ORIGINAL ARTICLE

INTERNATIONAL JOURNAL OF RESEARCH IN PHARMACEUTICAL SCIENCES

Published by JK Welfare & Pharmascope Foundation Journal Home Page: https://ijrps.com

Comparing the rotational control during canine retraction using two different bracket systems – Synergy and Self Ligating brackets – Split mouth study

Shreya Kishore, Saravana Dinesh SP*, Srirengalakshmi, Arvind Sivakumar

Department of Orthodontics and Dentofacial Orthopedics, Saveetha Dental College, Saveetha University, Chennai, Tamil Nadu, India

Article History:

Received on: 05.10.2018
Revised on: 24.03.2019
Accepted on: 27.03.2019

Keywords:

Rotational control,
individual canine retraction,
synergy brackets,
Self-ligating,
brackets,
sliding mechanics

ABSTRACT

Canine, being the cornerstone of the dental arches, shares an important role in oral functions, esthetics, arch shape and stability. With the new bracket systems that have come to light, which have reduced friction, there is not much literature on how much of a rotation control they have on the cuspids. Hence this study is conducted to compare the efficiency of two least frictional resistance offering brackets – Self-ligating and synergy brackets in terms of rotational control. The study was designed as a prospective randomized controlled split-mouth clinical trial, which included 16 subjects of ages 12-30 years, divided into two groups, left, and the right quadrants receiving Self Ligating and Synergy brackets based on simple randomization, along with a 19*25" SS wire and closed coil springs for individual canine retraction. The patients were reviewed every 21 days for four appointments, and records were taken for each review. Photographs were taken of the cast at every review, and the degree of canine rotation was measured and compared. The results indicate that there is no statistical difference between both the groups in the amount of canine rotation during individual canine retraction with a p-value greater than 0.05 at every interval. The results also indicate that there is a significant amount of canine rotation in Group 1 – Self-ligating brackets and Group 2 – Synergy brackets independently, when comparing T0 to every interval. Overall results show that there is no significant statistical difference between Synergy and Self-Ligating brackets in the amount of canine rotation during canine retraction. The mean or average amount of canine rotation for Group I Self-ligating was 3.32º ±6.55°. The mean or average amount of canine rotation for Group 2 Synergy was 4.08º ±3.85°.

* Corresponding Author

Name: Dr. Saravana Dinesh SP
Phone: +919940163652
Email: dr.shreyakishore@gmail.com

ISSN: 0975-7538
DOI: https://doi.org/10.26452/ijrps.v10i2.538

Production and Hosted by

IJRPS | https://ijrps.com

INTRODUCTION

Orthodontic tooth movement is greatly influenced by the characteristics of the applied force, including its magnitude, direction, moment-force ratio, and the physiological condition of the periodontal tissue of an individual patient. The characteristics of the applied force also depend on the orthodontic appliance used Orthodontic research has always focused on the development of faster and more effective tooth movement. Most orthodontic patients have a certain amount of crowding and to unravel this crowding, and many patients require extractions for correction of alignment and inclination of the teeth. After the first phase of orthodontic treatment, i.e., levelling and aligning, the remainder of extraction space is closed with an anterior retraction or posterior protraction (Proffit, 1979).

The selection of any treatment, whether a technique, spring or appliance design should be based on the desired tooth movement. Orthodontists have been able to believe that two-step closure – first cuspid retraction followed by, anterior retraction is less detrimental to the anchorage when compared to the method of en masse retraction of all six anterior teeth (Kuhlberg AJ, 2001).

One of the biomechanical alternatives to space closure is the retraction of canines with sliding mechanics performed prior to incisor retraction. The most common approach is a sequential procedure in which the canines and incisors are retracted in two separate and distinct steps. In the first step, the canine in each quadrant is retracted till full contact with the tooth distal to the extraction space is achieved. In the second step, the canines are fastened to the teeth distal to them. The resulting grouping is then used as a single anchorage unit to retract the incisors. This procedure has been called the '2-step' technique. However, there are some conceivable disadvantages to the 2-step approach. Closing space in two steps rather than one step might make treatment take a longer time. To note, when canines are retracted individually in quadrants, they tend to tip and rotate more when compared to when the anterior teeth are retracted as a single unit, thus requiring additional time and effort to re-level and re-align (Ziegler and Ingervall, 1989).

