Original Article

Access this article online
Quick Response Code:
Website:
www.jorthodsci.org
DOI:
10.4103/jos.JOS_65_17

Effects of force magnitude on torque control in the correction of bimaxillary protrusion with mass retraction

Jiao Li, Yunhe Zhao, Houxuan Li, Huang Li and Lang Lei

Abstract:

OBJECTIVES: This study was designed to explore whether force magnitude would influence incisor torque control and the overall outcome in patients with bimaxillary protrusion who need mass incisor retraction.

MATERIALS AND METHODS: Forty-one female patients (aged > 15 years) with bimaxillary protrusion requiring mass incisor retraction were selected. Two sliding mechanics were utilized, with the elastic group receiving a light force of ~100 g by wearing elastics and the power chain group receiving a moderate force of ~250 g by power chain. Lateral cephalograms obtained before and after treatment were traced and measured.

RESULTS: Patients in both groups displayed maxillary protrusion with a similar skeletal class II tendency. A longer treatment time was found in the elastic group. No difference in the distance of incisor tip movement was observed between the two groups; however, a larger inclination of upper incisors was found in the elastic group, indicating less loss of torque. In addition, larger reduction in Sella-Nasion-A and A-Nasion-B angle was observed in the elastic group, which was accompanied by a larger ratio of upper lip retraction to upper incisor retraction as well as more upper lip retraction.

CONCLUSIONS: Sliding mechanics with elastics to generate light forces can achieve better torque control with more reduction in skeletal and soft tissue protrusion.

Keywords:

Bimaxillary protrusion, cephalometrics, retraction, torque

Department of Orthodontics, Nanjing Stomatological Hospital, Medical School of Nanjing University, Nanjing, China

Address for correspondence:
Dr. Lang Lei, Nanjing Stomatological Hospital, Medical School of Nanjing University, Nanjing, China.
E-mail: leilangdental@163.com

Introduction

Bimaxillary protrusion, a dentoalveolar anomaly commonly found in Asian populations, is characterized by protrusive upper and lower incisors as well as an increased procumbency of the lips.[1] The goals of orthodontic treatment for bimaxillary protrusion include reduction of dental protrusion as well as facial convexity by retraction of upper and lower incisors. Therefore, extractions of the four premolars are often incorporated into the treatment regime, followed by retraction of incisors with maximum anchorage.[2]

Various mediums have been utilized to retract the proclined incisors, including elastics, elastic power chain, nickel-titanium spring, and closing loops. The magnitude and direction of orthodontic forces affect the speed and types of tooth movement, namely intrusion, extrusion, tipping, or translation.[3] In addition, in the edgewise bracket system, a couple of forces, which are of the same magnitude, parallel but in opposite directions, was generated by the contact of the two edges of the rectangular archwire with the gingival and

How to cite this article: Li J, Zhao Y, Li H, Li H, Lei L. Effects of force magnitude on torque control in the correction of bimaxillary protrusion with mass retraction. J Orthodont Sci 2018;7:13.

occlusal wall of the slot.[3] The interplay between forces and momentum affects the outcome of orthodontic treatment.

It is rather well accepted that the extraction of four premolars can be effective in correcting bimaxillary protrusion.[4,5] Moreover, sliding mechanism has been widely utilized in the straight wire appliances for *en masse* retraction of upper and lower incisors.[6] In review of the reports regarding the sliding mechanics, previous interest has been focused on the friction among different bracket systems[7] and the interplay between different archwires and slots,[8] difference between traditional anchorage, and mini-implant anchorage.[9] However, currently, there is relatively little information in the literature discussing the effects of force magnitude on the retraction of incisors in bimaxillary protrusion. Given the fact that the outcome of bimaxillary protrusion would be greatly dependent on the space closure, this study was designed to explore whether force magnitude would affect the incisor position and overall outcome of orthodontic treatment in bimaxillary protrusive patients who need mass incisor retraction.

