Original Article

Space Closure with Different Appointment Intervals: A Split-mouth Randomized Controlled Trial

Abstract

Background: Canine retraction has been successful with various force systems and retraction techniques. The appointment interval for force reactivation in canine retraction along the archwire is 4–8 weeks. **Aims:** The aim was to evaluate the effect of different reactivation intervals on the rate of space closure. **Settings and Design:** This split-mouth randomized clinical trial recruited 38 patients indicated for the first premolar extraction. **Methods:** Monthly digital models were acquired for 6 months. The first premolars were extracted, and temporary anchorage devices were placed for maximum anchorage control. The canines were retracted using elastomeric chains which were replaced every 2, 4, 6, or 8 weeks. The monthly rate of canine retraction was measured. The time to space closure was calculated. The secondary outcome was the mesial drift of the first molars. **Statistical Analysis:** The Kaplan–Meier survival analysis and the Friedman test evaluated and compared the groups. **Results:** There was no significant difference between the monthly canine retraction rate or the first molar mesial drift between the groups. The mean time to space closure was 5.74 months in the 2-week reactivation group, which was statistically less than the other groups. **Conclusions:** The 2-week reactivation interval may reduce time to space closure. Direct anchorage control with miniscrews limited anchorage loss significantly.

Keywords: *Anchorage loss, canine retraction, orthodontic space closure, reactivation interval, temporary anchorage devices*

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Introduction

Many cases with severe tooth size to arch length discrepancy or increased facial convexity require premolar extraction and canine retraction with maximum anchorage. Space closure can then be achieved by either sliding or frictionless mechanics.[1,2] Friction mechanics is the more common choice as it requires minimal archwire bending and is more comfortable for the patient.[3]

In many cases, optimum canine retraction can be achieved by distalizing the canine in a bodily manner with minimal tipping or rotation. The type of tooth movement achieved is generally dependent on the nature of the force system applied.[4]

Mesial molar movement accounted for approximately 25% of the space with reinforced anchorage.[5] Temporary anchorage devices (TADs) have successfully provided maximum anchorage control.[6]

The force system, bone anatomy, as well as cellular and molecular reactions, control the biomechanical tissue response.[7]

Appointments are generally scheduled every 4–8 weeks during canine retraction with friction mechanics.[8] However, there is little clinical evidence of the effect of reactivation intervals[9] on the rate of space closure and anchorage loss.

Authors reported interindividual variation in the rate of tooth movement.[10] Some patients have been labeled as slow or fast movers.[11] Frequent activations of the orthodontic force have shown more osteocytes which may enhance tooth movement.[12]

The aim of this trial was to investigate the effect of different reactivation intervals on the rate of canine retraction using an elastomeric chain.

Methods

This randomized controlled trial was conducted at the orthodontic outpatient clinic between April 2017 and February 2019. Inclusion criteria were a permanent

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dentition, bimaxillary dentoalveolar protrusion, Class II division 1 or Class III malocclusions planned for the first premolar extraction, and TADs for anchorage control. Patients were excluded if they were pregnant or smokers. Other exclusion criteria were previous orthodontic treatment, dental anomalies, periodontitis, and medication or diseases that affect bone metabolism. The trial protocol was accepted by the institute's Review Board (Protocol ID: 20153110-(8) 14-2017), and the trial was conducted in compliance with the Declaration of Helsinki. Eligible subjects joining the trial signed consent forms before the start of treatment. The patients' average age was 19.5 ± 4 years.

The sample size was estimated *a priori* from a pilot study. The estimated sample size, for the rate of retraction, was 144 quadrants (36 in each group) based on an effect size of 0.241, 0.8 power, and 95% confidence interval (CI).

The principal investigator (PI) block randomized 74 maxillary and 71 mandibular canines, in 38 patients, using the CHOOSE and RAND functions in Microsoft Office Excel. The additional quadrant was in the 4-week group. Each canine was allocated to one of four reactivation intervals: 1, 4, 6, or 8 weeks. Allocation was concealed by the PI until the time of canine retraction.

The upper and lower first molars were bonded. If the molar tubes failed, the teeth were banded. The canines and the second premolars were bonded with 0.022" Roth brackets. The dental arches were leveled and aligned sequentially to 0.016" × 0.022" stainless steel archwires. Miniscrews (Unitek, 8 mm × 1.8 mm) were placed between the second premolars and first molars for direct anchorage [Figure 1]. The canines were retracted with 150 g applied by elastomeric chains. The force magnitude was checked every time the elastomeric chains were replaced using a digital force gauge (Morelli Orthodontia, range; 50–500 gm) [Figure 1]. The elastic chains were attached to the power arms in the canine brackets and the TADs [Figure 1]. The first premolars were then extracted and retraction was started in 1–2 weeks.

