A comparative evaluation of rate of space closure after extraction using E-chain and stretched modules in bimaxillary dentoalveolar protrusion cases

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ABSTRACT

BACKGROUND

Aim of this study was to compare the rate of space closure between E-chain mechanics in one side of upper arch and by elastomeric module with ligature wire on the contralateral side in same patient.

METHODS

Thirty bimaxillary dentoalveolar protrusion cases were taken up for comprehensive fixed orthodontic treatment after extraction of all first premolars to retract both upper and lower anterior teeth. After initial alignment and levelling, alginate impressions were made for upper and lower arches and models constructed. In the upper arch model a vernier caliper was used to measure the extraction space in both sides from middle point of distal surface of canine to the middle most point of mesial surface of second premolar. This is the amount of space present before the onset of retraction mechanics. During space closure procedure two different retracting components were applied in right and left sides of each case. On right side elastic chain (E-chain) applied in both upper and lower arches and on left side elastomeric module with steel ligature (0.010") stretched double its diameter fixed in both arches. Both the mechanisms produced approximately 250–300 g of force as measured by a tension gauge. After onset of retraction mechanism all patients were recalled after every six weeks for three visits. In all these three visits modules and E-chains were changed. In all three visits impression was made, models constructed, and the remaining available space was measured by a vernier caliper up to 0.1 mm level variations.

RESULTS

Mean value for total space closure in case of E-chain was 2.777 mm whereas in case of module with ligature wire the value increased to 3.017 mm. Mean value for rate of space closure in case of E-chain was 0.2143 mm, whereas in case of module with ligature wire the value increased to 0.2343 mm with a standard deviation of 0.001104 and 0.001194, respectively. The standard deviation for total space closure was 0.1305 for E-chain and 0.1487 for module with ligature wire.

CONCLUSION

Space closure by elastomeric module with ligature wire is better than the E-chain.

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Key Words: bimaxillary dentoalveolar protrusion; elastic chain; elastomeric module with ligature

INTRODUCTION

Bimaxillary dentoalveolar protrusion is a relatively common malocclusion condition found in patients reported for orthodontic treatment. The most frequent clinical features include convex profile proclination of upper and lower incisors, minimum or nil crowding, class I or class II molar relation, decreased or normal overjet and relatively decreased or normal overbite, skeletal class I or mild class II jaw relationship, and average or mild vertical growth pattern. All these features substantiate the use of contemporary fixed orthodontics after extraction of all first premolars to reduce proclination of incisors in most of the cases of bimaxillary dentoalveolar protrusion.

Most frequently the situation demands extraction of first premolars followed by fixed orthodontic therapy necessary for retraction of upper and lower anterior teeth. Among the three stages of comprehensive fixed orthodontic treatment, the second stage (space closure) is one of the most challenging aspects of the complete process of contemporary orthodontic approach. However, this is also the most crucial stage to bring the obvious improvement in aesthetics in both facial and dental aspects particularly in bimaxillary dentoalveolar protrusive cases. This necessitates the use of an effective space closure mechanics for smooth retraction of the upper and lower anterior teeth after necessary alignment and levelling.

Among the different space closure (anterior retraction, posterior protraction, or combination) options which are available today in preadjusted mechanotherapy, sliding mechanics for en masse retraction have gained a substantial popularity particularly after the evolution of MBT philosophy. Previously the sliding mechanics for same type of retraction was only confined to Begg and Tip Edge mechanics. In sliding mechanics the space closure is carried out nowadays with the help of

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either E-chain, NiTi closing spring, or stretched modules with ligatures.¹ Comparatively both E-chain and elastomeric module with ligature wire are more economical and should produce an optimum level of force without damage to the supportive periodontium when used judiciously for space closure. However, no study has yet been found comparing the rate of space closure between these two procedures.

The aim of this study was to compare the rate of space closure between E-chain mechanics in one side of upper arch and by elastomeric module with ligature wire on the contralateral side in same patient.

MATERIALS AND METHODS

A total of 30 cases were selected for the study from patients reported with orthodontic problems in Armed Forces Dental Clinic, New Delhi. The following criteria were taken for consideration during the selection process:

- Age between 13 and 17 years.
- Permanent dentition with second molars erupted.
- Skeletal class I or mild class II relation of jaws. This was diagnosed through clinical and lateral cephalometric evaluation. Only those skeletal class II cases were considered which were well manageable with orthodontic camouflage treatment.
- Bilateral class I molar relation with bimaxillary dentoalveolar protrusion with average growth pattern.
- Condition of oral hygiene and periodontal status were satisfactory.
- Absence of any craniofacial anomaly, cleft lip, and palate.
- All cases were well motivated, cooperative, and eager to get the benefit of the treatment.

All the selected 30 cases were taken up for comprehensive fixed orthodontic treatment after extraction of all first premolars to retract both upper and lower teeth. The mechanotherapy considered was 0.022" MBT Gemini series brackets with upper double and lower single buccal tube. The second molars were also included in the posterior anchorage segment. Some of them were banded with second molar tubes and were aligned, and the rest that were already naturally aligned were bonded buccally with buttons which were later ligated with hooks of first molar tubes passively to reinforce anchorage.

