International Journal of Dental Research
Online ISSN: 2664-9055, Print ISSN: 2664-9047
Received: 25-12-2020; Accepted: 09-01-2021; Published: 12-02-2021
www.dentaljournal.net
Volume 3; Issue 1; 2021; Page No. 13-17

Efficiency of anterior retraction in 18 versus 22 slot orthodontic brackets: An *in vitro* comparative study

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Abstract
Background: Space closure is one of the most challenging processes in Orthodontics. Hence; the present study was undertaken for assessing the efficacy of anterior retraction in 18 versus 22 slot.
Materials and methods: A total of 120 samples were included and broadly divided into 6 study groups as follows: Group A: 0.022” slot bracket and eastomeric chain for retraction, Group B: 0.022” slot bracket and nickel titanium coil spring for retraction, Group C: 0.018” slot bracket and eastomeric chain for retraction and Group D: 0.018” slot bracket and nickel titanium coil spring for retraction. All the results were recorded in Microsoft excel sheet and were analysed by SPSS software.
Results: Significant results were obtained while comparing the tipping, rotation and rate of closure among all the study groups. Mean tipping was highest for group A and group B. Mean rotation was highest for group A and group B. Mean rate of closure was highest for group A and group B.
Conclusion: Bracket slot 0.022” groups demonstrated maximum tipping, rotation and space closure rate.

Keywords: undertaken for assessing the efficacy of anterior retraction, space closure rate

Introduction

Space closure is one of the most challenging processes in Orthodontics. Tooth extraction, molar distalization, expansion of dental arches, interproximal reduction, among other things, have been part of the orthodontic armamentarium to correct malocclusion and allow dental space gain with which the orthodontist should deal. The ability to close spaces, especially those resulting from tooth extraction, is an essential skill required during orthodontic treatment. Space closure mechanics without knowledge can result in failure to achieve an ideal occlusion. Current knowledge in biomechanics, allied with the development of new material and techniques, made significant upgrading possible in space closure, which has simplified mechanics [1].

The biomechanical basis of space closure enables clinicians to determine anchorage and treatment options, reach the prognosis of various alternatives, as well as decide specific adjustments that can improve the outcomes of care. In order to achieve good treatment outcomes, it is crucial to understand the principles behind space closure. Regulation of space closure is ultimately determined by the biomechanical forces applied to the teeth, variation in force and moment magnitude, moment-to-force ratio (M/F), force-to-deflection rate, and anchor unit [2, 3].

Extraction treatment has gained popularity from 1930s. This was to achieve a more stable result. Premolars were chiefly considered for extraction followed by canine retraction. Since space closure is a routine procedure in orthodontics, researchers have always tried to find efficient methods for canine retraction. Canines can be retracted by two ways: Frictional (sliding) mechanics, and Non frictional (non sliding) mechanics. Frictional mechanics is the sliding of a tooth along an arch wire by application of force. Non frictional mechanics uses loops for tooth movement (non sliding). Canines can be retracted individually or can be retracted along with the incisors. Retraction of the canines along with the anterior teeth as one unit is known as en masse retraction. Both techniques depend on the type of malocclusion and operators' skill and preference [4- 6].

Abu-Shahba R *et al* evaluated the maxillary canine retraction rate and anchorage loss with active and passive self-ligating brackets (SLBs). The pre- and post-canine retractions CBCT were superimposed to evaluate the pattern and rate of canine movement and anchorage loss. The result of this study showed no statistically significant difference between the two groups. The type of SLB, either active or passive, does not affect the rate or type of canine movement during its retraction in the orthodontic extraction cases, and the anchorage loss of the upper molars was nearly the same in both type [9- 13].

Keng FY *et al* conducted a prospective randomized controlled clinical trial to evaluate the rate of space closure and tooth angulation during maxillary canine retraction using preactivated T-loops made from titanium-molybdenum alloy (TMA) and nickel-titanium (NiTi). The mean rate of canine retraction using preactivated NiTi and TMA T-loops was 0.91 mm/month (±0.46) and 0.87 mm/month (±0.34), respectively. The canine tipping rates were 0.71 degrees/month (±2.34) for NiTi and 1.15 degrees/month (±2.86) for TMA. Both the rate of space closure and the tipping were not significantly different between the two wire types. The average percentage distortion of the TMA T-loop was 10 times greater than that of the NiTi loops when all other variables were matched. There was no difference in the rate of space closure or tooth angulation between preactivated TMA or NiTi T-loops when used to retract upper canines.[14]Hence; the present study was undertaken for assessing the efficacy of anterior retraction in 18 versus 22 slot.

