The Comparison of Space Closure Rate between Conventional and Passive Self-ligating System Using Elastomeric Chain in Maxilla

Sabrina[1], Krisnawati[2], Benny Mulyono Soegiharto[2]*

1. Orthodontic Residency Program, Faculty of Dentistry, Universitas Indonesia, Jakarta, Indonesia.
2. Department of Orthodontics, Faculty of Dentistry, Universitas Indonesia, Jakarta, Indonesia.

Abstract

The effectiveness of orthodontic treatment during en-masse space closure is investigated between passive self-ligating system and conventional system. Prospective randomized controlled clinical trial with a split mouth design is carried out for 11 months. Eleven subjects (3 men and 8 women with age minimum of 15 year old) with extraction of first premolars, who have completed leveling and aligning stage, are included in this study. Each subject is bonded with conventional bracket on one side of the arch and with passive self - ligating on the other side, which has determined randomly, and is given a force of 150 g with power chain on .019 x .025 SS wire. The measurement of en-masse space closure rate and amount of anchorage loss are performed at T0, T1 (4 weeks), and T2 (8 weeks). A pair student's T-test and a Wilcoxon test are carried out to analyze the data statistically.

There is significant difference of the average rate of closing space between passive self-ligating system and conventional system group (p = 0.01), for which a group of passive self-ligating system has a greater speed compare to conventional group, though there is no difference of the anchorage demands between the two groups. The passive self-ligating system has more rapid space closure rate, which might relate to shorter duration of orthodontic treatment.

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Introduction

Self-ligating brackets have become very popular over the course of the last decades, their occurrence enlarges variation of bracket system type in orthodontic treatment. Efficiency of treatment mechanics is a major focus in modern orthodontics, as well as effective ligation, as it ensures that forces generated between the arch wire and the brackets are transmitted to the tooth. In later stages of treatment, when single teeth or groups of teeth are slid along the arch wire by traction from elastics or coil springs, the ligation maintains the existing alignment.[1] During mechano therapy involving movement of the bracket relative to the wire, friction at the bracket-wire interface may prevent the attainment of optimal force levels in the supporting tissues. Friction is defined as the resistance to motion when one object moves tangentially against another.[2]

****Corresponding author:***
Dr. Krisnawati
Department of Orthodontics, Faculty of Dentistry, Universitas Indonesia, Jakarta
Indonesia
E-mail: krisnawati_et@yahoo.com

During orthodontic tooth movement with the pre adjusted conventional system, friction generated at the bracket/arch wire interface may impede the desired movement. An elastic modules that are used for ligating the wire to the bracket produces a force of 50-150 g and the magnitude of this force is heavy enough to generate friction between the wire and bracket slot. The use of stainless steel wire ligature could actually reduce the friction, but provide different force magnitude and quite time consuming during installation.[3]

Self-ligating bracket is kind of bracket that does not require elastic or wire ligation, because it has an open-close mechanism for placing the wire in the slot of bracket, which is part of the bracket itself. According to Harradine (2008), a system ligation should ideally has the following characteristics; secure and robust, ensure full bracket engagement of the arch wire, exhibit low friction between bracket and arch wire, quick and easy to use, permit high friction when desired, permit easy attachment of elastic chain, assist good oral hygiene, and comfortable for the patient.[4] One of self-ligating bracket that is widely used today is Damon bracket system.[5] Damon system actually been introduced since 1994. This is a passive self-ligating system. Introduced by Dwight Damon with a few improvements in bracket design from time to time, with the latest generation is Damon Q. Based on Damon system principle, the orthodontic force system applied is biologically acceptable by the tissue, but optimal enough to stimulate tooth movement. The force is must be low enough to prevent occluding the blood vessels in the periodontal membrane to allow the cells and the necessary biochemical messengers to be transported to the site where bone resorption and apposition will occur and thus permit tooth movement. To achieve this goal, one of which required a ligation method with minimal friction, which is obtained by passive self-ligating system. This system not only provides the bracket design in such a way giving frictionless effect so the force is optimal, but also the type of wire, the stages of treatment with its wire sequences and specified duration of each stages of which aims to give the natural forces system that is appropriate to growth and development.[6]

