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Original Article

Comparative Evaluation of Interrupted and Intermittent Forces on Canine Retraction: an In Vivo Study

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Abstract

Introduction: Various force systems are used in orthodontics to move teeth such as continuous, intermittent and interrupted. Teeth respond differently to these orthodontic forces.

Aims: The aim of the study was to compare the rate of canine retraction with intermittent and interrupted forces.

Materials and methods: A split mouth study was carried among eighteen participants. One side of the maxillary arch randomly received interrupted force with elastomeric powerchain while the other received intermittent force with elastics with magnitude of 150-170 g for canine retraction on each side. For 15 weeks, participants were asked to wear the elastics for 8 hours a day whereas the elastomeric powerchains were replaced by operator every 5 weeks. The outcomes were assessed using scanned images of study models collected at the beginning (T0) and 15 weeks later (T3) as well on OPG. Linear and angular measurements were used to measure the distal movement, rotation as well tipping of canines and the results were statistically analysed using an independent t-test.

Results: The distal movement of canine on the interrupted force side was 0.98 mm/5 weeks and on the intermittent force side was 1.06 mm/5 weeks. The distopalatal rotation on interrupted and intermittent force side was 8.38° and 5.72°. Tipping measured on OPG was 5.72° and 5.27° for interrupted and intermittent force, respectively. No statistically significant differences were found.

Conclusions: The rate of canine retraction with interrupted force and intermittent force showed no statistically significant differences. Less canine rotation and tipping with intermittent force compared to the interrupted force though not statistically significant.

Keywords

elastomeric powerchain, latex elastics

INTRODUCTION

Forces for tooth movement are classified as continuous, intermittent, and interrupted on the basis of the duration of the applied force. Continuous force (CF) is a force that is maintained between certain intervals. Interrupted force (IF) is a force whose magnitude declines to zero between activations; the force gradually decreases until it reaches a level at which it is incapable of producing tooth movement. In contrast, an intermittent force (IF) acts over a shorter period and is completely eliminated with the removal of the force-generating device. The force levels decline abruptly to zero intermittently when the appliance is removed by the patient.[1]

It is generally thought that continuous force is suitable for optimal tooth movement. Previous studies have shown that continuous forces produced greater tooth movement than other types of forces.[2-4] In contrast, some studies have shown comparable rate of tooth movement with continuous and interrupted force.[5-7] This would, however, seem to apply only if these devices were to be activated to deliver approximately the same clinical forces. However, intermittent forces are also used in orthodontic practice. Oppenheim[8] suggested that the intermittent force was suitable for optimal tooth movement because there was a rest period that allowed reconstruction of the periodontal tissues. Reitan[9,10] suggested that hyalinised tissues are resorbed more rapidly if a given force is applied intermittently rather than continuously. To our knowledge, however, there is no study comparing the effects of an interrupted orthodontic force with an intermittent orthodontic force.

AIM

The purpose of this in vivo split mouth study was to compare the effect of two force systems, interrupted and intermittent forces, on canine retraction.

MATERIALS AND METHODS

This clinical study was conducted on eighteen patients (6 males, 12 females, age range 13-27 years), whose treatment required extraction of first premolar and split canine retraction with a written consent from the parents of patients included in the study. Total minimum sample size was calculated by power analysis established by G*Power, version 3.0.1 (Franz Faul Universitat, Kiel, Germany) that would yield 85% power to detect significant differences at significance level of 0.05. Intraoral periapical radiographs were taken to assertion the canine root morphology and only such patients were included in study.