Figure 1: Canine retraction by stretching the elastomeric chain between the miniscrew and power arm

Dental impressions were taken and poured in stone at the start of canine retraction (T0) and monthly thereafter for 6 months (T1, T2, T3, T4, T5, and T6). The stone models were laser scanned using the R500 3Shape scanner (3Shape, Copenhagen, Denmark). Three planes, namely, the sagittal, horizontal, and frontal planes, were constructed to orient the preretraction digital model. The monthly digital models were superimposed on the preretraction model using three points on the palatal rugae, including the right and left medial points of the 3rd rugae. The distance between the corresponding canine tips, of the monthly models, was measured using the OrthoAnalyzer software (3Shape, Copenhagen, Denmark) [Figure 2]. The distance between the mesiobuccal cusp tips of the maxillary first molars was measured between T0 and T6. The time to space closure was recorded when the canine was in contact with the second premolar [Figure 2].

A single outcome assessor measured the monthly rate of canine retraction and the mesial molar displacement after 6 months. Ten records were remeasured by the same assessor and a second assessor to calculate the intra- and inter-rater agreement.

Statistical analysis

Data were presented as mean, standard deviation, 95% CI, medians, and ranges. The Kolmogorov–Smirnov and Shapiro–Wilk tests of normality showed that all data were nonparametrically distributed. The intra- and inter-rater agreement were calculated using the intraclass correlation coefficient (ICC).

The monthly rate of canine retraction over time within each group, the intergroup monthly rate of retraction, and the intergroup mesial displacement of the first molar at 6 months were compared with the Friedman test. Pair-wise comparisons were performed using the log-rank test.

The Kaplan–Meier survival analysis was used to estimate and compare the mean time to complete canine retraction in the 2-, 4-, 6-, and 8-week groups.

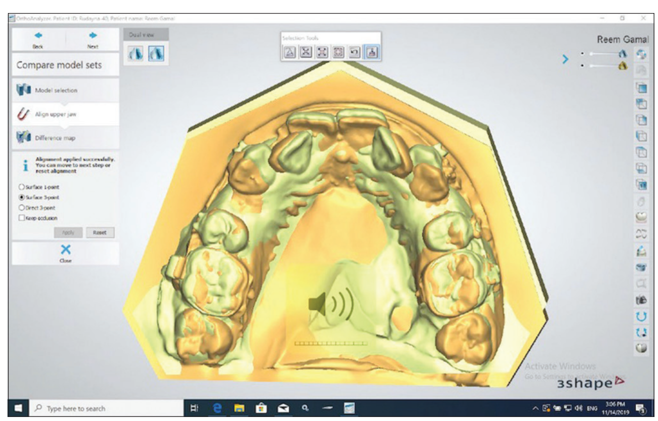

Figure 2: Superimposition of preretraction and 6-month retraction digital models in the Ortho Analyzer software

The significance level was set at $P \leq 0.05$ for the two-tailed test. The SPSS Statistics for Windows (IBM, version 23.0. Armonk, NY, USA) was used for the data analysis.

Results

All patients were followed until the end of the trial. Two mandibular quadrants were excluded due to the failure of the TADs. The CONSORT flow chart summarizes the details of patients' recruitment, allocation, follow-up, and trial data analysis [Figure 3].

The data showed a nonparametric distribution. The ICC for the monthly rate of retraction was 0.99 and 0.98 for intra- and inter-rater agreement, respectively. The ICC for the molar displacement was 0.97 and 0.89, respectively.

There was no significant difference in the monthly rate of canine retraction in the 4, 6, or 8-week interval groups over 6 months. However, the monthly rate was statistically different in the 2-week interval ($P = 0.043$, effect size = 0.143). There was no statistical difference between the median monthly rate of retraction in the four groups [Table 1].

The canine was completely retracted in 27 out of 145 quadrants during the 6 months of the trial. The number of closed quadrants was twelve, seven, four, and four in the 2-, 4-, 6-, and 8-week groups, respectively [Figure 4].

