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Original Article

Comparative evaluation of anchorage loss between self-ligating appliance and Conventional pre-adjusted edgewise appliance using sliding mechanics – A retrospective study

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ABSTRACT

Background: Although a number of studies have been undertaken to evaluate the friction characteristics of self-ligating brackets, there have been only few studies which have actually evaluated the clinical efficiency of these self-ligating brackets. This study was done to evaluate the clinical efficiency of Passive SLB (Smart Clip) in terms of anchorage loss and total treatment duration by comparing it with a Conventional pre-adjusted edgewise (M.B.T.) bracket system.

Methods: This was a retrospective study in which the study sample comprised of ten patients treated with Passive SLB (Smart Clip, 0.022") and ten patients treated with Conventional pre-adjusted edgewise (M.B.T.) bracket system (0.022") who required therapeutic extraction of U/L first premolars as a part of their orthodontic treatment plan. Pretreatment and post treatment lateral cephalograms were taken to evaluate the amount of anchorage loss. The total time required to complete the treatment was also recorded.

Results: Anchorage loss observed with Passive SLB (Smart Clip) sagittally was 1.90 ± 0.68 mm in the maxilla and 1.90 ± 0.43 mm in the mandible and vertically was 0.52 ± 0.53 mm in the maxilla and 0.70 ± 0.69 mm in the mandible. Anchorage loss observed with Conventional pre-adjusted edgewise (M.B.T.) bracket system sagittally was 2.08 ± 0.43 mm in the maxilla and 1.95 ± 0.44 mm in the mandible and vertically was 0.50 ± 0.49 mm in the maxilla and 0.68 ± 0.53 mm in the mandible. The average time taken for the completion of treatment in Passive SLB (Smart Clip) and Conventional pre-adjusted edgewise (M.B.T.) bracket system was 14.0 ± 2.4 and 17.2 ± 2.6 months respectively.

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Conclusion: There was no statistically significant difference in the quantum of anchor loss between Smart Clip self-ligating bracket system and Conventional pre-adjusted edgewise (M.B.T.) bracket system although Smart Clip self-ligating bracket system is efficient in reducing the overall treatment time.

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Introduction

In orthodontic treatment, anchor loss is a potential side effect of orthodontic mechanotherapy and one of the major causes of suboptimal results. Its cause has been described as a multifactorial response in relation to the extraction site, appliance type, age, crowding, and overjet.¹ Therefore, clinicians throughout the years have made an effort to find biomechanical solutions to control anchorage.²

The development of the Straight-wire appliance by Andrews brought about a new technology with simplified mechanics, which has allowed orthodontists to treat patients efficiently with consistent results.³ The increasing use of sliding mechanics in orthodontics has led to considerable research interest in the frictional forces developed between the archwire and bracket, which may inhibit tooth movement, require larger retraction forces and lead to anchorage taxation. The magnitude, control and clinical significance of this frictional resistance are largely unknown.⁴ Upto 60% of the applied force is dissipated as friction which reduces the force available for tooth movement, such that an adequate translating force must be applied in order to overcome the frictional force. With increasing frictional resistance, proportionally greater forces would be required.⁵

Self-ligating brackets are ligature less bracket systems that have a mechanical device, an active clip or a passive slide built into the bracket to close off the edgewise slot. The self-ligating bracket was introduced to create a “friction-free” environment with the belief that it would allow for better sliding mechanics; as the teeth move more rapidly, treatment time is decreased. In the absence of wire or elastomeric ties frictional resistance is dramatically reduced and tooth movement occurs at a greater velocity.⁴

This study was conducted to compare and evaluate the anchorage loss and total treatment time between Passive SLB (Smart Clip) and Conventional pre-adjusted edgewise (M.B.T.) bracket system, using sliding mechanics.

Materials and methods

Twenty consecutive patients who met the selection criteria were drawn from the department O.P.D. for the study.

Sample selection

The study group sample eligible for this study was selected on the basis of following criteria:

Inclusion criteria

- 1) Comprehensive medical and dental history ruling out any systemic illness.
- 2) Patients requiring therapeutic extraction of the first premolar.
- 3) In the cases selected as sample, extraction decision was taken mainly for retraction following leveling and aligning.

Ten patients were treated with Smart Clip self-ligating bracket system (Figs. 1 & 2) and ten were treated with Conventional preadjusted edgewise (M.B.T.) bracket system (Figs. 3 & 4). Mean age of the patients in Smart Clip self-ligating bracket group and Conventional pre-adjusted edgewise (M.B.T.) bracket group was 17.8 ± 2.1 years and 17.6 ± 2.1 years respectively.