All patients were treated with pre-adjusted edgewise brackets (MBT prescription, 0.018×0.025" slot, 3M Unitek) and a Nance holding arch was cemented. Subsequent canine retraction using 0.016 stainless steel arch wire was done. The magnitude of force had to be comparable, hence the force within the range of 150-170 g was applied for canine retraction from molar hook to canine power arm measured with dontrix gauge on each side. Each patient was to receive an interrupted force by elastomeric powerchains (150-170 g) on one side of maxillary arch and an intermittent force (150-170 g) by elastics on the other side at random to the right and left sides **(Figs 1A, 1B)**. Records for each patient were collected at the beginning of study period (T0) and at the follow-up visits which were scheduled every five weeks for fifteen weeks (T3). The records included alginate impression for maxillary arch and orthopantomogram (OPG). Records were analysed as follows:

1. Measurements on scanned images of study models:

a) Distal movement of canine

Measurements were done directly on study models and scanned images of study models with no magnification. The study models were used to calculate the amount of canine retraction. Distal movement of canine was measured on study models using a digital calliper from most convex mesial surface of the premolar to the most convex distal surface of the canine bracket. On the scanned model images, a reference line was used, midpalatal line (MPL), a line passing along midpalatine raphe. The perpendicular distance from the cusp tip of canine to MPL was measured in millimetres **(Fig. 2)**.

b) Rotation of canine

Canine rotation was measured as the angle formed between MPL and the line joining mesial and distal surface of canine (CR-A) **(Fig. 2)**.

2. Measurements on OPG

Angular measurement were done on OPG **(Fig. 3)** to check the canine inclination (CI) before (T0) and after canine retraction (T3). Canine angulation was measured as the mesial angle formed by long axis of canine on infraorbital line. Infraorbital line was drawn passing through the most inferior points of the right and left orbits as per Ursi et al.[11]

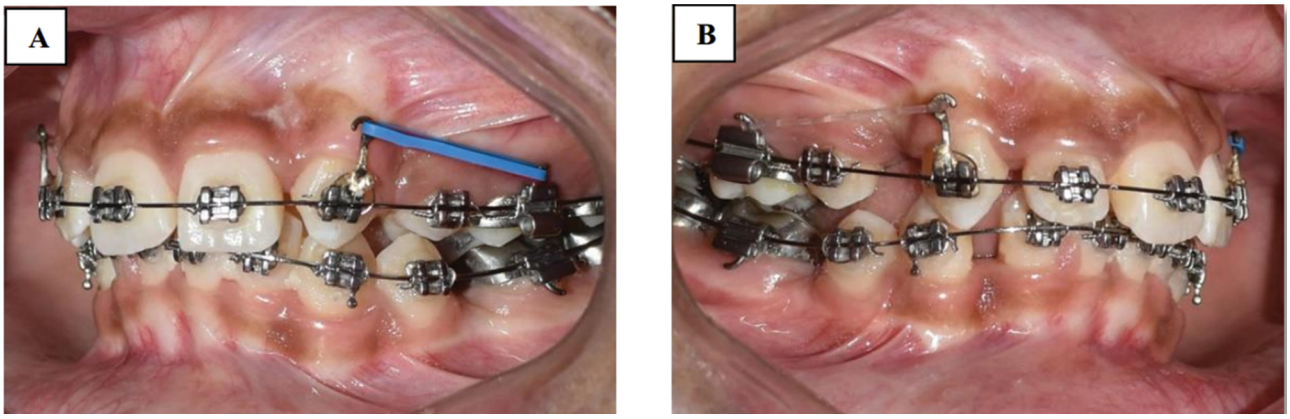

Figure 1. A. Canine retraction carried out with intermittent force side with elastomeric chain; **B**. Canine retraction carried out interrupted force side with latex elastics.

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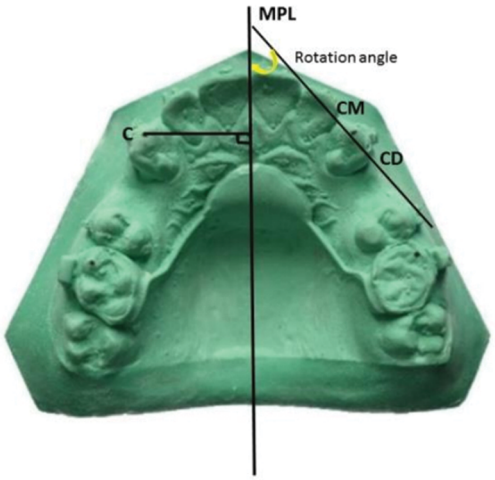

Figure 2. Linear and angular measurements on scanned models. Perpendicular distance from canine cusp tip (C) to midpalatal line (MPL) and rotation angle formed by MPL to mesial and distal surface of canine.