Materials and Methods

Study sample

The sample in this study was selected from the patients diagnosed with bimaxillary protrusion and treated at a university orthodontic clinic. The rights and privacy of all patients in the sample were protected, and approval was obtained from the Institutional Review Board of the university where the research was conducted. Only female patients who met the following criteria were included in the study:

1. A minimum age of 15 to reduce the effects of growth on dental structures;
2. Cases with Class I molar relationship;
3. Pretreatment interincisal angle less than 124°;
4. Orthodontic treatment consisting of the extraction of four premolars with subsequent retraction of anterior teeth;
5. Pre- and posttreatment cephalometric radiographs of adequate diagnostic quality;
6. Maximum anchorage was incorporated to guarantee notable incisor movement.

Orthodontic treatment

All 41 patients satisfying the inclusion criteria were treated by the authors using straight wire appliances with a 022 × 028-in MBT prescription. Four premolars were extracted and temporary anchorage devices (TADs), which were implanted between the upper second premolars and upper first molars, were used to achieve the maximum anchorage control and avoid unexpected movement such as the mesial movement of posterior teeth. Depending on the mechanics used, the patients were divided into two groups – elastics group and power chain groups.

For the patients in the elastic group ($n = 18$), the extraction space was closed by wearing elastics on a 0.018 × 0.025-in stainless arch wire by patients themselves, and the force was controlled at ~100 g, which was detected by hand-held dynamometer at every visit. For the patients in the power chain group ($n = 21$), the extraction space was closed by using elastic power chains on a 0.019 × 0.025-in stainless arch wire, and the force was controlled at ~250 g by using a dynamometer.

Cephalometric analysis

Pretreatment and posttreatment cephalometric radiographs were digitized, traced, and superimposed by one examiner, and then calibrated and analyzed in Winceph 7.0 cephalometric software (Rise, Sendai, Japan). Cephalometric parameters utilized in this study to evaluate the skeletal, dental and soft tissue changes included: Sella-Nasion-A(SNA), Sella-Nasion-B(SNB), A-Nasion-B (ANB), Mandibular plane-Frankfurt Horizontal plane(MP-FH), Mandibular plane-(Sella-Nasion) plane(MP-SN) [Figure 1].

To evaluate the changes in lip and incisor position, a constructed Frankfort horizontal plane (constructed by subtracting 7° from the sella-nasion line) served as the x-axis and a line perpendicular to it through the sella served as the y-axis. Following measurements were conducted on the superimpositions to minimize inaccuracy – upper incisor position (U1 tip-y axis), lower incisor position (L1 tip-y axis), upper lip protrusion (the most anterior point of the upper lip -y axis), and lower lip protrusion (the most anterior point of the upper lip-y axis). In addition, changes in the nasolabial angle

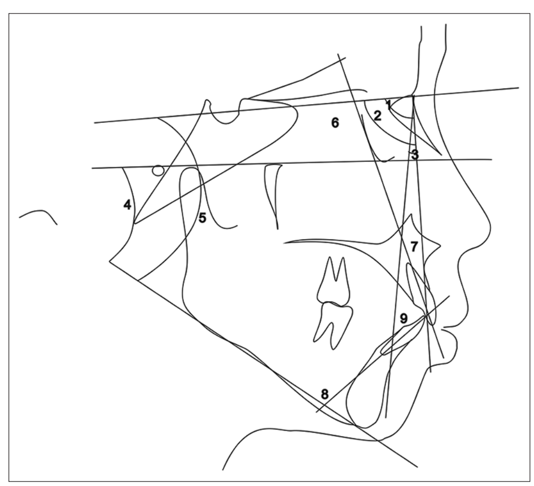

Figure 1: Dentoalveolar measurements of the lateral cephalometric analysis: 1, SNA; 2, SNB; 3, ANB; 4. MP-FH; 5, MP-SN; 6. U1-SN; 7. U1-NA; 8. L1-MP; 9. L1-NB

and labiomental angle were also measured to reflect soft tissue alterations [Figure 2].

Error measurement

For error testing, pre- and posttreatment cephalograms were traced at the same time and all radiographs were traced by the same operator. Ten patients were selected and pre- and posttreatment radiographs were traced, and then retraced by the same operator at least 2 weeks later. The tracings were analyzed and the differences in measurements between the two different tracings of the same radiograph were calculated. Paired *t*-tests were performed to determine the significant differences between the two tracings. No significant difference was found between any of the measurements on the 10 cephalograms.