Therefore, an alternative treatment approach called ''en-masse retraction'' came into use in which the anterior (i.e. incisors and canines) are retracted as a single unit. One treatment technique that uses this approach is the MBT system developed by Bennett and McLaughlin. This en-masse technique has gained popularity because of its mechanical simplicity. But, in theory, it might be expected to tax the posterior anchorage more than the 2-step technique (Ziegler and Ingervall, 1989).

In friction or sliding mechanics, the force is applied via elastomeric modules or coil springs from the anchor unit to the posts soldered to archwires. Sliding mechanics required minimum wire bending and decreased chairside time.

Frictionless mechanics is based on incorporation of loops in archwire. In situations where canine retraction is necessary, a loop may be incorporated into a section of an archwire extending from the anchor teeth to the canine on each side, passing through the main archwire tube of the molar and the slot of the second premolar bracket. The loops are activated to retract the canines alone. The loops, when made in continuous archwires, can be used for en-masse retraction of the anterior teeth or protraction of posterior teeth (Rhee et al., 2001).

Treatment mechanics and their efficiency are necessary to ensure optimal results in lesser clinical time and shorter treatment duration. With the advent of the straight wire appliances, the sliding mechanics have reduced the need for wire bending that was so predominant in the standard edgewise appliances. The principal of the mechanics behind moving the teeth is that there will be friction between the archwire, bracket surface and ligature surfaces, which is estimated as 50 per cent of the force is applied to overcome the friction in the system.

In recent years, scientific studies have further mitigated the situation by documenting that bracket design is one of the several variables capable of effecting tooth movement (Krishnan et al., 2015; Sheibaninia et al., 2011).

The concept of self-ligating brackets was proposed to eliminate this force of friction. It was to provide a friction-free environment which would allow better sliding mechanics and thereby reduce the treatment time (Kulshrestha et al., 2015).

Recently came the evolution of Synergy brackets. Synergy bracket is one of the commercially available brackets that is most versatile and active. It brings about the increased amount of treatment control options than conventional edgewise brackets, reduces the frictional resistance drastically and also reduces the total treatment duration. All of this comes together in a very low profile patented Synergy design.

Testing shows that Synergy brackets have significantly lower friction and binding than self-ligating brackets. Synergy's patented rounded arch walls, and floor significantly reduces friction and binding for a gentler, more continuous force. Additionally, these features increase inter-bracket distance for more efficiency. Synergy is known for its bond strength due to its mesh bonding base, and low profile is unlike bulky self-ligating brackets which have occlusal interference and bond failures (Crincoli et al., 2013; Krishnan et al., 2017; Ravichandran and Dinesh, 2017; Samantha et al., 2017; Yeh et al., 2007).

Canine, being the cornerstone of the dental arches, shares an important role in oral functions, esthetics, arch shape and stability. With the new bracket systems that have come to light, which have reduced friction, there is not much literature on how much of a rotation control they have on the cuspids. Hence this study is conducted to compare the efficiency of two least frictional resistance offering brackets – Self-ligating and synergy brackets in terms of rotational control.

MATERIALS AND METHODS

This study conducted is a prospective randomised control trial – split-mouth study, conducted in the Department of Orthodontics and Dentofacial Orthopaedics, Saveetha Dental College, Chennai, Tamil Nadu, India, also approved by the Institutional review board of human ethical committee. The sample size was based on the statistical evaluation of the previous study with 90% power, with the actual sample size of 16. The patients included were selected based on the inclusion criteria with their consent to take part in the study.

The inclusion criteria are as follows: Subjects with permanent dentition, Patients who required upper first premolar extraction.