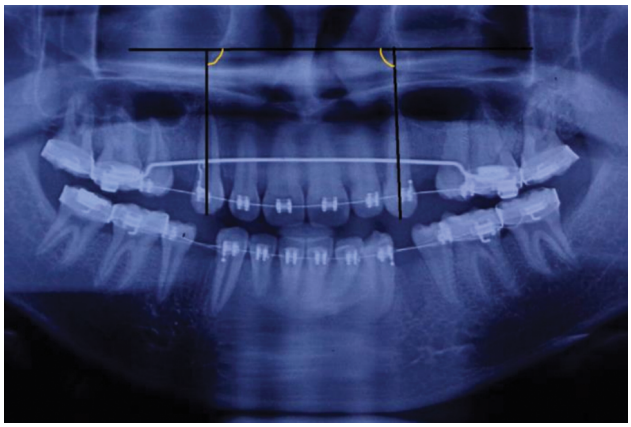

Figure 3. Canine inclination (CI) measured on OPG – the mesial angle measured between infraorbital plane and the long axis of canine on both the sides.

Statistical analysis

Statistical analysis was performed using the SPSS for Windows, Version 16.0 (SPSS Inc. Chicago, IL, USA). Statistical analysis was done by using tools of descriptive statistics such as means, and SD for representing quantitative data (e.g. angular measurement recorded in degrees). An independent t-test between two samples was used to compare means of measurements of interrupted group and intermittent group respectively.

RESULTS

The total amount of distal canine movement in 15 weeks has been summarized in **Table 1**. The movement of canine distally in extraction space was less on the interrupted force (elastomeric powerchain) side (2.96 mm) than on the intermittent force (elastics) side (3.18 mm). When compared, this difference was not statistically significant (p=0.523). The angular measurement from T2–T3 i.e. from week 10 to week 15 showed more canine rotation on the interrupted force side (2.88°) than on the intermittent force side (1.44°) which was statistically significant (p=0.047). The total change in the angular measurement of canine (T0-T3) showed that there was more distopalatal cuspid rotation on the interrupted force side (8.38°) as compared to intermittent force side (5.72°) but the difference was not statistically significant (p=0.073). The amount of canine inclination (CI) which was measured on the orthopantamogram was greater on the interrupted force side as compared to intermittent force side. The value for CI at T3 was 5.72° on the interrupted force side and 5.27° on the intermittent force side, which showed that there was more crown distal and root mesial inclination on the interrupted force side. When compared the difference was not statistically significant (p=0.769).

DISCUSSION

A split mouth design was chosen because the main advantages of prospective split-mouth studies is reduced variance and higher study power compared to conventional parallel-group designs.[12]

The interrupted force, though gradually decreasing over a period of time, is shown to have tooth movement similar to that of continuous force.[5-7] Oppenheim[13] suggested that the intermittent force was suitable for orthodontic tooth movement, because it provides a rest period that allows for reconstruction of the periodontal tissues. The rest period

Table 1. Comparison of tooth movement before and after canine retraction between the interrupted and intermittent force groups

	Groups	Mean	SD	*p* value
Distal movement of canine in extraction space (mm)	Interrupted force	2.96	0.89	0.523
	Intermittent force	3.18	0.91	
Canine rotation (degrees)	Interrupted force	8.38	3.82	0.073
	Intermittent force	5.72	3.36	
Canine tipping (degrees)	Interrupted force	5.72	4.17	0.769
	Intermittent force	5.27	4.79	

might also allow the resorbed cementum to heal and prevent further resorption. So in the present study, we compared intermittent and interrupted forces to calculate the rate of tooth movement during canine retraction.

Proffit and Seller[14] suggested for tooth position in humans to be permanently altered, the orthodontic force must be present from four to eight hours per day. Nakao et al.[15] and Haga et al.[16] concluded that 8-hour intermittent force was more effective for orthodontic tooth movement compared with continuous force. Kameyama[17] concluded from his study that 4-9-hour intermittent force groups showed less root resorption because they allowed restoration of blood flow during the time that forces are not active. Hence, the intermittent forces were applied for eight hours a day.