Materials and methods

The present study was conducted with aim of assessing the effect of Bracket's Slot Size on Canine Position and Space Closure Rate. A total of 120 samples were included and broadly divided into 6 study groups as follows:

- Group A: 0.022" slot bracket and eastomeric chain for retraction,
- Group B: 0.022" slot bracket and nickel titanium coil spring for retraction,
- Group C: 0.018" slot bracket and eastomeric chain for retraction
- Group D: 0.018" slot bracket and nickel titanium coil spring for retraction

The division of the groups was based on different slot sizes brackets and methods of force application. Retraction of right mandibular canine was carried out using either a short continuous elastomeric power chain (six rings) or nickel titanium closed coil spring (9 mm in length) which were attached posteriorly to the molar's band hook and anteriorly to the canine's bracket hook along stainless steel arch wire and across an 13mm extraction space, and arch wire was ligated to orthodontic bracket by using elastomeric ligature. A 200 gm of retraction force was employed on 0.017" X 0.025" stainless steel wire ligated to brackets by elastomeric ligatures along 13 mm available space. After immersion of the typodont in water bath with (50-55) C for 5 minutes, the rate of space closure were measured in milli meter using vernier (from the distal wings of canine bracket and the mesial wings of the second premolar), In both vertical and horizontal directions, digital images were taken by camera and the angle between canine extension bar and bite plane extension bar (BPB) was measured by protractor to determine tipping and rotation. All the results were recorded in Microsoft excel sheet and were analysed by SPSS software.

Results

Significant results were obtained while comparing the tipping, rotation and rate of closure among all the study groups. Mean tipping was highest for group A and group B. Mean rotation was highest for group A and group B. Mean rate of closure was highest for group A and group B.

Table 1: Descriptive results

Group		Mean	SD	p- value
Tipping	Group A	12.30	1.23	0.000 (Significant)
	Group B	12.25	1.88	
	Group C	6.12	1.34	
	Group D	6.30	1.56	
Rotation	Group A	32.36	2.85	0.001(Significant)
	Group B	34.85	2.42	
	Group C	20.07	2.75	
	Group D	20.12	2.13	
Rate of space closure	Group A	6.86	0.23	0.002 (Significant)
	Group B	7.69	0.81	
	Group C	3.96	0.77	
	Group D	3.91	0.86	

Discussion

Extraction of teeth is a common orthodontic procedure to minimize crowding or to accomplish maximum interarch interdigitation. Methods and materials to close the resulting space can be influenced by manufacturers claims for products and clinical training and experience. However, decisions to purchase new products or to use particular methods should be based on strong evidence of clinical efficiency. Understanding of the influence of these products or materials on space closure requires a basic understanding of mechanics. Closure of extraction space using orthodontic appliances is usually accomplished in one of two general approaches. The first involves using closing loops in a continuous or segmented arch wire. Once the wire is engaged in the brackets, the spring is activated with a distalizing force. The spring back properties of the wires cause the springs to close producing the forces necessary to initiate and continue tooth movement. The second technique, termed sliding mechanics, involves pushing or pulling a tooth along a continuous arch wire with a force delivery system adequate to produce and sustain movement. Generally, either a coil spring or a form of elastomeric material is used to accomplish the latter. Both techniques present advantages and disadvantages [2- 6].

Ideally, space closure results in translation of teeth with little or no tipping. However, the closure force is usually occlusal and buccal to the center of resistance of the tooth and produces moments, resulting in tipping and rotation of the tooth in the direction of the pull. If a closing loop is used on a segmental wire, the wire requires compensating bends to produce translation and counteract the undesired moments. Clinicians frequently place closing loops in continuous arch wire rather than segmental arch wire to minimize the undesired moments. When space is closed with tipping rather than translation, additional time is usually required to upright the roots under the crowns. The advantage to a closing loop is that friction between the arch wire and the bracket or ligature is removed, minimizing the effect of friction on movement. In sliding mechanics, the stiffness of the continuous arch wire supports the tooth, keeping it from tipping uncontrollably when a force is placed on it [2- 8].

The tooth will tip until the wire contacts the bracket at opposite corners of the slot, stopping the tipping motion. This contact with the corners of the bracket slot appears to produce a counteracting moment that pulls the root of the tooth in the same direction as the crown moved. Thus, a ratcheting movement of the tooth occurs producing net translation, requiring less time for root uprighting following space closure. Numerous *in vitro* studies suggest that variables such as coefficient of friction, size of wire, and force degradation affect the efficiency of sliding mechanics [5- 9].