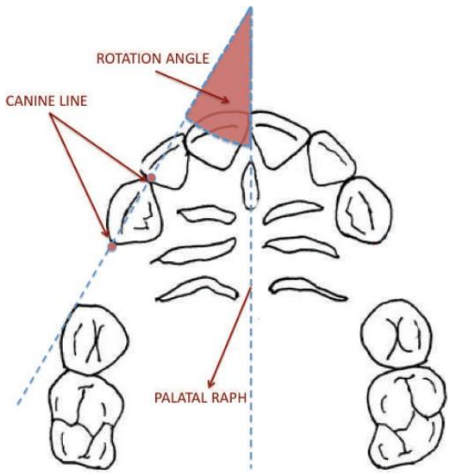

Figure 1: Measurement of canine rotation: angle between the median palatine suture and the line passing through the distal and mesial contact points of the canines.

The exclusion criteria include patients suffering from systemic illness, patients with TMD and craniofacial anomalies, patients who have previously undergone dental treatment for the upper canines or have undergone previous orthodontic treatment and, patients with any periodontal diseases.

This study comprised of 16 patients, in which each upper arch was split into two groups, group 1 being Self Ligating and group 2 being synergy.

All patients were strapped with 0.022" slot MBT prescription. Initial levelling and aligning were performed with MBT brackets, later the left and right canine brackets were replaced with Self Ligating and Synergy brackets randomly. Anchorage was augmented using trans-palatal arch. This would reduce anchorage loss during individual canine retraction. As the orthodontic treatment progressed to the levelling and aligning stage, photographs and study model casts were prepared. Each patient was reviewed every 28 days for four appointments. Impressions were taken every appointment, and the models were prepared.

Continuous archwire of dimension 0.019 × 0.025-inch SS wire was customized on a Sym-grid template, taking a cue from the patient's pre-treatment arch form. 0.019 x 0.025-inch SS wire is used to achieve bodily retraction of canine and to establish torque completely.

The canines were ligated to the arch-wire. A 0.019 × 0.025-inch stainless steel wire was placed in the upper arch, and individual canine retraction was initiated by placing Closed Coil Niti springs [GDC] from molar hook to the canine hook on both sides. Closed coil springs applied a force of 150g. The amount of force application was measured with the help of the Dontrix tension gauge. The Closed coil Springs[GDC] were stretched whenever required to maintain an optimum force of 150 gm.

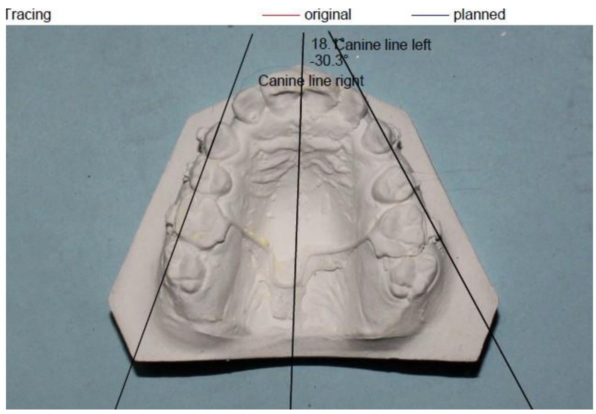

Figure 2: Measurements were done using the FACAD® software

The duration for retraction is four months (T0 to T4) in this study, and maxillary models were taken for each review appointment. Photographs were taken of the cast that was calibrated to standardise the photographs. The calibrated photographs were then cropped, and three lines were drawn digitally to measure the amount of canine rotation during each review while retraction. A single horizontal line was plotted along the median palatine raphe and two lines were drawn passing through the mesial and distal contact points of the canines on either side, as shown in Fig 1 and Fig 2. The total rotation was measured as the difference between the values of T0 and T4. The rotation measurements were taken using a digital software FACAD® and repeated after seven days to check for reproducibility.

Table 1: Showing the Group Statistics (mean, SD) of group 1 and Group 2

Group Statistics

	Group	N	Mean	Std. Deviation	Std. Error Mean
T0	Self-Ligating	16	34.9063	6.10568	1.52642
	Synergy	16	35.4500	4.62702	1.15676
T1	Self-Ligating	16	31.5813	6.58100	1.64525
	Synergy	16	31.2938	5.08324	1.27081
T2	Self-Ligating	16	27.2500	6.73568	1.68392
	Synergy	16	26.5625	5.04828	1.26207
T3	Self-Ligating	16	24.2313	6.29462	1.57366
	Synergy	16	22.8188	4.95032	1.23758
T4	Self-Ligating	16	21.6188	6.55543	1.63886
	Synergy	16	19.1000	3.85660	.96415

RESULTS

The results obtained from the statistical evaluation are given in table 1 & table 2. The arithmetic mean and standard deviation were calculated and tabulated as shown in Table 1. Independent T-test with a confidence interval of 95% was calculated to test the amount of canine rotation. The statistical significance level was established at $p<0.05$. A paired sample T-test was also calculated and tabulated to analyse the amount of canine rotation in each group independently.