Quinn and Yoshikawa[18] summarised that a force between 100-200 g would be most efficient for canine retraction. Rietan[9] advocated a 150-to-250-gram force during the final stage of continuous bodily movement of maxillary canines. The force selected for retraction in this study was 150-170 grams.

Unwanted movements like rotation and tipping occur during canine retraction. Mezomo et al.[19] concluded that rotation greater than 10° may be critical for treatment sequence. Derotation and root uprighting phases after canine retraction would extend the treatment time and eventually compromise finishing quality. Hence in this study distal tipping and rotation was studied.

The tendency toward rotation is related to the point of application of the force which does not pass through the center of resistance of the teeth. Hence power arms of 6-7 mm height was welded and soldered to maxillary canine bracket hooks as the force to be applied should be closer towards the center of resistance. Burstone et al.[20] observed that the average position of the center of resistance of maxillary canine was 6.7 mm from the alveolar crest. Yamaguchi et al.[21] found the center of resistance of the maxillary canine to be at approximately 35% of the root length measured apically from the cervical margin. Using finite element model, Vollmer et al.[22] found the center of resistance of the maxillary canine to be 8.2 mm below the alveolar crest, i.e. two-fifth of the root length from the alveolar margin. It was observed that chances of friction increased as bracket slots were filled.[23] In the present study, Australian Premium Plus 0.016 stainless steel arch wire with 15° bite opening curve was given as base archwire. To reduce friction during retraction, the distal wing of the canine brackets were ligated gently with stainless steel ligature.

Butler[24] compared the histologic effects of light continuous versus heavy intermittent orthodontic forces by split mouth study in monkeys. The heavy intermittent force of 200 gm/cm^2 of root surface were delivered. The findings showed that the alveolar bone crest was affected by both types of force, but the light continuous force was more damaging causing root resorption on pressure side.

Elastomeric chains which are composed of polyurethanes have been shown to lose approximately 50%–75% of their initial force over the first 24 hours, followed by 10%–20% force decay in the first 4 weeks.[25-27] Lu et al.[28] found the force reduced by about 40%–59% and 32%–50% of the original force value at the 4th and 5th weeks, hence interrupted forces were maintained for five weeks. Whereas in elastics, it was observed that nearly 25% of the force loss occurred in the first 30 minutes. At 4 and 8 hours, the force losses were near 35% and 40%.[29] Yang et al.[30] concluded in his study that the force degradation of latex elastic in vivo is much greater than that in both air and artificial saliva. In vivo, the force value of the orthodontic latex elastics decreased sharply in the first hour.

During the entire study period of fifteen weeks, there was no significant difference seen in reduction of extraction space between the intermittent force side (2.77 mm) and interrupted force side (2.55 mm).

A similar study by Sonis (1994) observed that the rate of space closure by elastics (TP Orthodontics) was 1.08 mm/4 week whereas in the present study it was 0.91 mm/5 week on elastics (TP Orthodontics) side.[31] The difference in the tooth movement of both studies might be because they asked the patient to change the elastics daily whereas in our study 8 hours/day protocol was followed. Also the magnitude of force was different in both studies. Dixon et al.[5] observed that the retraction with elastomeric powerchain (Rocky Mountain) was 0.58 mm/4 week with the initial force of 200 grams whereas in the present study with elastomeric powerchain (Rabbit Force) it was 0.84 mm/5 week with the initial force of 150-170 g. The difference might be of use of elastomeric powerchain from two different companies with the manufacturing variations. Another study by Nightingale and Jones[6] observed closure of extraction space by elastomeric chain and Niti spring in patients with age group 12-18 years. The amount of closure of extraction space was 0.84 mm/4 week by elastomeric powerchain (Durachain, Orthocare) with the initial force of 70-450 g. In our study, the amount of closure of extraction space was 0.84 mm/5 week in patients with age group 12-27 years with the initial force of 150-170 g. The difference in both studies might be because of factors like patient's growth pattern and patient's age. As suggested by Reitan[32], variations in bone density and periodontal ligament cellularity are related to patient age. Children demonstrate increased cellularity of the periodontal ligament and larger marrow spaces within the alveolar bone relative to adults. Consequently, in the child patient, the cell-mediated changes necessary for tooth movement may occur more rapidly and the bone volume requiring resorption may be less. The net result is a more rapid tooth movement than that observed in adults. Bokas and Woods[7] observed closure of extraction space by elastomeric chain (Alastik, 3M/Unitek) with an initial force of 200 g was about 1.68 mm/4 weeks whereas in our study it was 0.84 mm/5 week by elastomeric powerchain (Rabbit Force) with the initial force of 150-170 g. The results of their study were not in accordance with our study. This may be because of factors like delivery of initial forces and the use of elastomeric powerchain from two different companies with manufacturing variation.

