Original Research
Journal of Pierre Fauchard Academy (India Section), *Vol 35(2), DOI: 10.18311/jpfa/2021/27803, June 2021 p. 49-57*
ISSN (Print) : 0970-2199
ISSN (Online) : 2405-772X

Rate of Canine Retraction and Anchorage Loss – In Smart Clip versus Conventional Brackets (An in-vivo study)

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Abstract

Background: To analyse the rate of maxillary canine retraction and anchorage loss in Smart Clip Self Ligating (SCSL) and Conventional (CV) brackets. **Materials and Methods:** Forty four subjects were selected for the study requiring sectional maxillary canine retraction in first premolar extraction space during orthodontic treatment. The self ligating bracket (Smart Clip, 3M Unitek) on maxillary canine was compared to CV bracket (APC Victory series) on the contralateral side in a random split-mouth study design. Sectional canine retraction was done with a NiTi coil spring (150 gms force, 9 mm) on 0.016 × 0.022" slot stainless steel wire. **Results:** The mean rate of distal movement of maxillary canine for the conventional (CV) bracket per 28 days was 1.048 mm and 1.027 mm for smart clip self ligating bracket (SCSL). Anchorage loss in molar was 0.586 mm and 0.652 mm for CV and SCSL bracket respectively. **Conclusion:** The rate of canine retraction for conventional bracket was faster than self ligating bracket, but not statistically significant (p>0.05). Comparatively, no major difference was found in terms of molar anchor loss between both bracket types. Therefore, this study indicates that conventional brackets are equally efficient as compared to self ligating brackets for segmental canine retraction mechanics.

Keywords: APC, Canine retraction, Self-ligating

1. Introduction

Biocompatibility of the appliance, patient comfort level and efficiency of orthodontic treatment are the major issues in contemporary orthodontics. Faster retraction of canine by sliding mechanics with minimum friction and anchorage loss is desired. Therefore, it is interesting to know if latest innovations as self ligating brackets are actually more efficient in this aspect or similar to conventional brackets. In literature, self ligating (Sl) brackets are claimed to be better than conventional (CV) brackets.

Friction is observed during sliding mechanics at bracket-archwire interface which opposes the movement[1]. In order to achieve desired movement, the force applied should be greater than the frictional force within the appliance. Frictional force generated between arch wires and brackets may vary with ligation methods (elastomeric and ss ligatures, active and passive SL brackets)[2–4], and ultimately changes the rate of tooth movement[5]. SL brackets were first used in Orthodontics by Stolzenberg[6] (1935). Wildman[7] (1972) and later on[8,9] significant modifications were introduced in self ligating brackets. The advantage of quick ligation of arch wires

saves chair side time along with better clinical efficiency[10]. SL brackets have been claimed to reduce friction between bracket-arch wire interface, deliver better biological force levels, lessen treatment time, better plaque control and improve patient comfort level[11,12]. Still, most of these findings are controversial[11,13]. In order to analyse the efficiency of SCSL brackets vis-a-vis conventional ones during sliding mechanics, this study was undertaken. The null hypothesis was "there is no difference in the rate of retraction of upper canines and anchorage loss with sliding mechanics using self-ligating brackets (Smart Clip, 3M Unitek) and conventional brackets".

1.1 Aim of the Study

To compare rate of sectional canine retraction and anchorage loss in sliding mechanics with SCSL brackets when compared to conventional brackets in split mouth study design.