The results indicate that there is no statistical difference between both the groups in the amount of rotation of canine during individual canine retraction between group 1 and group 2 with a p-value greater than 0.05 at every interval.

The results also indicate there is a significant amount of canine rotation in Group 1 – Self-ligating brackets and Group 2 – Synergy brackets independently, when comparing T0 to every interval as shown in Table 3 and Table 4.

DISCUSSION

Profit and Fields had recommended individual canine retraction followed by incisors retraction, stating that this approach would allow the reaction force would be constantly dissipated over the large periodontal ligament area in the anchor unit. Roth also recommended separate canine retraction for maximum anchorage extraction cases. Kuhlberg AJ., 2001, described individual canine retraction as less taxing on anchorage because the two canines are opposed by multiple posterior teeth in the anchor unit (Kuhlberg AJ, 2001).

Canine retraction can be achieved through two types of mechanics frictionless or friction mechanics. The first type, segmental or sectional mechanics, involves closing loops fabricated in a sectional archwire (Farrant, 1977), (Ziegler and Ingervall, 1989), (Staggers and Germane, 1991). The teeth move through activation of the wire loop which can be designed to provide a low load deflection rate and controlled moment to force ratio (Drescher et al., 1989).

In friction mechanics, the extraction space is closed with the help of elastic chain or Ni Ti coil spring which is attached to the tooth, and the continuous arch-wire placed. Otherwise, canine, through the application of a force, is expected to slide distally along and is guided by a continuous archwire. As the tooth moves in the direction of the applied force, kinetic friction occurs between the bracket and the arch-wire (Bednar et al., 1991).

Movement of the crown mostly precedes displacement of the root because a tipping moment is placed on the crown of the tooth. This crown tipping leads to increased friction from the interaction between the arch-wire and bracket restricting movement of the entire tooth. Engagement of the arch-wire with the bracket creates a counter-moment that will bring the root of the tooth in the direction the crown has moved (Drescher et al., 1989). The coupled sequence of successive crown tipping then root uprighting will continue along the same plane of space as the direction of the applied motive force. This allows approximation translation of the tooth during sliding mechanics. Friction mechanics are superior to frictionless mechanics for rotation control and arch dimension maintenance (Rhee et al., 2001).

In frictionless mechanics, retraction is accomplished with forces and couples built into the loops or springs, which offer more controlled movement than friction mechanics. This approach is friction-free; when activated, the archwire loops distort from their original configuration; as the tooth (or teeth) moves, the loop gradually returns to its undistorted (preactivated) position, delivering the energy stored at the time of activation. However frictionless mechanics can cause undesirable movements such as rotation of the molar and canine which can cause an increase in treatment duration. Sliding mechanics give superior rotational control compared with the retraction spring (Ziegler and Ingervall, 1989).

Table 2: Table 2: Showing the independent samples t-test values of Group 1 and Group 2

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
								Lower	Upper
T0	1.892	.179	-.284	30	.778	-.54375	1.91521	-4.45514	3.36764
			-.284	27.956	.779	-.54375	1.91521	-4.46716	3.37966
T1	1.675	.205	.138	30	.891	.28750	2.07890	-3.95817	4.53317
			.138	28.200	.891	.28750	2.07890	-3.96956	4.54456
T2	1.031	.318	.327	30	.746	.68750	2.10438	-3.61021	4.98521
			.327	27.810	.746	.68750	2.10438	-3.62445	4.99945
T3	1.548	.223	.706	30	.486	1.41250	2.00200	-2.67612	5.50112
			.706	28.421	.486	1.41250	2.00200	-2.68567	5.51067
T4	3.887	.058	1.325	30	.195	2.51875	1.90143	-1.36449	6.40199
			1.325	24.272	.198	2.51875	1.90143	-1.40328	6.44078