Statistics

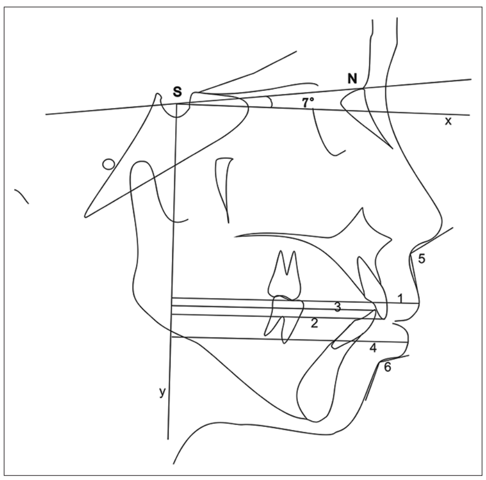

Figure 2: Horizontal position of the upper and lower incisor tips as well as lips. 1, most anterior point of upper lip to y axis; 2, upper incisor tip-y axis; 3, mandibular incisor tip-y axis; 4, most anterior point of lower point-axis; 5, nasolabial angle; 6, mentolabial angle

All data were statistically analyzed using a commercially available statistical software package (SPSS 17.0, Chicago, IL, USA). The means and standard deviations of pretreatment and posttreatment cephalometric measurements in both groups were calculated and compared using analysis of variances (ANOVA). Statistical significance was set at the level of 0.05.

Results

The mean ages of the patients in the elastic group and power chain group were 19.77 ± 3.23 years and 20.28 ± 3.67 years, respectively. The treatment time was longer in the elastic group (28.94 ± 4.93 years) than the power chain group (24.52 ± 4.42 years), suggesting a slower tooth movement rate in the elastic group.

Pretreatment characteristics

Descriptive data regarding the pretreatment characteristics are listed in Table 1. For comparison, the norms of the adult patients with normal occlusion from the same population were also given.

Patients in both the elastic and power chain group displayed similar dentoalveolar pattern, showing no statistical difference in any items. A moderate skeletal class II pattern was found in both the elastic and power chain group (7.40 ± 1.85 and 6.86 ± 1.35, respectively); in addition, SNA in both groups was significantly larger than the normal control, showing the maxillary protrusion. Decreased interincisal angle was found in both the elastic group (109.73 ± 7.19) and power chain group (110.32 ± 7.42); moreover, upper incisor and low incisor inclination was more protrusive in both the elastic group and power chain group than normal control.

Table 1: Pretreatment and Posttreatment Cephalometric Characteristics of Individuals With Bimaxillary Protrusion in Elastics Group and Power Chain Group.

Measurement	Pretreatment		Post-treatment		Norm[a]
	Elastics	Power Chain	Elastics	Power Chain	
Skeletal					
SNA	85.77±2.56	84.19±2.61	84.26±2.46	83.44±2.68	82.79±2.97
SNB	78.36±2.18	77.41±2.46	78.33±2.20	77.20±2.39	78.94±3.07
ANB	7.40±1.85	6.86±1.35	5.87±1.68	6.33±1.49	3.85±1.75
MP-FH	29.75±7.59	32.90±4.74	29.88±7.41	33.45±6.23	25.31±4.18
MP-SN	35.67±6.65	36.99±5.53	35.90±6.51	37.65±5.37	30.4±4.95
Dental					
U1-L1(°)	109.73±7.19	110.32±7.42	127.27±8.33	132.24±7.20	126.86±6.30
U1-SN(°)	110.96±6.22	110.00±4.53	100.19±3.99*	94.01±3.42	104.8±5.40
U1-NA(°)	25.41±6.22	26.15±4.48	17.31±5.90*	11.47±3.77	22.04±5.30
L1-MP(°)	104.89±7.43	105.09±5.60	97.19±6.91	95.16±5.22	96.76±4.56
L1-NB(°)	38.63±3.58	39.84±4.43	30.56±5.87	30.59±5.46	32.25±4.25
Soft tissue					
Nasolabial angle	94.79±10.95	92.42±12.29	104.33±9.65	101.62±10.45	91.35±12.56
Mentolabial angle	130.10±20.49	126.32±15.73	129.67±13.67	126.71±15.17	133.27±18.66

*P<0.05 vs its counterpart in Powerchain group. [a]values from the local population

Posttreatment characteristics

Although both groups showed similar skeletal pattern after treatment, a significant difference in upper incisor inclination was observed with a larger U1-SN and U1-NA in the elastic group than power chain group, indicating better torque control in the elastic group. No difference in nasolabial angle and mentolabial angle was found in both the elastic group and power chain group.