The mean time to complete space closure was significantly different between the four groups ($P = 0.041$). Log-rank pair-wise comparisons showed that the 2-week group

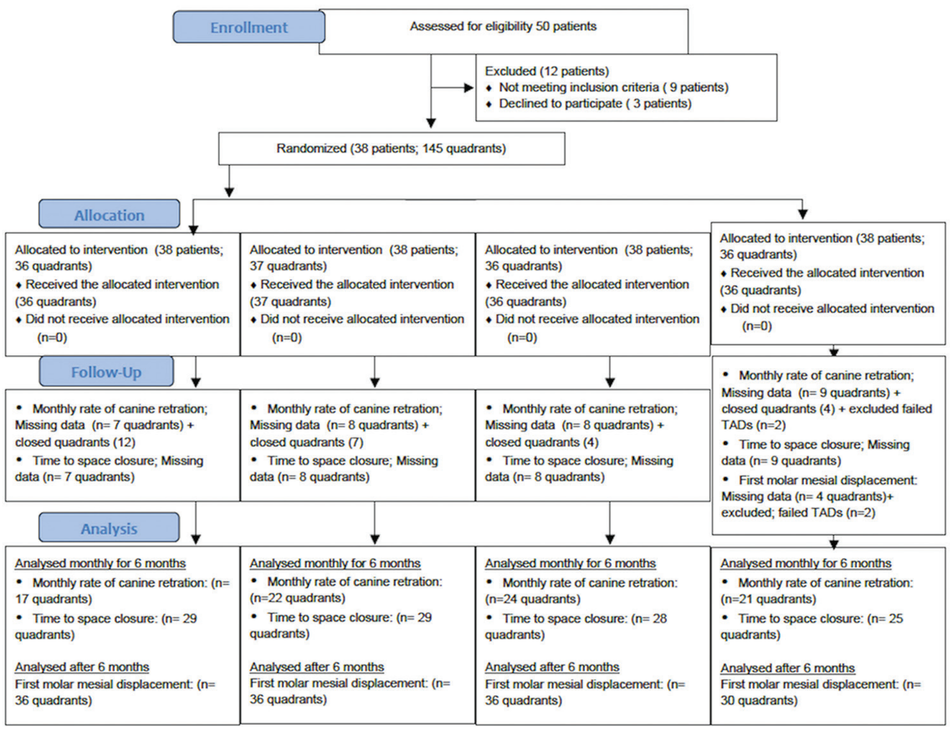

Figure 3: CONSORT flowchart. TADs: Temporary anchorage devices

Table 1: Descriptive statistics and comparison within and between the 2-, 4-, 6-, and 8-week reactivation groups for the monthly rate of canine retraction

	Median (range)				*P*	Effect size (w)
	2 weeks	4 weeks	6 weeks	8 weeks		
T0–T1	0.99 (0.1–3.57)^{A}	0.97 (0.12–2.29)	0.81 (0.06–1.98)	0.79 (0.05–1.89)	0.623	0.029
T1–T2	0.85 (−1.97–2.55)^{B}	0.86 (0.04–2.23)	0.73 (−0.79–2.43)	0.89 (−0.87–1.99)	0.153	0.088
T2–T3	0.93 (−0.65–2)^{A}	1.2 (−1.12–2.93)	0.84 (−0.74–1.53)	0.72 (−0.35–2.69)	0.243	0.070
T3–T4	1.31 (−1.12–4.35)^{A}	0.69 (−0.47–2.57)	0.72 (−0.9–3.47)	0.73 (−0.88–2.44)	0.198	0.078
T4–T5	0.69 (−0.46–2.61)^{B}	0.61 (−0.59–2.15)	0.84 (−0.33–2.77)	0.78 (−0.34–1.86)	0.241	0.070
T5–T6	0.78 (−0.55–1.58)^{B}	0.55 (−0.81–2.62)	0.36 (−1.52–1.56)	0.59 (−0.49–1.56)	0.392	0.050
P	0.043*	0.365	0.108	0.709		
Mean monthly rate (mm/mo)	0.885±0.22	0.832±0.14	0.728±0.25	0.772±0.12		

*Significance $P \leq 0.05$. Different superscripts indicate a statistically significant difference between groups had the least closure time, statistically. The time to closure between the other groups showed no statistical difference [Table 2].

There was no statistically significant difference in the amount of mesial displacement of the first molar between the groups [Table 3].

Discussion

Surveys show that orthodontists prefer scheduling appointments every 4 weeks to prevent overcorrection, monitor patient cooperation, and facilitate payment schedules. Others commonly use 6–8-week intervals since recent orthodontic appliances allow a wider range of action.[8] Most studies that evaluate canine retraction use a 4-week reactivation period.[5,13]

The effect of orthodontic force reactivation frequency has rarely been investigated in humans or animals. A retrospective clinical study by Alger[9] showed that extending the appointment intervals to 6 weeks instead of 3 or 4 weeks did not prolong the overall treatment time. An animal study[12] investigated the effect of orthodontic force reactivation after 4 days of the initial force application. The compression side showed evidence of a secondary wave of osteoclasts 10 days after the initial cell recruitment.[12] Theoretically, the increase in the number of osteoclasts may increase the rate of bone remodeling and rate of tooth movement.