Table 3: Paired sample T-test measuring the significant difference between intervals in Group 1

Paired Samples Correlations – Group 1				
		N	Correlation	Sig.
Pair 1	T0 & T1	16	.946	.000
Pair 2	baseline & second	16	.883	.000
Pair 3	baseline & third	16	.878	.000
Pair 4	baseline & fourth	16	.876	.000
Pair 5	first & second	16	.907	.000
Pair 6	first & third	16	.871	.000
Pair 7	first & fourth	16	.863	.000
Pair 8	second & third	16	.929	.000
Pair 9	second & fourth	16	.890	.000
Pair 10	third & fourth	16	.968	.000

Table 4: Paired sample T test measuring the significance difference between intervals in Group 2

Paired Samples Correlations Group 2				
		N	Correlation	Sig.
Pair 1	baseline & first	16	.949	.000
Pair 2	baseline & second	16	.749	.001
Pair 3	baseline & third	16	.775	.000
Pair 4	baseline & fourth	16	.683	.004
Pair 5	first & second	16	.751	.001
Pair 6	first & third	16	.791	.000
Pair 7	first & fourth	16	.672	.004
Pair 8	second & third	16	.918	.000
Pair 9	second & fourth	16	.677	.004
Pair 10	third & fourth	16	.789	.000

The amount of force delivered by these mechanisms differs from each other. However, the frictionless system fails to produce better results in practice because of the complexity of loop forming and the presence of unknown factors (Siatkowski, 1997; Ziegler and Ingervall, 1989).

Self-ligation was by far the subject assessed by the majority of included trials and has reported advantages both in terms of treatment duration and friction. However, these claims have been contradicted, and various factors have been attributed to it. It has been proved that self-ligating brackets do provide an environment with lesser friction but their efficiency to influence the outcome has not been established (Harradine and Birnie, 1996; Kapur R et al., 1998) (Loftus et al., 1999). However, Thorstenson and Kusy (Thorstenson and Kusy, 2002) proved that resistance to sliding is observed in both bracket types, SLB and conventional brackets, due to the angulation of the arch-wire in the slot and that the arch-wire binding-releasing phenomenon plays a much greater role than the bracket-arch-wire friction as believed (Fansa et al., 2009; Southard et al., 2007). Treatment duration may be influenced by various factors like extractions, appliance design etc. (Mavreas and Athanasiou, 2008).

The Empower bracket (American Orthodontics) is a dual activation system of self-ligating brackets (Fig 8.1). Dual Activation brackets combine interactive anterior brackets with a passive posterior for a hybrid system that minimizes ligation forces, frictional resistance, while still offering full anterior control for precise finishing.

Considering the fact that reduced friction reduces the treatment time, a search for a system with less friction was undertaken. Some in-vitro studies showed that Synergy brackets had low friction (Ehsani et al., 2009).

Synergy conventional low frictional bracket system was recently introduced by, RMO (Rocky Mountain Orthodontics), the reduced friction appliance system. Synergy brackets have six tie wings with a rounded arch slot walls and floor (Fig 3 and Fig 4), which is said to reduce the friction giving a gentler, more continuous force. Treatment time is claimed to be reduced and is more comfortable for the patient (RMO®).

Figure 3: Synergy canine bracket, with MBT prescription - 0°/±7° torque, RMO®

Another advantage of the synergy system is the friction selection control, where based on the variations of ligation, the force varies. The variations are as follows (Fig 5):

1. For reduced friction, only the central two wings are engaged.
2. For moderate rotation, four tie wings are engaged.
3. For maximum rotation, the corner two tie wings are engaged
4. For maximum control, the corner tie wings on either side are engaged with a figure of 8 ligation
5. For conventional control, all the six tie wings are included (RMO®).

Among the methods as mentioned above, ligation placed around the inner tie-wings yields the best performance (Crincoli et al., 2013).

Figure 4: Rounded arch slot floor reduces friction since the archwire contacts the floor at only two points. Synergy®, RMO®

Keeping in mind, that there aren't many in-vivo studies comparing the efficiency of Synergy brackets in terms of canine rotation, this study was undertaken to assess its efficiency during individual canine retraction in fixed orthodontics, in comparison to the Self-ligating brackets.