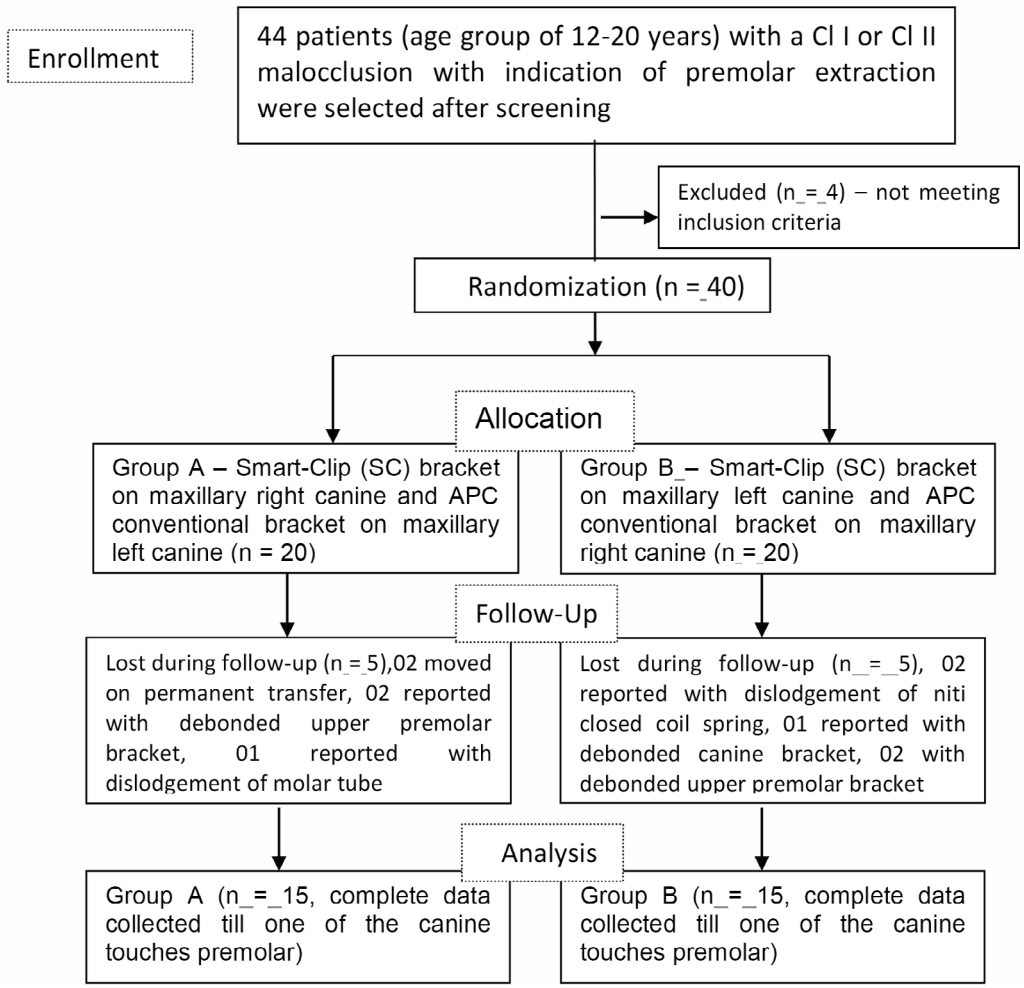
2. Materials and Methods

The sample size of ≥25 was found to be adequate (estimated differences between 2 groups of 0.2 mm, SD of 0.3 mm, α of 0.05 and P of 90%). 44 healthy patients (26 girls and 18 boys) with age group of 12-20 years were selected for this study. The statistical analysis software used for this study was Statistica software 7.0 (StatSoft, USA).

Inclusion criteria:

- Class I or Class II malocclusion with associated crowding or proclination of incisors.
- Planned therapeutic extraction of first premolars followed by maxillary canine retraction by sliding mechanics.
- Moderate anchorage requirement.
- Good oral hygiene and periodontal health.
- Average growth pattern.

Study design:



Patients were selected as per inclusion criteria. The randomization was done with block randomization sequence. A total of 44 kits of 0.018-inch slot PEA brackets (22 SCSL appliance kits and 22 APC Victory series MBT appliance kits) were used in the study. Each patient had a 0.018-inch CV bracket bonded on one canine (Figure 1) and a 0.018-inch SCSL bracket placed on the other (Figure 2), with the side (right/left) chosen with a random sequence. Remaining teeth were bonded with Victory Series (CV) brackets/Smart clip brackets and the molars were cemented with preformed molar bands having prewelded molar tubes.