The appearance of self-ligating bracket system nowadays enlarges variation of bracket system type in orthodontic treatment. The question raises among clinicians regarding this issue, which type of bracket system gives an optimum outcome of orthodontic treatment. There were many studies investigating characteristic of various bracket system to compare the effectiveness of one system over another. Some of them observed treatment time required to fix malocclusion.[5,7] There has been many studies that compares post extraction space closure rate using different bracket sytems, among those studies using Smart clip self-ligating bracket and previous Damon bracket generations.[8-13] There were no studies comparing the space closure rate using the latest Damon bracket (Damon Q) towards the conventional bracket together with the measurement of anchorage loss. The method to measure anchorage loss in this study was adapted from Mezomo et al, who compared anchorage loss between self-ligating bracket and conventional bracket.[9]

The objective of this study is to compare the effectiveness of orthodontic treatment which is performed using self-ligating bracket system and conventional pre adjusted bracket during the space closure, by analyzing the difference en-masse space closure rate and anchorage loss between the two systems after applying retraction force using elastomeric chain within certain period.

Materials and methods

This study is conducted in January until November 2013. It has previously tested by the ethics committee of Faculty of Dentistry, University of Indonesia and is approved. Subjects are patients undergoing orthodontic treatment at Orthodontic Clinic Dental Hospital Faculty of Dentistry, University of Indonesia. All subjects who meet inclusion criteria are included as the sample. The inclusion criteria are as follows; good general health condition with minimum age of 15 years old (past the growth spurt phase), the case of four first premolars extraction, not using the additional anchorage such as mini screw implant, no missing teeth up to the second molar, has been treated with conventional orthodontic treatment which has completed leveling and aligning stage and willing to admit the treatment in accordance with the research procedure from beginning to end. The sample size is 11 patients. The study is a prospective study randomized controlled clinical trial with split-mouth technique, wherein the determination of the split mouth design is done randomisely.

There are two split-mouth designs in this study, as shown below:

	Group A		Grup B		
RA	Damon Q™	Conventional preadjusted edgewise MBT	Conventional preadjusted edgewise MBT	Damon Q™	RA
RB	Conventional preadjusted edgewise MBT	Damon Q™	Damon Q™	Conventional preadjusted edgewise MBT	RB

Group A : Damon Q on right upper and left lower, while left upper and right lower use conventional preadjusted MBT.

Group B: Damon Q on left upper and right lower, while right upper and left lower use conventional preadjusted MBT.

The independent variable in this study is the bracket system, the passive self-ligating bracket on one side of the dental arch and the conventional bracket on the contra-lateral arch. The dependent variables are the space closure rate after the first premolar extraction and amount of anchorage loss.

Data collection procedures are outlined as follows; after preparation of the subjects (including informed consent), the bracket placement is conducted based on split mouth technique. Bracket debonding is done randomisely according to the A or B group design, on quadrant for self-ligating bracket (Damon Q). Then etching the labial surfaces. Bracket placement is started from central incisor to first molar with the guide of working wire SS 0,019 x 0,025.The crimpable hook placement is at the distal of lateral incisor on SS 0,019 x 0,025working wire. Measurements are carried out on the study model of the patient which impression is taken at T0, T1 and T2. The initial study model (T0) is obtained by taking impression prior to retraction with elastomeric chain. Before taking the impression, all brackets are covered in wax for the purpose of blinding the operator in performing measurements on study models. Identification only on the serial number of the study model, thus the operator unable to identify which quadrant is conventional bracket or self-ligating bracket.