Attempts to maximize efficiency of sliding mechanics by controlling these variables have produced numerous commercially available products. Although laboratory studies can support the claims of a product, the relevance to clinical situations can be difficult to establish because laboratory studies tightly control the multiple variables present in a clinical situation. Hopefully, the benefit of a product should be greater than the cost or other problems associated with the product. Previous authors suggested that optimal force delivery for tooth movement is a constant force. Although a constant force is rarely produced with a closing loop, super-elastic nickel-titanium coil springs used as part of a sliding force system on a straight wire approach this ideal constant force system in the laboratory. These springs are costly, though, and many clinicians prefer a less expensive product, elastomeric power chain, as an alternate. This presents a problem as an elastomeric power chain and other elastic orthodontic materials can show a significant degradation of force within a short time after placement in the mouth. It is unclear whether there is a clinical advantage of the nickel titanium spring over the elastomeric power chain in closing space [6- 8].

Orthodontic treatment planning is more than just deciding on extraction or non-extraction. Although many approaches towards space closure have been described, the biomechanical principles defining the nature of the force systems applied show many similarities among diverse techniques. Many details determine the tooth movement required during space closure, and it can be performed either by means of frictional or frictionless mechanics [10, 11].

Applying force by means of coil springs or power chain elastics in sliding mechanics will produce friction between the bracket and the archwire, and the tooth feels less force than the orthodontist is in fact applying. Additionally, the guiding wire provides moments required for prevention of tipping and rotation. In frictionless mechanics, there is no guiding wire, so there is no loss of applied force due to sliding friction. With pros and cons, each technique has its particularities. Simplicity is a goal of clinical practice management, and it may be at odds with the desired biomechanical properties of the appliance [12- 16].

In the present study, significant results were obtained while comparing the tipping, rotation and rate of closure among all the study groups. Mean tipping was highest for group A and group B. Mean rotation was highest for group A and group B. Mean rate of closure was highest for group A and group B. Saporito I *et al* identified in general if one type of system is more suitable for planning the extractive therapy, without considering the clinical aspect necessary for an adequate orthodontic approach. A resin maxilla without the first premolars was used to test the self-ligating and conventional brackets system. Space closure was achieved on 0.016x0.022" in stainless steel wires with nickel-titanium coil springs 150 grams in strength and 10 mm in length. During the closing phase of extraction spaces both systems are equable since there are no significant statistical differences (P=0.70). Their typodont model showed no significant difference in the efficiency of space closure between the self-ligating bracket and conventional bracket tied with stainless steel ligatures.[16]Miles P *et al*assessed the effect of the Accele Dent Aura appliance (Ortho Accel Technologies, Houston, Tex) on the rate of maxillary premolar extraction space closure in adolescent patients. Forty Class II adolescents treated with full fixed appliances and maxillary premolar extractions participated in this randomized clinical trial. They were recruited in a private practice and treated by 1 clinician. Randomization was accomplished in blocks of 10 patients assigned to either a no-appliance group or the Acceledent Aura appliance group with the allocations concealed in opaque, sealed envelopes. Both the operator and the outcome assessor were blinded; however, it was not feasible to blind the patients. Models were taken of the maxillary arch at the start of space closure and just before complete space closure. The space was measured parallel to the occlusal plane from the cusp tips of the teeth mesial and distal to the extraction spaces. There was no clinically (0.05 mm per month; 95% confidence interval [CI], -0.24, 0.34) or statistically significant difference in the rate of space closure (P = 0.74). In both the univariable and multivariable analyses, the mean rate of tooth movement was slower by 0.13 mm per month (95% CI, -.26, .005) on the left side compared with the right side, but this was not statistically significant (P = 0.06). The Accele Dent Aura appliance had no effect on the rate of maxillary premolar extraction space closure [17]

In another study conducted by Miles P *et al*, author sassessed the effect of the Accele Dent Aura appliance (Ortho Accel Technologies, Houston, Tex) on the rate of maxillary premolar extraction space closure in adolescent patients. Forty Class II adolescents treated with full fixed appliances and maxillary premolar extractions participated in this randomized clinical trial. There was no clinically or statistically significant difference in the rate of space closure. In both the univariable and multivariable analyses, the mean rate of tooth movement was slower by 0.13 mm per month on the left side compared with the right side, but this was not statistically significant. The Accele Dent Aura appliance had no effect on the rate of maxillary premolar extraction space closure.[18]Samuels RH *et al* studied of the efficiency of space closure after premolar extraction was undertaken, comparing a nickel-titanium closed coil spring and an elastic retraction module by using sliding mechanics along an 0.019 x 0.025-inch stainless steel arch wire in 0.022 x 0.028-inch preadjusted stainless steel brackets. The rate of space closure in 17 subjects was analyzed from study models and was found to be significantly greater and more consistent with the nickel-titanium closed coil springs than with the elastic modules, in both arches. There were no clinically observable differences in the tooth positions between the respective techniques [19].