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During canine retraction the force was applied on the labial surface of canine, i.e. it was applied labially to the center of resistance, so the canine rotated distopalatally. At the end of study period, rotation was greater on the interrupted force side, i.e. 8.38° as compared to intermittent force side i.e. 5.72° (p=0.073) but was not statistically significant. Some factors that may influence the canine rotation are the clearance between archwire and the bracket slot, the elastic deformation of the archwire and the tightness of the ligature tie.

The angular changes measured on the panoramic radiographs between time intervals T0-T3 showed that canine tipped more on interrupted force side by 5.72° as compared to intermittent force side by 5.27° but this difference was not statistically significant (p=0.769). This can be explained by the tissues and periodontal ligament on the intermittent force side get enough time for repair and healing which leads to gradual tipping and uprighting of the canine i.e. the natural walking of the canine can be seen.

CONCLUSIONS

Based on the results of this study, we can say that though not statistically significant the distal movement of canine was greater on the intermittent force side as compared to the interrupted force side. There was more canine rotation on interrupted force side by elastomeric powerchain with a statistically significant values form time interval T2-T3 also the tipping was more on interrupted side. Hence, intermittent force gave rapid rate of space closure

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Сравнительная оценка воздействия прерывистых и непрерывных сил на ретракцию клыков: исследование in vivo

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Резюме

Введение: В ортодонтии используются различные силовые системы для перемещения зубов: прерывистые и непрерывные. Зубы по-разному реагируют на эти ортодонтические силы.

Цели: Целью исследования было сравнить частоту ретракции клыков при прерывистых и непрерывных нагрузках.

Материалы и методы: Исследование было проведено среди восемнадцати участников. Случайным образом одна часть верхней челюсти подвергалась воздействию эластомерной силовой цепи, в то время как другая подвергалась периодическим нагрузкам с внутриротовыми эластиками 150-170 г для ретракции клыков с каждой стороны. В течение 15 недель участники носили резинки по 8 часов в день, а резиновые цепи менял оператор каждые 5 недель. Результаты оценивались с использованием сканированных изображений моделей исследования, сделанных на исходном уровне (T0) и через 15 недель (T3), а также с помощью ортопантомографа (ОПГ). Линейные и угловые измерения использовались для измерения дистального смещения, вращения и типирования клыков, а результаты были проанализированы статистически с использованием независимого t-критерия.

Результаты: Дистальное движение клыков со стороны прерывистой силы составляло 0.98 мм/5 недель, а со стороны непрерывной силы – 1.06 мм/5 недель. Дистопатическая ротация сторон с прерывистой и непрерывной силой составила 8.38° и 5.72° соответственно. Смещение пиков клыков, измеренное на ОПГ, составило 5.72° и 5.27°, соответственно, для прерывистой и непрерывной силы. Статистически значимых различий не обнаружено.

Заключение: Степень ретракции клыков с прерывистой и непрерывной силой не показала статистически значимых различий. Была обнаружена более низкая степень вращения клыков и смещение пиков прерывистой силы по сравнению с непрерывной силой, хотя это не было статистически значимым.

Ключевые слова

эластомерная силовая цепь, латексные резинки