2):232-8.
25. Al-Moghrabi D, Johal A, O'Rourke N, Donos N, Pandis N, Gonzales-Marin C, Fleming PS. Effects of fixed vs removable orthodontic retainers on stability and periodontal health: 4-year follow-up of a randomized controlled trial. *American journal of orthodontics and dentofacial orthopedics*. 2018 Aug 1;154(2):167-74.
26. Egli F, Bovali E, Kiliaridis S, Cornelis MA. Indirect vs direct bonding of mandibular fixed retainers in orthodontic patients: Comparison of retainer failures and posttreatment stability. A 2-year follow-up of a single-center randomized controlled trial. *American Journal of Orthodontics and Dentofacial Orthopedics*. 2017 Jan 1;151(1):15-27.
27. Shapiro PA. Mandibular dental arch form and dimension. Treatment and post retention changes. *Am J Orthod*. 1974;66:58-70.
28. Millett, D. The rationale for orthodontic retention: piecing together the jigsaw. *Br Dent J* ; 2021, 230, 739–749.
29. Kučera J, Marek I. Unexpected complications associated with mandibular fixed retainers: A retrospective study. *Am J Orthod Dentofac Orthop*. 2016; 149:202–11.
30. Vergara, a. D.; llinás, h. J. & bustillo, j. M. Lower anterior third molar impact on dental crowding. A new approach. *Int. J. Odontostomat*. 11(3):327-332, 2017.
31. Burke SP, Silveira AM, Goldsmith LJ, Yancey JM, Van Stewart A, Scarfe WC. A meta-analysis of mandibular intercanine width in treatment and postretention. *Angle Orthod*. 1998 Feb;68(1):53-60.