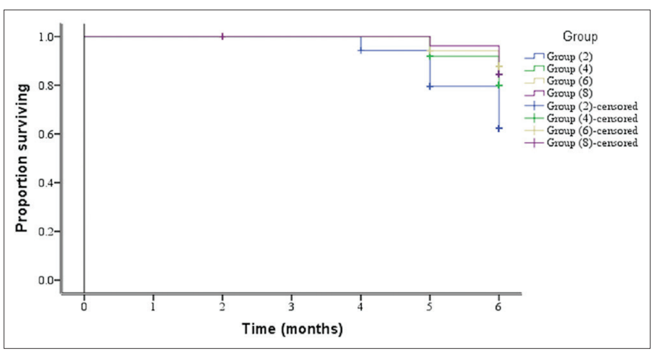

Figure 4: The Kaplan–Meier survival analysis of time to space closure

Several studies have reported the monthly rate of canine retraction with the assumption that the amount of tooth movement is similar in each month of retraction.[5,13] Few studies measured the monthly rate of canine retraction using friction mechanics. Chaudhari and Tarvade[14] show a constant monthly rate (0.62 mm/mo) for 4 months of canine retraction.

Other studies reported some variation in the monthly rate of retraction. Alqadasi *et al*.[15] ligated the 2nd premolar and the 1st molar and attached the molar to TADs. They used NiTi coil springs (150 g) attached to the first molars and power arms on the canine brackets. The average monthly rate was 1.17, 0.7, and 0.18 mm over 3 months of canine retraction. While Aboul Ela *et al*.[16] reported a range of 0.75–0.93 mm with similar anchorage reinforcement for 4 months of retraction.

Similarly, we observed some variation in the monthly rate of retraction. The difference was insignificant, both statistically and clinically, for the 4-, 6-, and 8-week groups. Only the 2-week reactivation group showed statistically significant variations across the 6 months [Table 1]. However, the difference in this group was again of no clinical significance. The lowest rate was seen in the 6-week reactivation group (0.36 mm/mo) and the highest rate was in the 2-week group (0.99 mm/mo). A wide variation of the rate of retraction between individuals was shown by the nonnormal distribution of the results [Table 1]. The intergroup comparison showed similar amounts of monthly canine retraction. These coincide with the reports in the literature for different retraction methods and force systems.[14]

The number of canines completely retracted using elastomeric chains was evaluated in some studies. Although most studies did not follow the canine until complete retraction, these trials reported the percent of extraction spaces in which the canines were fully retracted. Dixon *et al*.[13] reported the closure of 30% of the extraction sites (12/40) in 4 months with a monthly reactivation of the elastomeric chains, while Davidović *et al*.[17]

Table 2: The Kaplan–Meier survival analysis comparing time to space closure in months between the 2-, 4-, 6-, and 8-week reactivation groups

2 weeks		4 weeks		6 weeks		8 weeks		*P*
Mean (months)	95% CI	Mean (months)	95% CI	Mean (months)	95% CI	Mean (months)	95% CI	
5.74B	5.55–5.93	5.92A	5.82–6.01	5.94A	5.85–6.03	5.96A	5.88–6.05	0.041*

*Significant at $P \leq 0.05$. CI: Confidence interval, A and B are annotations that indicate a statistically significant difference between groups. Two weeks group (B) is statistically different than four, (A) six (A) and eight (A) weeks group

Table 3: Descriptive statistics and comparison between the first molar mesial displacement in the 2-, 4-, 6-, and 8-week reactivation groups

2 weeks		4 weeks		6 weeks		8 weeks		*P*	Effect size (w)
Median (range)	Mean±SD	Median (range)	Mean±SD	Median (range)	Mean±SD	Median (range)	Mean±SD		
−0.21 (−3.9–6.91)	0.37±2.47	0.24 (−5.2–11.05)	0.39±3.11	0.27 (−8–7.49)	0.73±2.89	–0.44 (−8.95–5.86)	0.36±2.76	0.303	0.04

SD: Standard deviation

showed that 83.3% of the extraction sites were closed by 4 months (20/24). The greater number of spaces closed in the study by Davidović *et al*.[17] compared to Dixon *et al*.[13] may have been due to attaching the elastomeric chain to the canine bracket instead of the archwire.