In both the groups, after initial alignment, a 0.019×0.025 -in SS archwire was placed with a hook mesially to the canines and then left in place for 5 weeks. The 6 anterior teeth were consolidated with elastic chain, and the archwire ended flush with the distal aspect of the first molar bracket on each side. After alignment, active tie-backs were placed across the extraction sites from the bracket hook on the first molar and ligated with SS ligature to the archwire hook mesial to the canine.

Anchorage loss was recorded as the amount of movement in millimeters that occurred in the direction opposite to the direction of the applied resistance. Each patient had two

Fig. 1 – Smart Clip self-ligating bracket system: pretreatment photographs.

Fig. 2 – Smart Clip self-ligating bracket system: (a) post space closure, (b) & (c) post treatment photographs.

lateral cephalometric radiographs taken, one before treatment and another after completion of retraction. Therefore the amount of anchorage loss observed is the net effect of initial leveling and aligning, followed by space closure using sliding mechanics. Radiographs were traced and land-marks were identified, bilateral structures were bisected and then considered mid-sagittal points.

Linear measurements of the spatial position of various points were determined by the construction of Cartesian Co-ordinate System.⁶ The X axis of the Cartesian coordinate was a line drawn 7° from the SN line on the pretreatment cephalometric radiograph that was then transferred to the post treatment cephalometric radiograph. The Y axis was generated by dropping a line from Sella perpendicular to the X axis. These measurements were used to describe changes in the position of the maxillary and mandibular permanent first molar. Horizontal measurements related to the Y axis revealed forward movement of the molars and vertical measurements related to the X axis revealed extrusion of the molars during orthodontic mechanotherapy (Fig. 5). The difference between the initial and the final measurements was calculated to give the total amount of anchor loss by using a digital caliper (150 mm ECP-015D digiMax caliper, Moore and Wright, Buchs, Switzerland) to the nearest 0.1 mm.

The treatment time in months from first placement of fixed appliances to their removal were maintained for each and every patient in both the groups.

To reduce the method error in defining the different measuring points and reference structures, all radiographs were analyzed twice by the same investigator with a 2-week interval between the recordings. The mean value of the 2 recordings was used as final measuring value. Arithmetic mean and standard deviation were used for descriptive statistics. All the data were analyzed with MINITAB version 13.1. Results are presented as mean $\pm$ SD. Paired t-test was used for intragroup comparisons (i.e. Pre–Post changes) and unpaired t-test was used for inter-group comparison of changes between study

and control groups. A *p*-value of 0.05 or less was considered for the results to be statistically significant.

Results

Anchorage loss (Tables 1 and 2)

U6 (sagittal): In Smart Clip bracket system mean anchorage loss was 1.90 ± 0.68 mm which was highly significant ($t = 8.85$, $P < 0.001$). The conventional bracket had a mean anchorage loss of 2.08 ± 0.43 mm which was also highly significant ($t = 15.40$, $P < 0.001$). However the mean difference in anchorage loss between the two groups was 0.18 mm which showed that anchorage loss was reduced by 0.18 mm with Smart Clip self-ligating brackets sagittally. This difference in the amount of anchorage loss was not statistically significant ($t = 0.69$, $P = 0.50$).

L6 (sagittal): In Smart Clip bracket system mean anchorage loss was 1.90 ± 0.43 mm which was highly significant ($t = 14.03$, $P < 0.001$). The conventional bracket had a mean anchorage loss of 1.95 ± 0.44 mm which was also highly significant ($t = 14.10$, $P < 0.001$). However the mean difference in anchorage loss between the two groups was 0.05 mm which showed that anchorage loss was reduced by 0.05 mm with Smart Clip self-ligating brackets sagittally. This difference in the amount of anchorage loss was not statistically significant ($t = 0.26$, $P = 0.80$).

U6 (vertical): In Smart Clip bracket system mean anchorage loss was 0.52 ± 0.53 mm which was significant ($t = 3.12$, $P < 0.05$). The conventional bracket had a mean anchorage loss of 0.50 ± 0.49 mm which was also significant ($t = 3.25$, $P < 0.05$). However the mean difference in anchorage loss between the two groups was 0.02 mm which showed that anchorage loss was reduced by 0.02 mm with conventionally ligated M.B.T. brackets vertically. This difference in the amount of anchorage loss was not statistically significant ($t = 0.11$, $P = 0.91$).