In this study, the casts reproduced at every interval were photographed and the canine angle was measured digitally using the FACAD® software. There was a significant amount of canine rotation in both Self-ligating and the synergy group, but an insignificant difference between the two groups.

In this study, the synergy brackets were ligated in the central wings during canine retraction for reducing the amount of friction. The rounded arch slot floor reduces the friction but plays a role in reducing the control over canine rotation while retraction of the canines. Hence there was a significant difference in the amount of canine rotational control loss in this group.

While in group 1, self-ligating brackets, there was a loss of canine rotation during retraction as the brackets used were interactive brackets in this study, leading to a play of the archwire within the slot, resulting in the canine rotation loss during retraction.

The amount of canine rotation is represented in Graph 1, of both Group 1 and Group 2.

CONCLUSION

Overall results show that there is a certain degree of canine rotation during retraction in both the groups, but there is no significant statistical difference between Synergy and Self-Ligating brackets in the degree of canine rotation during canine retraction. The mean or average degree of canine rotation for Group I Self-ligating was 3.32º ±6.55°. The mean or average degree of canine rotation for Group 2 Synergy was 4.08º ±3.85°.

REFERENCES

Bednar, J.R., Gruendeman, G.W., Sandrik, J.L., 1991. A comparative study of frictional forces between orthodontic brackets and archwires. Am. J. Orthod. Dentofac. Orthop. Off. Publ. Am. Assoc. Orthod. It is Const. Soc. Am. Board Orthod. 100, 513–522. https://doi.org/10.1016/0889-5406(91)70091-A

Crincoli, V., Perillo, L., Bisceglie, D., Beatrice, M., Balsamo, A., Serpico, V., Chiatante, F., Pappalettere, C., Boccaccio, A., 2013. Friction Forces during Sliding of Various Brackets for Malaligned Teeth: An In Vitro Study [WWW Document]. Sci. World J. https://doi.org/10.1155/2013/871423

Drescher, D., Bourauel, C., Schumacher, H.A., 1989. Frictional forces between bracket and archwire. Am. J. Orthod. Dentofac. Orthop. Off. Publ. Am. Assoc. Orthod. It is Const. Soc. Am. Board Orthod. 96, 397–404.

Ehsani, S., Mandich, M.-A., El-Bialy, T.H., Flores-Mir, C., 2009. Frictional resistance in self-ligating orthodontic brackets and conventionally ligated brackets. A systematic review. Angle Orthod. 79, 592–601. https://doi.org/10.2319/060208-288.1

Fansa, M., Keilig, L., Reimann, S., Jäger, A., Bourauel, C., 2009. The levelling effectiveness of self-ligating and conventional brackets for complex tooth malalignments. J. Orofac. Orthop. Fortschritte Kieferorthopadie OrganOfficial J. Dtsch. Ges. Kieferorthopadie 70, 285–296. https://doi.org/10.1007/s00056-009-9916-z

Farrant, S.D., 1977. An evaluation of different methods of canine retraction. Br. J. Orthod. 4, 5–15.

Harradine, N.W., Birnie, D.J., 1996. The clinical use of Activa self-ligating brackets. Am. J. Orthod. Dentofac. Orthop. Off. Publ. Am. Assoc. Orthod. It is Const. Soc. Am. Board Orthod. 109, 319–328.

Kapur R, Sinha PK, Nanda, 1998. The History and Development of Self-Ligating Brackets. Journal of Clinical Orthodontics.

Krishnan, S., Pandian, S., Kumar S, A., 2015. Effect of Bisphosphonates on Orthodontic Tooth Movement—An Update. J. Clin. Diagn. Res. JCDR 9, ZE01-ZE05. https://doi.org/10.7860/JCDR/2015/11162.5769

Krishnan, S., Pandian, S., Rajagopal, R., 2017. The six-month bracket failure rate with a flowable composite: A split-mouth randomized controlled trial. Dent. Press J. Orthod. 22, 69–76. https://doi.org/10.1590/2177-6709.22.2.069-076.oar

Kuhlberg AJ, K.A., 2001. Steps in orthodontic treatment. In: Bishara SE, ed. Textbook of Orthodontics.