Similar results are reported by Thiruvenkatachari *et al*.,[18] using NiTi coil springs. In their study, most spaces were closed during the 5th month (15/18) and all quadrants were closed by the end of 6 months. Aboul Ela *et al*.[16] reported that none of the canines were completely retracted in 4 months of follow-up. Such variation has been frequently attributed to individual responses.[2,5,19]

Bokas and Woods[5] and Nightingale and Jones[19] evaluated the time to complete canine retraction using elastomeric chains. The average time to complete canine retraction was 67 ± 48 days (minimum–maximum, 42–182 days).[19] The earliest space closure was seen in 4 out of 22 quadrants within the first 4–6 weeks of retraction.[19] In the study by Bokas and Woods,[5] four quadrants closed within 56 days, another four in 84 days, and 16 out of the 24 quadrants closed by 112 days. Similarly, Thiruvenkatachari *et al*.[18] show an average space closure time of 4.8 ± 0.54 months, while da Costa Monini *et al*.[20] reported a longer mean of space closure (13.55 ± 3.88 months) for mandibular canines using NiTi coil springs.

The time to space closure during the 6 months of our trial was longer than other studies using elastomeric chains with a force between 100 and 200 g.[5,18,19] This may have been due to the use of power arms in our study to retract the canine bodily. The 2-week reactivation group showed the shortest time to space closure [Table 2] as well as the highest number of fully retracted canines, in comparison to the 4-, 6-, and 8-week reactivation groups. This was despite the rate of canine retraction being similar in all the groups. Similarly, Dixon *et al*.[13] reported that the highest number of closed extraction spaces was in the active ligature group which had the lowest rate of retraction. Out of the 27 completely closed extraction spaces, 24 quadrants had severe crowding at the start of treatment. Further studies may elucidate the effect of contributing factors, such as skeletal and dentoalveolar characteristics on the time to extraction site closure.

The amount of anchorage loss in relation to the overall extraction space may provide a useful guide in the treatment planning of anchorage control. The use of reinforced moderate and maximum anchorage has allowed space closure with less forward molar movement.[5,21] Burrow,[22] da Costa Monini *et al*.,[20] and Thiruvenkatachari *et al*.[18] reported the percent of space closed by molar mesialization using conventional brackets. The space taken up by the molars was 17%, 17%, and <20%, respectively.

In the current study, the canines were retracted using TADs for maximum direct anchorage. The first molars showed mesial displacement despite not being loaded. The median mesial drift in all four groups was between 0.21 and 0.44 mm. This may have been prevented by ligating the first molars to the TADs.

A recent systematic review and meta-analysis of low-quality studies concluded that anchorage control was better when TADs were used compared to molars.[6] Davis *et al*.[23] evaluated the amount of first molar mesial displacement. In the maxilla, the molars moved mesial by 1.3 ± 0.422 and 0.1 ± 0.21 mm with molar and implant-supported anchorage, respectively. Anchorage loss was negligent in the TADs group compared to the molar anchorage group.

The following studies compared the anchorage control by the TADs to transpalatal arches. Sharma *et al*.[24] and Bokas and Woods[5] showed anchorage loss of 0 ± 0.021 and 0.45 mm in the TADs groups, respectively. Despite the different retraction methods and force systems, the amount of mesial molar displacement was similar in the trials that used friction mechanics with TADs.

We expected that the 2-week reactivation would produce significant binding between the canine bracket and wire with subsequent anchorage loss. Yet, the anchorage loss was similar between all reactivation intervals. Using similar biomechanics to those we used, Aboul Ela *et al*.[16] and Al Suleiman and Shehadah[25] reported insignificant mesial molar displacement of 0.12 mm and 0.2 ± 0.5 mm with TADs, respectively.

In our assessment, the selection and detection bias was low for this study due to proper randomization, reliable allocation concealment, and blinding of the outcome assessor. Except for the intervention, the treatment was standardized to minimize performance bias. Trial randomization and standardization of the treatment also eliminated the possible effect of the force biodegradation of the elastics which may affect the rate of space closure. However, some data were missing for the monthly rate of canine retraction which may introduce attrition bias. Attrition bias was negligent for the molar displacement.

A limitation that should be considered in the interpretation of the time to space closure is that only 27 canines out of 145 completed retractions during the 6 months. A follow-up to complete retraction of all canines may provide a more reliable estimate.

Conclusions

The effect of reactivation intervals on the rate of tooth movement and space closure during canine retraction has not been previously investigated. The preliminary data from this study showed that:

1. The monthly rate of canine retraction was statistically and clinically similar for the 2-, 4-, 6-, and 8-week reactivation intervals

2. The 2-week reactivation interval had the shortest time to complete canine retraction, the difference was 5–10 days over 6 months
3. Mesial molar displacement was of no clinical significance with TADs as direct anchorage.

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Conflicts of interest

There are no conflicts of interest.

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