Fig. 3 – M.B.T. bracket system: Pretreatment photographs.

Fig. 4 – M.B.T. bracket system: (a) post space closure, (b) & (c) post treatment photographs.

L6 (vertical): In Smart Clip bracket system mean anchorage loss was 0.70 ± 0.69 mm which was significant ($t = 3.23$, $P < 0.05$). The conventional bracket had a mean anchorage loss of 0.68 ± 0.53 mm which was also significant ($t = 4.04$, $P < 0.01$). However the mean difference in anchorage loss between the two groups was 0.02 mm which showed that anchorage loss was reduced by 0.02 mm with conventionally ligated M.B.T. brackets vertically. This difference in the amount of anchorage loss was not statistically significant ($t = 0.09$, $P = 0.93$).

Treatment time (Table 3): Mean treatment time to complete treatment with Smart Clip self-ligating bracket system was 14.0 ± 2.4 months whereas that with Conventional pre-adjusted edgewise (M.B.T.) bracket system was 17.2 ± 2.6 months. The mean difference in treatment time between the

two groups was 3.2 months, which was statistically significant ($t = 2.86$, $P < 0.05$).

Discussion

Two types of self-ligating brackets have been developed: those that have a spring clip that presses against the archwire ('active' or 'interactive' SLBs), such as In-Ovation, SPEED, and Time brackets, and those in which the self-ligating clip does not press against the archwire ('Passive' SLBs) such as the Damon and Smart Clip brackets. With every self-ligating bracket, whether active or passive, the movable fourth wall of the bracket is used to convert the slot into a tube. The Passive SLB does not apply a ligation force to the archwire because the slide covers only the slot, thus restraining the archwire.⁷

Reduction of friction can mainly be achieved either by decreasing the friction coefficient of the bracket or wire materials or by decreasing the force of ligation acting on the wire. Numerous studies have demonstrated a dramatic decrease in friction for SLBs, compared to conventional bracket designs.^{8–11} Such a reduction in friction can help shorten overall treatment time and anchorage considerations, especially in extraction cases where tooth translation is achieved by sliding mechanics. A number of studies have also shown some self-ligating brackets to be superior to the conventional brackets in terms of clinical efficiency and effectiveness¹² and some have shown that there is no difference between the two bracket systems.^{13–15}

Badri et al¹⁶ showed that 5%–50% of the total extraction space can be taken up by an anchor unit made up of the first molar and the second premolar when used to retract a canine. Aronsen et al²⁷ showed anchorage losses of 2.4 mm in 1 monkey and 1.4 mm in another. The results of these previously studies matched the results of our human study, in which anchorage losses of 2.08 ± 0.43 mm in the maxilla and 1.95 ± 0.44 mm in the mandible were observed with M.B.T. bracket system and anchorage losses of 1.90 ± 0.68 mm in the maxilla and 1.90 ± 0.43 mm in the mandible were observed with Passive SLB (Smart Clip). In the maxillary arch, mean difference in anchorage loss between self-ligating and conventional (M.B.T.) bracket was 0.18 mm (sagittal) and 0.02 mm (vertical) respectively. In the mandibular arch, mean difference in anchorage loss between self-ligating and conventional (M.B.T.) bracket was 0.05 mm (sagittal) and 0.02 mm (vertical) respectively. However looking at the values, there appears to be a small clinical difference but it was not statistically significant.

Fig. 5 – Superimposition technique for assessment of anchorage loss.

Table 1 – Post treatment changes – intragroup comparisons.

Group	Linear measurements	Pre		Post		Mean diff.	Significance	
		Mean	S.D.	Mean	S.D.		t ^a	P
Group I (Smart Clip)	U6 (sagittal)	45.50	6.99	47.40	7.03	1.90	8.85	P < 0.001 HS
	L6 (sagittal)	47.00	8.52	48.90	8.68	1.90	14.03	P < 0.001 HS
	U6 (vertical)	65.63	3.47	66.15	3.50	0.52	3.12	P < 0.05 S
	L6 (vertical)	64.85	3.42	65.55	3.64	0.70	3.23	P < 0.05 S
Group II (M.B.T.)	U6 (sagittal)	45.35	7.98	47.43	8.20	2.08	15.40	P < 0.001 HS
	L6 (sagittal)	47.30	7.13	49.25	7.12	1.95	14.10	P < 0.001 HS
	U6 (vertical)	64.50	4.46	65.00	4.45	0.50	3.25	P < 0.05 S
	L6 (vertical)	64.30	4.42	64.98	4.44	0.68	4.04	P < 0.01 S

^a Paired t-test.