Arches were aligned and leveled by 0.014" and 0.016" preformed thermally active NITI arch wires and gradually to 0.016" and 0.016 × 0.022" SS arch wire finally. Incisors were tied together and second premolars were tied to first molars with 0.10 inch stainless steel ligature. No anchorage reinforcement was done for molars. The CV canine bracket was tied with a SS ligature wire. Leveling and alignment of arches was ensured prior to canine retraction.

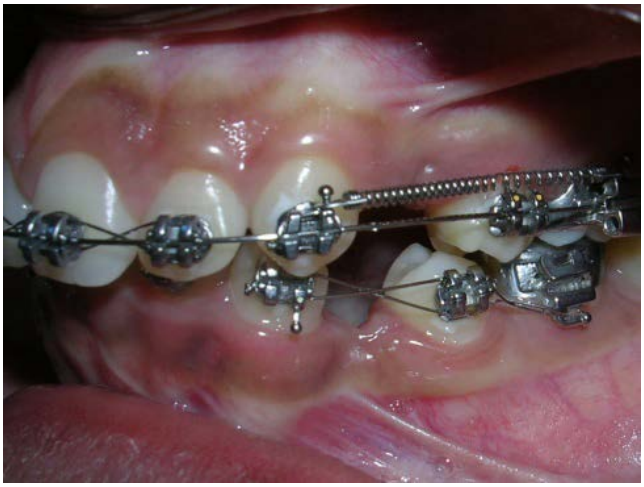


Figure 1. Sectional canine retraction with conventional brackets and NiTi coil spring.



Figure 2. Sectional canine retraction with Self ligating (Smart clip, 3M-USA) brackets and NiTi coil spring.



Figure 3. Method to measure rate of canine retraction from maxillary dental midline with the help of Digital caliper.

Intra-arch retraction mechanics was started when the SS arch wire rests passively in the brackets and the canines were retracted on 0.016" × 0.022" inch SS wire (Figures 1 and 2). Closed coil springs were fixed to the power arm of canine bracket and molar hooks. GAC Sentalloy retraction spring force 150 g as shown in Figure 1 and Figure 2. Patients were followed up every 4 weeks. Measurement of canine retraction was done by the same investigator intraorally by using divider and digital caliper (Figure 3). The amount of canine retraction was noted from upper dental midline to the centre of the mesial edge of the canine bracket slot. Similarly distance was also measured from maxillary dental midline to the mesial portion of the molar tube on the arch wire after canine retraction. Each measurement was written three times and the results were

noted after their average. The measurements were noted upto two decimal points of a millimeter.

The rate of retraction of the canine is the distance moved divided by the time taken for closing the extraction space. The distance of canine retraction was noted at each recall visit during space closure, but only the distance covered divided by the number of 28-day recall visit was noted till one of the canines was in the correct position; i.e, the end date for the retraction was when the canine touched second premolar on any one of the sides of the extraction space. Anchorage loss was noted as the extent of mesial movement of the maxillary molars after completion of canine retraction.



Figure 4. Completion of canine retraction with self-ligating Smart clip brackets.



Figure 5. Completion of canine retraction with conventional brackets.

The intra and inter-observer variability was assessed after 01 week for 20 patients. Thekappa score was 0.9 for both, suggesting excellent intra and inter-observer variability.

3. Results

The amount of canine retraction measured per appointment (28 days) is shown in the Table 1. Anchorage loss has been shown in Table 3. were excluded for not meeting inclusion criteria. There was 10 drop-outs (lost to follow up). These 14 studies were excluded. The mean, standard deviation (Table 2 and 4) and student's paired t-test (for remaining 30 patients) were used for statistical analysis. The underlying normalcy in distribution of data was assessed prior to the statistical analysis.

The rate of canine retraction of CV bracket was 0.044 mm more than that of SCSL bracket. The rate of movement of the CV bracket was faster than SCSL brackets but it was not statistically significant (p-value = 0.358). The anchorage loss due to SCSL brackets was 0.066 mm more than that due to CV brackets but it was not statistically significant (p-value = 0.156).