The impression process such the above steps are repeated at the time of activation within 4 weeks interval, after 4 weeks (T1) and after 8 weeks (T2). Each subject has three study models; T0, T1, and T2 models. Once the model T0 is obtained, then en-masse retraction with elastomeric chain is carried out, the retraction force is 150 g, measured by tension gauge on each quadrant in maxilla.

Figure 1. Activation with elastomeric chain in maxilla to perform en-masse retraction.

Elastomeric chain is replaced with a new one with the same amount of force on each control / activation time, and the ligature elastomeric as well. The distance between most mesial point of the second premolar to distal point of the canines are measured using a digital caliper (Masel), as shown in the picture below. The measurements are performed on T0, T1 and T2 study model. The rate of retraction is obtained by calculating the difference between T1-T0 and T2-T1. While the average rate in each month is obtained from the difference between T2-T0 divided by two months. The calculation is performed 3 times on each model.

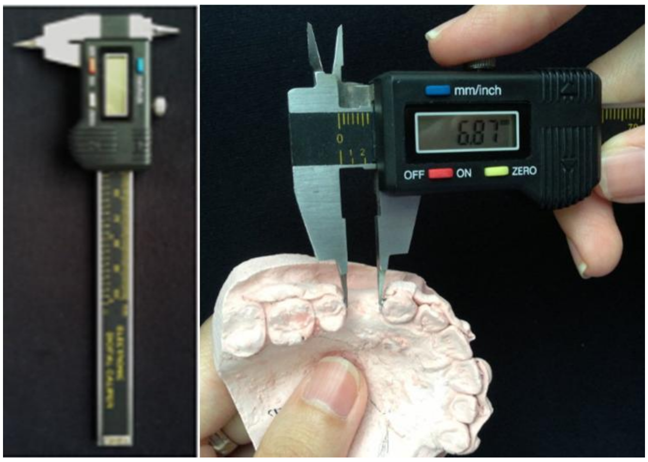

Figure 2. Measurement method of the distance between premolar and canine in study model using digital caliper (Massel).

Anchorage loss is measured using an acrylic plate guide on the maxillary palatal rugae with wire along the distance of the acrylic plate to first molar cusp mesiopalatal based on T0 study model of the maxilla, this distance is compared to the T1 and T2 study model using acrylic plate guide. Self-curing resin acrylic plat is made on maxillary palatal rugae with 0.7 mm diameter SS wire extends from acrylic plat to mesiopalatal cusp of maxillary first molar on T0 study model. Measurements are conducted with acrylic plate placed on the anatomical structure of the palatal rugae of T1 and T2 study models. Measurements are also performed using a digital caliper (Masel) from the end of the wire on acrylic plate to the mesiopalatal cusp of maxillary first molar on T1 and T2 study model. Measurement is performed 3 times on each study model.

The data obtained in this study are analyzed descriptively to obtain the average value and standard deviation, and are analyzed using paired T test if they have normal data distribution. However, if the data distribution not normal, the alternative test, Wilcoxon test will be considered.

Results

The intra-observer agreement test in this study is conducted using Bland-Altman test, the test is performed to verify the agreement between the first and second measurements of both, the measurement of distance from mesial second premolar to distal canines and also distance of anchorage loss. Bland-Altman test results on the measurement of the distance between mesial second premolar to distal canines and anchorage loss can be seen in the Bland-Altman plots as follows.