It should be stressed that in vitro studies cannot reproduce exactly what occurs in vivo in the oral cavity during orthodontic tooth movement. Minimal adjustments at the bracket/wire/ligature system may significantly change frictional resistance because of physiologic oral functions as well as the oral tissues or food contacting the orthodontic appliance. A recent study concluded that compared with conventional brackets, self-ligating brackets produce lower friction when coupled with small round archwires in the absence of tipping and/or torque in an ideally aligned arch. Sufficient evidence could not be found to claim that with large rectangular wires, in the presence of tipping and/or torque and in arches with considerable malocclusion, self-ligating brackets produce lower friction compared with conventional brackets.¹⁷

For many years arguments has raged over whether the fluid media is a lubricant or an adhesive when a bracket is slid through an archwire. In vitro studies have demonstrated friction to be more in dry state as compared to wet states.

Unquestionably, both the dry and wet states exist in the oral cavity, the former as the contact (s) between the archwire and the brackets squeeze out the boundary layer of saliva (thereby contacting two “dry” surfaces), and the latter as the appliance is bathed from the salivary ducts in the normal orthodontic patient. In oral cavity amount of friction is not constant; binding is intermittently released as a result of mobility of teeth. Exact timing and amount of release are unknown.

Hixon et al¹⁸ conducted an in vivo study & proved that resistance to sliding was less than that observed in laboratory. In oral cavity, forces from mastication could have dislodged the wire from binding areas thus permitting free sliding. In

another study Liew et al¹⁹ placed an oscillating force of 25–400 g at 90 Hz on the archwire as it was drawn through the bracket. Resistance to sliding was reduced by 60%–85% with wire displacement. He concluded that the effective frictional resistance between the orthodontic brackets & archwires was substantially reduced by the masticatory forces & other oral functions. Small forces well within the range exerted in the mouth are sufficient to produce this effect.

In a similar lab study Braun et al²⁰ evaluated frictional resistance. As the wire was drawn through the bracket, either the wire or the bracket was tapped with the finger (20–200 g) in random directions & random frequencies. They noted that resistance to sliding was reduced to zero whenever displacement was applied, irrespective of method of ligation, wire size, material etc. O'Reilly et al²¹ oscillated the test bracket while measuring sliding resistance. Authors found that repeated displacement of the bracket, equivalent to as little as 0.16 mm of mesiodistal crown movement could reduce sliding resistance by as much as 85%.

However the amount of anchorage loss observed in vertical dimension (molar extrusion) can be attributed to the mechanotherapy as the point of force application is at the level of the clinical crown; the moments thus generated lead to the extrusion of the molars and subsequent loss of the anchorage in the vertical dimension.

The importance of comparative friction force studies of new brackets is that they give clinicians independent data within the limits of in vitro models. However, results of in vitro studies results may not be relevant for clinical situations. Therefore it is recommended to extend the scope of similar studies, testing these newer bracket systems, in in vivo conditions also.

Average treatment time with Smart Clip self-ligating brackets system was 14.0 ± 2.4 months, whereas that with Conventional pre-adjusted edgewise (M.B.T.) bracket system was 17.2 ± 2.6 months. This difference in treatment time was statistically significant. The mean difference in treatment time between the two groups was 3.2 months, which showed that treatment time was reduced by 3.2 months with Smart Clip self-ligating brackets. This difference in treatment time is of clinical significance and does favor the choice of Smart Clip brackets in the clinical practice.

This difference might be because of the substantially greater free play of the self-ligating appliances, an effect that facilitates undisturbed movement of the crown. In contrast,

Table 2 – Comparison of treatment changes between Smart Clip (group i) and M.B.T. (group ii).

Linear measurements (mm)	Smart Clip		M.B.T.		Smart Clip vs M.B.T	
	Mean	S.D.	Mean	S.D.	t ^a	P
U6 (sagittal)	1.90	0.68	2.08	0.43	0.69	0.50, Ns
L6 (sagittal)	1.90	0.43	1.95	0.44	0.26	0.80, Ns
U6 (vertical)	0.52	0.53	0.50	0.49	0.11	0.91, Ns
L6 (vertical)	0.70	0.69	0.68	0.53	0.09	0.93, Ns

^a Unpaired t-test.