After initial alignment and levelling, alginate impressions were made for upper and lower arches and models constructed. In the upper arch model a vernier caliper was used to measure the extraction space in both sides from middle point of distal surface of canine to the middle most point of mesial surface of second premolar. This is the amount of space present before the onset of retraction mechanics (A). In all the cases, space closure procedure initiated only when 0.019" × 0.025" SS wire passively placed in both the arches, and when all the brackets were ligated with the arch wire by preformed steel ligatures. To facilitate tying of retracting component anteriorly, a small piece of 0.019" × 0.025" wire was shaped as "S" and welded to the base arch wire in all four quadrants immediately

distal to canines. This "S"-shaped wire was ligated by the force delivery system in all the four quadrants with molar hooks. During the space closure procedure two different retracting components were applied in right and left sides of each case. On right side E-chain (Ortho organiser) applied in both upper and lower arches (Figure 1) and on left side stretched (double its diameter) module or elastomeric ligature (Ortho organiser) with 0.010" steel ligature fixed in both arches (Figure 2). Both the mechanisms produced approximately 250–300g of force as measured by a tension gauge.

After onset of retraction mechanism all patients were recalled after every six weeks for three visits. In all these three visits modules and E-chains were changed. In all three visits impression were made, and models were constructed, and the remaining available space was measured by a vernier caliper up to 0.1 mm level variation (Figure 3).

In all the cases before initiation of space closure, available space after alignment and levelling measured in model by the vernier caliper and has been named A. The same has been repeated after 6, 12, and 18 weeks interval. Remaining space after

Figure 1 Retraction with elastomeric chain.

Figure 2 Retraction with elastic module.

Figure 3 Measurement on study model.

18 weeks has been designated as B and so the total space was closed after 18 weeks $C=A - B$. This was later divided by the total duration in days and the rate of space closure was obtained.

The statistical analysis of the data obtained was carried out to find the mean, standard deviation, total space closure, and rate of space closure for both the mechanics. A student “t” test was also carried out to compare the results between the two mechanics.

RESULTS

The followings have been observed (Figures 4 and 5):

Mean value for total space closure in case of E-chain is 2.777 mm, whereas in case of module with ligature wire the value increased to 3.017 mm (Table 1).

Mean value for rate of space closure in case of E-chain is 0.02143 mm, whereas in case of module with ligature wire the value increased to 0.02343 mm with a standard deviation of 0.001104 and 0.001194, respectively (Table 2).

The standard deviation of total space closure for both the procedures has been found to be 0.1487 for modules with ligature wire and 0.1305 for E-chain. *P* value was also calculated and found to be 0 which signifies that the rate of space closure is more in case of module with ligature and is statistically significant.

DISCUSSION

Orthodontic tooth movement during space closure is achieved through two different mechanisms. The first mechanism is by closing loops which is a frictionless technique. The other mechanism is sliding mechanics in which friction plays a very important role. Sliding mechanics is preferred by many clinicians presently due to its simple application. Additionally, the mechanics should give predictable results since the arch wire helps maintain the occlusal plane and preferred arch form. In this study space closure in all the cases were carried out with sliding mechanics. However, the rigid 0.019×0.025 SS

Figure 4 Comparison of space closure between E-chain (red pyramid) and elastomeric module (green pyramid).

Figure 5 Comparison of change in space over time between E-chain (blue) and module (pink).

Table 1 Total space closure.

S. No.	Space closure method	No. of patients	Mean	Std. dev.	t value	P value
1	E-chain	30	2.777	0.1305	6.644	0
2	Module	30	3.017	0.1487		

Table 2 Rate of space closure.

S. No.	Space closure method	No. of patients	Mean	Std. dev.	t value	P value
1	E-chain	30	0.02143	0.001104	6.734	0.000
2	Module	30	0.02343	0.001194		

wire remained the base arch wire to maintain torque during retraction of anterior teeth in all the cases.

The applied force was through E-chain in right side and module with ligature tie in left side in each patient with same amount of force. E-chains are made from synthetic rubber polymers that are capable of large elastic deformation due to their patterns of folded or kinked molecular chains at rest. When extended, they unfold in an ordered linear fashion. In vitro exposure to ozone and ultraviolet ray break down the unsaturated double bonds at the molecular level. This reduces the tensile strength and flexibility. To reduce this effects E-chains are often treated with antioxidants and antiozonates. In vivo i.e., in the oral cavity elastics absorb water and saliva, which cause a breakdown of the internal bonds and permanent deformation of the material. Secondly, the E-chains swell and stain due to the filling of the voids in the rubber matrix by fluids and bacterial debris. The effects of salivary enzymes, mastication, oral hygiene, and temperature may all influence the degradation rates of E-chains in vivo.^{2,3} Ferrier et al⁴ investigated the effect of pH of plaque (4.95) and saliva (7.26) on E-chains and found that chains subjected to the more basic solution exhibited significantly more force decay over the four-week testing period. This could lead to a drop in optimum force level. In this study rate of space closure has been found statistically significantly slower in the left side of maxillary arch where E-chain mechanics were applied compared to the right side where a single stretched module with ligature wire was applied in each case ($P = 0.000$).