Effect of treatment

A significant improvement in maxillary skeletal protrusion was found with SNA, and ANB decreased more in the elastic group than in the power chain group, whereas no difference was found in the changes in the mandibular plane [Table 2]. The upper incisor retraction was similar with a retraction of 6.78 ± 0.91 mm in the elastic group and a retraction of 6.59 ± 0.92 mm in the power chain group; in contrast, more retroclination of the upper incisor was found in the power chain group (15.98 ± 5.60°) than elastic group (8.84 ± 8.53°).

Regarding lip position changes, upper lip retraction was larger in the elastic group (3.53 ± 1.63 mm) than power chain group (2.32 ± 1.31 mm), whereas no difference in the retraction of both lower incisors and lower lips was observed in the elastic group and in the power chain group [Figure 3]. Furthermore, we calculated the ratio of upper lip retraction to upper incisor retraction, the ratio in the elastic group was much larger (0.50 ± 0.16) than power chain group (0.35 ± 0.18) showing more prominent lip changes in relation to incisor changes. However, we did not observe difference in the ratio of the lower lip retraction to low incisor retraction, which showed a marked variation [Figure 4].

Discussion

Successful orthodontic correction of bimaxillary protrusion has been reported in the literature. Patients with bimaxillary protrusion in an East Asian population were often accompanied by skeletal problems, usually skeletal class II tendency.[10] Therefore, the aim of orthodontic treatment should incorporate both correction of dental protrusion and improvement in skeletal discrepancy. This was the first study designed to explore whether force magnitude would influence the outcome of orthodontic treatment, and we found that sliding mechanic with light force can achieve more skeletal effects.

Maxillary incisor labiolingual inclination and anteroposterior position have a key effect on the appearance of the smiling profile. Interestingly, a smiling profile with a 5° lingual inclination of the upper incisor obtained the highest score in Chinese and Mideast population,[11,12] and an excessive maxillary incisor lingual inclination was the least favorable regardless of the mandibular position.[11,13] Our study stressed the importance of utilizing light forces to achieve better torque control for smiling esthetic. In addition, light force has also been advocated for less discomfort, reducing the chance of root resorption and avoiding periodontal damages.[14]

The labiolingual inclination of the maxillary incisors is a challenge when extensive retraction is needed to

Table 2: Cephalometric Changes After Orthodontic Correction of Bimaxillary Protrusion (Postreatment - pretreatment).

Measurement	Elastics (*n*=18)	Power chain (*n*=21)
Skeletal		
SNA	-1.51±0.84*	-0.74±0.81
SNB	-0.03±0.21	-0.27±0.67
ANB	-1.53±1.85*	-0.48±1.10
MP-FH	0.14±0.53	0.64±1.13
MP-SN	0.15±0.67	0.71±1.03
Dental		
U1-L1(°)	16.88±9.70	21.92±10.75
U1-SN(°)	-8.84±8.53*	-15.98±5.60
U1-NA(°)	-7.72±8.44*	-14.68±5.30
L1-MP(°)	-7.69±5.54	-9.92±5.73
L1-NB(°)	-8.07±5.51	-8.52±5.01
Soft tissue		
Nasolabial angle	9.54±9.30	9.20±7.53
Mentolabial angle	-0.46±13.88	0.40±12.32

*P<0.05 vs Power chain group

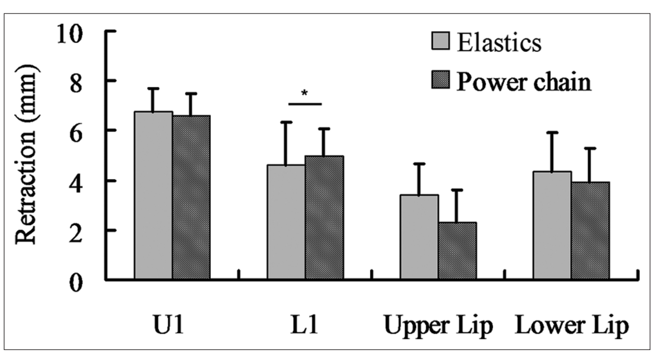

Figure 3: Changes in lip position and incisor tip poison (*P < 0.05)