Table 3 – Descriptive statistics for differences in age and treatment time based on bracket systems.

Group	Sample size	Sex	Mean age (years) $\pm$ S.D.	Mean treatment time (months) $\pm$ S.D.
Group I (Smart Clip)	10	F	17.8 $\pm$ 2.1	14.0 $\pm$ 2.4
Group II (M.B.T.)	10	F	17.6 $\pm$ 2.1	17.2 $\pm$ 2.6
Unpaired t-test			t = 0.22 P = 0.74, NS	t = 2.86 P < 0.05, S

elastomeric modules or steel ligatures act as obstacles because of the stress they exert on the wire adjacent to the bracket sides, precluding free sliding of the wire into the slot walls and adversely affecting movement rate.

One may postulate that the reduction in treatment time clinically associated with the Passive SLB systems, as compared with conventional systems, may be due to a decrease in the level of frictional forces, archwire binding and the variable responsible for such observations may be the means of ligation.

A similar study²² has described the clinical use of Damon brackets and proposed that this low friction is a major factor in enabling more efficient treatment. In another study¹² comparing treatment time between Damon self-ligating brackets and Conventional pre-adjusted edgewise brackets showed an average reduction in treatment time of 6.46 months with Damon self-ligating brackets. Harradine¹² compared the treatment time between Damon self-ligating brackets and Conventional pre-adjusted edgewise brackets and noted that cases treated with Damon self-ligating brackets required an average of 4 fewer months to complete the treatment. Shortened chair time and slightly less incisor proclination appear to be the only significant advantages of self-ligating systems over conventional systems that are supported by the current evidence.²³

On the other hand, Pandis et al¹⁵ found no difference in time required to correct mandibular crowding with Damon 2 as compared to conventional brackets. Miles et al^{13,14} showed in detailed clinical studies that Smart Clip and Damon brackets are no more effective than the conventional brackets ligated with elastomeric modules or stainless steel ligatures during the leveling and aligning stages of treatment and that the Smart Clip and Damon brackets were equally effective during leveling and aligning stage. The time taken by these brackets to level and align was also comparable. Current clinical studies support the view that resistance to bodily tooth movement by sliding has little to do with friction and, instead, are largely a binding-and-release phenomenon that is about the same with conventional and self-ligating brackets. The limited clinical trial data available now does not support the contention that treatment time is reduced (presumably because of lower friction) with self-ligating brackets.²⁴ In a recently conducted randomized clinical trial of orthodontic treatment efficiency with self-ligating and conventional orthodontic appliances the author concluded that the bracket type did not influence the duration of treatment or the number of visits required.²⁵

Thorstenson and Kusy²⁶ explained the level of resistance to sliding of SLBs and conventional brackets in various angulations in terms of the contact angle between the bracket slot and the archwire. They concluded that, although the rate of

binding as a function of relative angulation was similar regardless of bracket design, brackets with passive slides exhibited the lowest resistance to sliding. In another study, early in treatment, when smaller wires were in place, the low friction of the self-ligating brackets permitted lighter forces to be used for moving teeth. Unwanted rotations do not occur during retraction, because the spring clips and light forces control any rotation tendencies. Early torque control from the interactive spring clips allows treatment to be finished sooner. The author concluded that taken together, the benefits of the self-ligating system means shorter treatment time and reduced chair time.

Studies mentioned above support our finding of a greater treatment time with Conventional pre-adjusted edgewise (M.B.T.) bracket system as compared to Smart Clip self-ligating bracket system.

Conclusion

Although greater amount of anchor loss was observed with Conventional pre-adjusted edgewise (M.B.T.) bracket system as compared to Smart Clip self-ligating bracket system, the results were not statistically significant, indicating that the Conventional pre-adjusted edgewise (M.B.T.) bracket system are as efficient as Smart Clip self-ligating bracket system.

The results also showed that there was statistically significant reduction in treatment time with Smart Clip self-ligating bracket system as compared to Conventional pre-adjusted edgewise (M.B.T.) bracket system. As this study shows, reduced chair time is a significant advantage of self-ligating brackets, whether the time is used to schedule more patients, increase practice efficiency, or improve relationships with patients.

However this being a preliminary study, further studies with a larger sample size, will be needed to evaluate the long-term efficacy of the self-ligating appliance.

Conflicts of interest

All authors have none to declare.

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