4. Discussion

Many invitro studies[14,15] have been carried out in the past to know the performance of self ligating brackets in relation to coefficient of friction and have shown statistically significant lesser coefficient of friction when compared to conventional brackets. That is why it becomes an important issue to carry out an in vivo clinical trial[16] to evaluate these brackets in sliding mechanics.

Some studies retracted canines utilizing NITI closed coil springs/e chains in each side of the maxillary arches[17]. Other studies used randomization of the side in subjects to decrease research bias clinically[18–20]. In the present clinical trial, randomization of the arch side was done since the accuracy in bracket placement may vary due to patient's side and can be a confounding factor.

The analysis of space closure can be done by intraoral measurements [19,21], radiographic methods, plaster models etc. Radiographic methods though an effective tool for measuring canine retraction[22], expose patients to unnecessary radiation. Intraoral method using divider and digital caliper were used here to increase the accuracy of measurements up to two decimal points of a millimeter.

Table 1. Average rate of maxillary canine retraction in each subject on 0.016 × 0.022" SS arch wire

Subject	Rate of canine retraction in mm/28 days	
	SCSL brackets	CV brackets
1.	1.35	1.12
2.	1.13	1.17
3.	0.95	1.03
4.	0.98	0.78
5.	1.21	1.34
6.	0.86	0.89
7.	0.94	1.13
8.	0.69	0.82
9.	0.89	1.01
10.	1.23	1.32
11.	1.12	1.09
12.	0.99	0.89
13.	1.08	1.23
14.	0.99	1.12
15.	1.29	1.25
16.	1.12	1.29
17.	0.79	0.95
18.	0.99	0.96
19.	0.88	0.93
20.	0.88	0.97
21.	1.17	1.23
22.	0.96	1.02
23.	1.01	0.89
24.	0.82	0.89
25.	1.43	1.27
26.	1.23	0.98
27.	0.89	0.88
28.	0.97	1.08
29.	1.05	0.94
30.	0.93	0.98

Table 2. Mean, standard deviation and p-value

Type of bracket	Average mean (rate of canine retraction in mm/28 days)	SD	p-value
SCSL	1.027	0.172	0.358
CV	1.048	0.158	

Table 3. Comparison of anchorage loss of maxillary first molars (SCSL vs. CV)

Subject	Anchorage loss of maxillary first molars (in mm) during canine retraction on 0.016 X 0.022" SS arch wire	
	SCSL brackets	CV brackets
1.	0.61	0.41
2.	0.79	0.59
3.	0.91	0.76
4.	0.86	0.61
5.	0.91	0.48
6.	0.37	0.59
7.	0.51	0.31
8.	0.21	0.15
9.	0.59	0.65
10.	0.49	0.61
11.	1.00	0.88
12.	0.41	0.62
13.	0.62	0.67
14.	0.61	0.54
15.	1.00	0.92
16.	0.89	0.18
17.	0.68	0.66
18.	0.69	0.54
19.	0.31	0.81
20.	0.61	0.74
21.	0.79	0.66
22.	0.89	0.63
23.	0.89	1.00
24.	0.82	0.77
25.	0.41	0.63
26.	0.53	0.52
27.	0.20	0.61
28.	0.59	0.31
29.	0.49	0.11
30.	0.88	0.61

Table 4. Mean, Standard deviation and p-value

Type of bracket	Average mean (anchorage loss)	SD	p-value
SCSL	0.652 mm	0.229	0.156
CV	0.586 mm	0.213	

In contemporary orthodontics, the lower resistance to sliding mechanics is of utmost importance as this may lead to shorter duration of treatment, lesser amount of force applied, anchorage conservation, better periodontal health and increased efficiency. The rate of tooth movement is influenced by the amount of force applied, dimensions of bracket slot, diameter of the arch wire and the play between the arch wire and the bracket slot.