In another study conducted by Dixon V *et al* compared the rates of orthodontic space closure for: Active ligatures, polyurethane power chain and nickel titanium springs. Patients entering the space closure phase of fixed orthodontic treatment attending six orthodontic providers. Twelve patients received active ligatures (48 quadrants), 10 patients received power chain (40 quadrants) and 11 patients, nickel-titanium springs (44 quadrants). Patients were randomly allocated for treatment with active ligatures, power chain or nickel titanium springs. Upper and lower study models were collected at the start of space closure (T (o)) and 4 months later (T (1)). There was no effect of inter-arch elastics on rate of space closure. NiTi springs gave the most rapid rate of space closure and may be considered the treatment of choice [20].

In another study conducted by Barlow M *et al*, authors determined strength of clinical evidence concerning the influence of various factors on the efficiency (rate of tooth movement) of closing extraction spaces using sliding mechanics. An electronic search (1966-2006) of several databases limiting the searches to English and using several keywords was performed. Also a hand search of five key journals specifically searching for prospective clinical trials relevant to orthodontic space closure using sliding mechanics was completed. Outcome Measure - Rate of tooth movement. Ten prospective clinical trials comparing rates of closure under different variables and focusing only on sliding mechanics were selected for review. The results of clinical research support laboratory results those nickel-titanium coil springs produce a more consistent force and a faster rate of closure when compared with active ligatures as a method of force delivery to close extraction space along a continuous arch wire; however, elastomeric chain produces similar rates of closure when compared with nickel-titanium springs [21].

Shaik JA *et al* evaluate the rate of canine retraction and the amount of anchor loss while using ceramic brackets and ceramic brackets with metal slots and with conventional preadjusted edgewise appliance (PEA) metal brackets. The patient sample consists of 12 patients. Six patients received ceramic brackets on one canine and conventional PEA metal brackets on the opposite canine within the same arch. The other six patients received ceramic brackets with metal slot on one canine and conventional PEA metal brackets on the opposite canine within the same arch. Unpaired t-test was used to analyze the data using SPSS version 20 (3M Unitek, Bangalore, Karnataka, India). The rate of retraction was calculated for individual canine retraction after initial leveling and aligning. Anchor loss was also calculated using the pterygoid vertical to the mesiobuccal cusp of the upper first molar on the lateral cephalograms. The result of their study showed that the difference in the rate of retraction between ceramic brackets with metal slot and conventional PEA metal brackets and ceramic bracket while clinically significant was not statistically significant. The difference in the amount of loss of anchorage of both the groups was not statistically significant. Incorporation of the metal slot in ceramic brackets has reduced frictional resistance for more efficient and desired tooth movement [22].

Every orthodontist knows that a wire is stiff, and applying forces at each end will create elongation that is not detectable to the naked eye. The force-deflection rate is too high and would make a useless spring. Adding bends to the wire (i.e., making loops) can dramatically reduce the force-deflection rate. Over the years, different space closure loop configurations have been developed. Some designs have more advantages than others [21].

Stainless steel tear drop loops are the most common design due to their ease of fabrication; however, they deliver very high forces with only 1 mm of activation. Simple loops are associated with small activations and rapid force decay, including intermittent force delivery; thus, having a negative impact on treatment efficiency. Also, as shown by previous studies, 6 an error as small as 0.3 mm in the horizontal length of the common vertical loop produces large changes on the M/F ratio, making difference enough to change from root movement to tipping. Due to its characteristics, T-loop has a high M/F ratio and delivers more constant forces over a large deactivation span than vertical loops [22].

Increasing wire length in the loop design, i.e., adding a helix, or using metal alloys with lower modulus of elasticity (i.e., beta-titanium), reduce the force delivered at the same activation. Due to the depth of the vestibule, the orthodontist is limited to how high the loop can be made. In order to overcome this problem, a wire, such as a T-loop, can be added horizontally, or there might be addition of helices [20-22].

Conclusion

From the above results, the authors conclude that bracket slot 0.022” groups demonstrated maximum tipping, rotation and space closure rate.

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