Kulshrestha, R.S., Tandon, R., Chandra, P., 2015. Canine retraction: A systematic review of different methods used. J. Orthod. Sci. 4, 1–8. https://doi.org/10.4103/2278-0203.149608

Loftus, B.P., Artun, J., Nicholls, J.I., Alonzo, T.A., Stoner, J.A., 1999. Evaluation of friction during sliding tooth movement in various bracket-arch wire combinations. Am. J. Orthod. Dentofac. Orthop. Off. Publ. Am. Assoc. Orthod. It is Const. Soc. Am. Board Orthod. 116, 336–345.

Mavreas, D., Athanasiou, A.E., 2008. Factors affecting the duration of orthodontic treatment: a systematic review. Eur. J. Orthod. 30, 386–395. https://doi.org/10.1093/ejo/cjn018

Profit, 1979. Contemporary Orthodontics - 5th Edition [WWW Document]. URL https://www.elsevier.com/books/contemporary-orthodontics/proffit/978-0-323-08317-1 (accessed 11.8.17).

Ravichandran, P., Dinesh, S., 2017. Comparison of rate of maxillary canine retraction using two different bracket designs - conventional MBT and Synergy - A clinical Study.

Rhee, J.N., Chun, Y.S., Row, J., 2001. A comparison between friction and frictionless mechanics with a new typodont simulation system. Am. J. Orthod. Dentofac. Orthop. Off. Publ. Am. Assoc. Orthod. It is Const. Soc. Am. Board Orthod. 119, 292–299. https://doi.org/10.1067/mod.2001.112452

Samantha, C., Sundari, S., Chandrasekhar, S., Sivamurty, G., Dinesh, S., 2017. Comparative Evaluation of Two Bis-GMA Based Orthodontic Bonding Adhesives - A Randomized Clinical Trial. J. Clin. Diagn. Res. JCDR 11, ZC40-ZC44. https://doi.org/10.7860/JCDR/2017/16716.9665

Sheibaninia, A., Saghiri, M.A., Showkatbakhsh, A., Sunitha, C., Sepasi, S., Mohamadi, M., Esfahanizadeh, N., 2011. Determining the relationship between the application of fixed appliances and periodontal conditions. Afr. J. Biotechnol. 10, 16347–16350.

Siatkowski, R.E., 1997. Continuous archwire closing loop design, optimization, and verification. Part I. Am. J. Orthod. Dentofac. Orthop. Off. Publ. Am. Assoc. Orthod. It is Const. Soc. Am. Board Orthod. 112, 393–402.

Southard, T.E., Marshall, S.D., Grosland, N.M., 2007. Friction does not increase anchorage loading. Am. J. Orthod. Dentofacial Orthop. 131, 412–414. https://doi.org/10.1016/j.ajodo.2006.09.037

Staggers, J.A., Germane, N., 1991. Clinical considerations in the use of retraction mechanics. J. Clin. Orthod. JCO 25, 364–369.

Thorstenson, G.A., Kusy, R.P., 2002. Comparison of resistance to sliding between different self-ligating brackets with second-order angulation in the dry and saliva states. Am. J. Orthod. Dentofac. Orthop. Off. Publ. Am. Assoc. Orthod. It is Const. Soc. Am. Board Orthod. 121, 472–482.

Yeh, C.-L., Kusnoto, B., Viana, G., Evans, C.A., Drummond, J.L., 2007. In-vitro evaluation of frictional resistance between brackets with passive-ligation designs. Am. J. Orthod. Dentofac. Orthop. Off. Publ. Am. Assoc. Orthod. It is Const. Soc. Am. Board Orthod. 131, 704.e11-22. https://doi.org/10.1016/j.ajodo.2006.09.041

Ziegler, P., Ingervall, B., 1989. A clinical study of maxillary canine retraction with a retraction spring and with sliding mechanics. Am. J. Orthod. Dentofac. Orthop. Off. Publ. Am. Assoc. Orthod. It is Const. Soc. Am. Board Orthod. 95, 99–106.