Many appliances are available for retraction of the canines for closure of extraction spaces. The movement of canine depends on various factors: the appliance, the force applied, the periodontal ligament area, the technique used, properties of arch wire, diameter and shape of the working arch wire, play between arch wire and the bracket slot, quality of bone, curvature of root, thickness of mucosa etc. The rate of retraction can be hastened by various factors like moving through recent extraction socket (Hasler 1997), distraction, interseptal bone reduction, drugs, electromagnetic system etc. Faster retraction of canine helps in reducing treatment duration. The self-ligating bracket engages the archwire nicely in its slot in an all or none principle so as to achieve maximum engagement of archwire in the bracket slot. This may be presumed to be a contributing factor in better control of the teeth movement over conventional bracket ligation method. Oral hygiene is improved; the bracket tie-wings of smart clip bracket undercuts are better for self-cleansing effects of saliva and hence lesser probability of enamel discoloration and gingivitis. Thus self-ligating brackets seem to be a better option.

Many studies tested the relation between optimum force magnitude and speed of canine retraction; but only limited studies have been found. Story and Smith[23] found an optimum force for canine retraction to be in the range of 150 to 200 g. Lee[24] advised 150 to 200 g force. Most of the studies have claimed that light forces to be more biologic and less painful. As majority of them recommended a light and constant force for effective tooth speed, a force of 150 g was delivered by nickel-titanium closed-coil springs in our clinical study for retracting canines for closure of extraction space.

Paulson *et al.*[25] calculated canine retraction with sliding mechanics over a 0.016-inch wire with a force of 50 g-100 g. His average canine retraction rate was 1.08 mm/month that is similar to our study. Huffman and Way[26] did a clinical trial to calculate the quantum of movement, rate of retraction and angle of tipping when retracting a canine on a 0.016-inch wire through sliding mechanics. 200 g of force was used to retract the canine. The velocity was 1.37 mm/month on 0.016-inch arch wire. This value is higher than our study and may be due to higher forces applied and different diameter of arch wire used. In the above mentioned studies, 0.016" arch wire was used and is not recommended for sliding mechanics, being a little flexible wire which is likely to bend during retraction of canines (roller coaster effect). To prevent this effect, a thicker rectangular working arch wire of dimensions 0.016 × 0.022" was used for retraction of canines in our study. Sleichter[27] found canine retraction rate of 1 mm/month that is close to the value we got. Sonis *et al.*[28] delivered canine retraction force (250–400 g) by energy chains and latex thread on 0.016 × 0.022" inch archwire. The average velocity of retraction was 1.28 mm/3 weeks by elastic threads and 1.51 mm/3 weeks by e chains. The canine retraction in our study is less as compared to this study and may be dependent on the amount of force used.

Pioneers of sl brackets recommended their bracket designed on light forces, limited friction, lesser moments and resulting in more efficient (faster) tooth movement. Pandis *et al.*[30] found that the Damon brackets resulted in highest moments and the conventional brackets the lowest. Thorstenson and Kusy[31,32] also found Damon brackets associated with high binding forces (second-order) compared with conventional brackets. These studies comparing sl brackets with CV brackets lead to the same end result that SL brackets are likely to generate more moments. That may be the reason for faster rate of canine retraction in conventional brackets than smart clip brackets.

The tip at the point of wire interface with the corner of a bracket is dependent on bracket width. The SmartClip is 2.79 mm and the Victory Series bracket is 3.81 mm in their widths. A narrow width bracket will produce higher moments (heavy force at the edges) than that of wider one. The rotational tendency in a mesiodistal direction in smartclip will be more. This will result in increased binding forces at corners (stick-slip phenomenon) of smartclip bracket resulting in increased resistance to sliding. These higher forces may cause increased resistance to sliding[33]. It shows wider brackets are superior for sliding mechanics due to lesser contact angle. In this study, the average speed per 28 days was a little faster on the side with the conventional bracket than on the side with the self-ligating bracket probably due to narrower bracket width of smart clip brackets resulting in higher moments. This does not prove that only bracket width affects the mechanics

of tooth movement, biological response to the force, vascular supply, and turnover of cells of periodontium, bony structure is equally important. Variation in the rate of canine retraction of 30 patients in our study can be due to the difference in the biological response to the similar force applied.