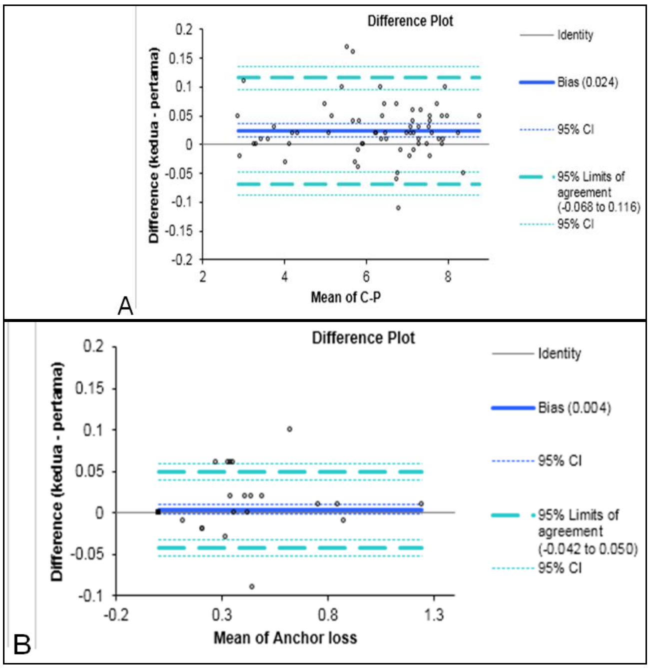

Figure 3. Bland-Altman difference plot: A. The measurement of mesial second premolar to distal canine distance (C-P). B. The measurement of loss anchorage.

Based on Bland-Altman test on the first and second measurement of the distance between mesial second premolar to distal canines (C-P) above, there is bias occurs at 0,024 with limits of agreement -0.068 to 0.116. The tests conclude that there is agreement between the first and second measurement, for the data distribution is within the limits of agreement. Likewise the Bland-Altman test on the first and second measurement of anchorage loss, there is bias occurs at 0,004 with limits of agreement -0.042 to 0.050. The data distribution is within the limits of agreement, concluded there is agreement between the first and second measurement. Hypothesis test results in this study are described in the tables below.

Variable	Self ligating			Conventional		
	T0-T1	T1-T2	T0-T2 (total)	T0-T1	T1-T2	T0-T2 (total)
En-masse retraction	0.75 ± 0.46	0.71 ± 0.56	0.73 ± 0.49	0.48 ± 0.34	0.48 ± 0.38	0.48 ± 0.31
Anchorage loss	0.12 ± 0.19	0.17 ± 0.39	0.15 ± 0.22	0.16 ± 0.27	0.16 ± 0.19	0.16 ± 0.16

Table 1. Mean values for en-masse retraction rate and anchorage loss.

Variable	Comparison between groups (self-ligating and conventional)		Comparison between time (T0-T1 and T1-T2)	
	time	*p*	group	*p*
En-masse retraction	T0-T1	0.03	self-ligating	0.00
	T1-T2	0.00	conventional	0.19
	T0-T2	0.01		
Anchorage loss	T0-T1	0.69	self ligating	0.50
	T1-T2	0.74	conventional	0.87
	T0-T2	0.74		

Table 2. Statistical analysis using paired-T test and wilcoxon test. (p< 0,05 = statistically significant different)

Discussion

According to Lesaffre (*cit* Pandis, 2012), split mouth design or intra-individual design was a design in which each subject received two interventions together in one dental arch. It required fewer samples than parallel studies, only a half of the sample of parallel design study, because of the variability that existed in one individual considered to be smaller than between different individuals.[14] The number of samples in this study is 11, with 90% power. According to Wong, the advantage of intra-individual design was it might allow more precise comparison between techniques by removing the confounding factor of variability between individuals that could affect the rate of tooth movement during retraction. However, he also stated that this design would introduce an additional confounder if the method of space closure on one side of the arch either increased or decreased the rate of tooth movement on the contralateral side.[13] Selection of split mouth technique for this study are consistent with previous studies regarding the movement of teeth during space closure such as Miles, Mezomo, Burrow, and Oz.[9-12]

Retraction method performed in this study uses elastomeric chain that extends from the first molar hook to the crimpable hook on the distal lateral incisor. The magnitude of force is 150 g on each side and measured with a tension gauge (Correx). Force measurement method in this study was also carried out in research by

Mezomo.[9] Other studies such as Wong and Miles measured the length of closed-coil spring with a ruler directly in patient's mouth.[10,13] While research by Burrow and Oz did not mention how the measurement was done.[12,13] According to Quin and Yoshikawa (cit Yee, 2009) the teeth movement rate was sensitive to force alteration that was applied.[15] Therefore, the authors believe that measuring the amount of force when retracting the teeth should be made properly to avoid different force magnitude resulting in different tooth movement rate.