When sliding mechanics are used friction occurs at the bracket-wire interface. If not applied properly and substantially, friction at bracket-wire interface may diminish the efficiency of sliding mechanics. Some of the applied force is therefore dissipated as friction and the remainder is transferred to supporting structures of the tooth to mediate tooth movement. It has been observed that the bracket undergoes a “stick-slip” action along the arch wire. This undesirable movement occurs as the tooth tips and the bracket then binds against the arch wire.⁵ On binding, movement ceases until the deflected arch wire forces the tooth to become upright. In addition, the frictional forces occurring during sliding mechanics reduce the delivery of desired force levels. So when forces above the recommended levels can cause tipping and friction, and thus, prevent the space closure, inadequate force may sometimes be a cause of slow or non-space closure in adult treatment. Therefore, maximum biological tissue response occurs only when the applied force is of sufficient magnitude to adequately overcome friction and lie within the optimum range of forces necessary for movement of the tooth.^{6,7} The elastomeric module tiebacks were originally described⁸ of the type used to hold archwires on to brackets, stretched to twice its normal size. This gives a force of 50–100g, if the module was pre-stretched or “worked” before use. When it is used direct from manufacturer without any pre-stretching, it may give 200–300g more force.⁹ It has been reported that different clinicians have successfully used elastomeric modules with different pre-stretching and different amounts of stretching when placed in the mouth. However, all the approaches with elastomeric tiebacks seem to achieve good space closure. Therefore, it seems that absolute precise force levels are not mandatory

for day-to-day success, and that adequate space closure occurs in most cases, when the general concept is followed.

According to Bennett et al⁸ space closure can continue for several months with module ligature tieback even if patient fails to turn up for normal adjustment for several months with an almost degraded module. Although Nattrass et al⁹ confirmed that force decay with NiTi springs was less than elastics and the space closure rate was faster, Bennett et al¹⁰ recommended the use of elastomeric modules with ligatures for space closure. According to them, if spaces are closed too rapidly, incisor torque can be lost and requires several months to regain at the end of space closure. Secondly, elastomeric modules are easy to use, economical and work well in most clinical situations. They also suggested that although coil springs can close all the spaces without replacement at monthly visits, this is practically not justified. As per the statistical findings in this study, space closure by E-chain may not be a better alternative to elastomeric module. This could be due to (a) force level is more specific and precise in case of module with ligature wire as chance of over or under stretching is minimum unlike E-chain and (b) much less biodegradability with concomitant force reduction than E-chain as the elastic tieback has only one polymer circle unlike E-chain which has multiple polymer circles.

CONCLUSION

The following conclusions have been drawn from the above study.

(a) Sliding mechanics when applied properly is an effective method to manage space closure in bimaxillary dentoalveolar protrusion cases with having a better control of tooth movement in a 0.022” MBT appliance.

(b) Module with ligature tieback is relatively a better alternative to E-chain for extraction space closure.

Intellectual Contributions of Authors

Study concept: Col Rajat Mitra

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Statistical analysis: Col Rajat Mitra

Study supervision: Col Rajat Mitra, Brig SM Londhe, Lt Col Prasanna Kumar

CONFLICTS OF INTEREST

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REFERENCES

1. Samuels RH, Rudge SJ, Mair LH. A comparison of the rate of space closure using a nickel titanium spring and an elastic module, a clinical study. *Am J Orthod Dentofac Orthop* 1993;103:464–467.

2. Kuster R, Ingervall B, Burgin W. Laboratory and intra oral test of the degradation of elastic chains. *Eur J Orthod* 1986;8:202–208.
3. Nattrass C, Ireland AJ, Sherriff M. The effect of environmental factors on elastomeric chain and nickel titanium coil springs. *EJO* 1998;20: 169–176.
4. Ferrier J, Meyers C, Lorton L. The effect of hydrogen ion concentration on the force degradation rate of orthodontic polyurethane E-chain elastics. *Am J Orthod Dentofac Orthop* 1990;98:404–410.
5. Loftus BP, Artun J, Nicholls JJ, Alonzo TA, Stoner JA. Evaluation of friction during sliding tooth movement in various bracket-archwire combinations. *Am J Orthod Dentofac Orthop* 1999;116: 336–345.
6. O'Reilly D, Dowling PA, Lagerstrom L, Swartz ML. An ex vivo investigation into the effect of bracket displacement on the resistance to sliding. *BJO* 1999;26:219–227.
7. Pizzoni L, Ravnholt G, Melsen B. Frictional forces related to self ligating brackets. *Eur J Orthod* 1998;20:283–291.
8. Bennett JC, McLaughlin RP: controlled space closure with a preadjusted appliance system. *J Clin Orthod* 1990;24:251–260.
9. Nattrass C, Ireland AJ, Sherriff M. An investigation into the placement of force delivery systems and the initial forces applied by clinicians during space closure. *BJO* 1997;24:127–131.
10. Bennett JC, McLaughlin RP, Trevisi JH. In: *Systemized Orthodontic Treatment Mechanics*. Mosby-Wolfe, 2001.

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