Smart clip self ligating brackets hold archwires with the help of their inbuilt niti clips. A little pressure is required for inserting archwire in the bracket slot with the help of an instrument or just pressing with the fingers. That may be the reason of some patients complaining of pain especially during insertion of arch wires. No patient reported pain or sensitivity while placing arch wires in APC conventional brackets. Oral hygiene was also found to be better in smart clip self ligating brackets than APC conventional brackets.

Monini *et al.*[34] tested the velocity of maxillary canine on 020" SS arch wire in 0.022 PEA with 100 g of force by NITI springs. There was no statistical significant difference between CV and SL bracket similar to our study. But the average velocity of canine in our study was more as compared to their study. Difference in velocity may be attributed to lesser force applied (100 g) as compared to our force applied (150 g). Hassan *et al.*[35] showed that SL brackets are better than CV brackets for retraction of canines and anchorage conservation in their RCT.

Burrow SJ[36] in his clinical study also recommended 150 g of retraction force with GAC NITI retraction spring similar to our study but the results regarding the rate of canine retraction of conventional brackets was statistically significant greater than smart clip brackets. In our study, speed of canine retraction of the types of brackets was found to be similar. They have also pointed out the narrower SCSL brackets resulted in lesser speed of canine retraction due to increased binding and higher moments as mentioned in our study also. This shows that even having similar methodology the results are different. Miles PG[37] also observed no difference in these two brackets. In a recent study by Monini *et al.*[38] no difference was found in the rate of canine retraction and anchorage loss between SCSL and CV brackets. The average rate of maxillary canine retraction in their study was less as compared to our study for both self ligating and CV brackets. This may be due to the fact that they have used 100 g of retraction force as compared to 150 g of force used in our study. Mean anchorage loss in their study was also significantly higher as compared to our study.

In narrow brackets like SCSL, the interbracket length of arch wire between canine and premolar may be increased which leads to increased flexibility in the wire and increased binding between wire and bracket. Anchorage loss was found to be a little more in smart clip as there are more moments and binding with the arch wire. Nascimento *et al.*[39] also pointed out more tipping movements in SCSL brackets as compared to more translatory movements in CV brackets as observed in their histological evaluation of cellular bone remodeling. In the end still a controversy exists about efficiency of self-ligating brackets. More studies may be needed to solve this controversy.

A few plus points of this study are:

1. This study was performed with 0.018" brackets on 0.016 × 0.022" SS working arch wire whereas most of the studies have been done with 0.022" slot brackets on 0.020" or 0.019 × 0.022" SS wire.
2. The rate of movement was measured at each appointment and the average was used rather than dividing the total movement by the total time taken.
3. The study was performed on primarily young adolescents rather than young adults.

Future recommendation of this study is to prepare a bracket which incorporates the advantages of both smart clip and conventional bracket. It may be a smart clip bracket with a bracket slot width of a conventional bracket (wider smart clip brackets). The recommended future study may also incorporate other confounding factors like effect of age and bone density on retraction rate and anchorage loss, viscosity of saliva, thickness and tightness of ligature ties, number of bracket tie wings ligated, precision in bracket positioning, oral hygiene, effect of drugs during retraction, positioning of molar tubes etc.

5. Conclusion

The rate of maxillary canine retraction in extraction space of first premolar using sliding mechanics is slightly faster in conventional brackets than smart clip self ligating brackets and molar anchorage loss was more in self ligating than conventional (both were not statistically significant in the present study). This shows that both the type of brackets is equally effective when compared for canine retraction and anchorage loss in sliding

mechanics. Owing to the advantages of smart clip self ligating brackets (lesser ligation time, decreased chair side time, better oral hygiene, longer appointment intervals); it is preferred over conventional brackets.

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