Statistical analysis in this study show the rate of en-masse retraction during space closure at T0-T2 in the group of self-ligating bracket is statistically significant different compared to conventional bracket group (p=0.01) (table 2). Average rate/month of self-ligating bracket group is 0.73 mm/month (±0.49) and conventional bracket group is 0.48 mm/month (±0.31) (table 1). The calculation of retraction rate at T0-T1 and T1-T2 also show a significant difference between the two types of bracket (table 2). Retraction rate of self-ligating group at T0-T1 is 0.75 mm/month (±0.46) and retraction rate of conventional group is 0.48 mm/month (±0.34) (table 1), with p value is 0.03 (table 2). Retraction rate of self-ligating group at T1-T2 is 0.71 mm/month (±0.56) and the retraction rate of the conventional group is 0.48 mm/month (±0.38) (table 1), with p value is 0.00 (table 2).

Miles gave a different result from this research. In his studies with a split-mouth technique on 13 samples, the average value of en-masse retraction rate with Smart Clip bracket was 1.1 mm/month whereas conventional bracket with ligature wire ligation was 1.2 mm/month, concluded that no statistically significant difference between the two groups (p=0.86).[10] Similarly, research by Wong, a parallel study of 45 samples that were divided into three groups concluded that there was no statistically significant difference of en-masse retraction rate between conventional brackets with elastomeric ligation, conventional brackets with elastomeric Super Slick ligation and self-ligating bracket 3MX Damon. In his study, the mean difference between the three types of brackets and ligation were very small, ranging from 0.1 mm to 0.3 mm, with p=0.718.[13]

The findings from laboratory studies suggested that self-ligating brackets exert less friction on the archwire and that lower forces can be employed to achieve tooth movement, reducing the anchorage demand during orthodontic treatment. A study conducted by Fok et al, which was a continuation of research by Badawi et al, concluded that resistance to sliding on self-ligating bracket was minimal and propagation of the force/couple systems around the arch was minimal, thus reduces the occurrence of unwanted force/couple systems, while the conventional bracket with elastic ligation produced significantly more resistance to sliding, contributing to higher forces and couples at the center of resistance.[16-18]

Anchorage loss analysis are also conducted in this study, uses an acrylic plate in the palatal rugae with some reference wire placed at specific anatomical points.[9] The objective is to compare the needs of anchorage on both types of bracket. This analysis is crucial because there is no additional anchorage in this study. Thus, the tooth movement that occurs during space closure can be distinguished, whether movement of the six anterior teeth distally or combined with posterior teeth movement mesially. The results of anchorage loss analysis in this study show that anchorage loss occurs on both bracket systems, but no statistically significant difference between the groups (p=0.735). The average loss of anchorage on self-ligating group is 0.15 mm/month whereas in the conventional group is 0.16 mm/month. These results are consistent with research by Mezomo.[9]

Conclusions

The results in this study indicate that the en-masse retraction with power chain in maxilla using passive self-ligating bracket system is faster and statistically significant differences compared to conventional bracket system. While the loss of anchorage between the two groups not differ significantly, but descriptively anchorage loss in passive self-ligating bracket system group is smaller than those of conventional bracket system. This results support previous studies, both laboratory and clinical studies on the effectiveness of treatment with passive self-ligating bracket system. It is concluded that the passive self-ligating bracket system can reduce friction, thereby enabling relatively faster tooth movement and might related to shorter duration of orthodontic treatment.

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Declaration of Interest

The authors report no conflict of interest.

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