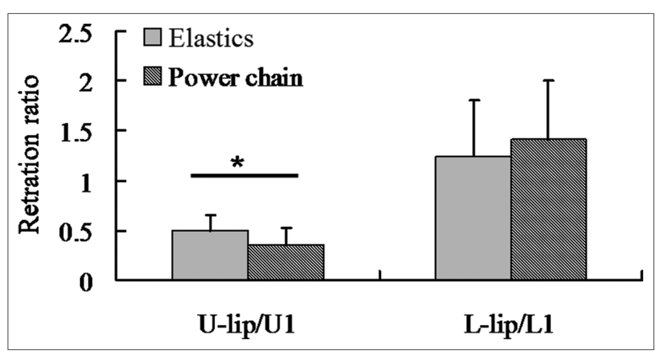

Figure 4: Changes in the ratio of the lip retraction to incisor retraction (*P < 0.05)

camouflage skeletal discrepancy in patients with a skeletal class II pattern.[15] The expression of the incisor labiolingual inclination was influenced by various factors, including the direction and magnitude of forces, the mechanical property of archwire, and bracket.[16] To counteract the loss of torque, Gioka and Eliades suggested that a high-torque prescription should be selected.[16] However, the use of a high-torque bracket system would strain the anchorage control and flare the incisors in nonextraction patients.

In sliding mechanics, the tooth will tip until the wire contacts the bracket at opposite corners of the slot, stopping the tipping motion.[17] Typically, when the momentum of the couple on the bracket is equal to the momentum of the retraction force, bodily movement ensues;[18] therefore, theoretically heavier the retraction force is, more torque loss accompanies. This phenomenon explained the bodily movement element in the light force of the elastic group, and the more retroclined inclination in the power chain group with moderate force.

There is an ongoing debate about the magnitude of an optimal force. In the early transition era of SWA, Andrews used forces of 600 g to close spaces; later, McLaughlin and Bennett advocated a force of 200 g,[19] which was also supported in other studies.[20-22] However, Burstone and Groves observed no threshold value but found optimal rates between 50 and 75 g for tipping of anterior teeth.[23] Similarly, in our present study, a continuous light unilateral ~100 g effectively finished *en masse* retraction with partial translational movement, albeit tooth movement rate was slightly slower than 200~250 g power chain group.

The force of elastomeric chain can degrade quickly; therefore, some orthodontists utilize nickel-titanium coil spring to deliver a constant force.[24] The information on the efficiency of elastics in closing space is limited, as currently there is only one clinical study that examined the efficiency of elastics to distalize the canine.[25] Slower canine distalization was observed in patients wearing elastics than nickel-titanium coil spring;[25] however, such a difference may arise from the different magnitude of forces rather than the materials. Changing the elastics by the patients themselves delivers an almost continuous force and avoids dental hygiene problem of power chain and coil spring.

Conflicting results have been reported in the literature regarding the ratios of incisor retraction to lip retraction, which can be attributed to the lack of standardization of lip position during radiography, variation in lip morphology and lip tonicity,[26] and difference in growth potential. For example, Bills *et al*.[1] reported a similar 1:2.2 upper lip retraction to upper incisor retraction, whereas Kusnoto *et al*.[27] found a ratio of 1:1.3 in an Indonesian bimaxillary protrusive patient; in contrast, Diels *et al*. reported a ratio of 1:3 in African-Americans.[28] Given the fact that orthodontic treatment can alter the position of A and B points and changes in A and B point would affect soft tissue profile,[29] a higher ratio of 1:2 of upper lip to upper incisor retraction in light force-treated elastic group compared to a ratio of 1:2.9 in the power chain group may arise from the different types of tooth movement.

Although we observed more skeletal effect in the elastic group, the drawbacks in using elastic with light force to close space should be noted. The tooth movement in the elastic group was slower than its counterpart, which may pose a challenge in adult patients; furthermore, wearing elastic to close space may be a problem for very young patients with less compliance.

Conclusion

Both mechanics demonstrated significant improvement in the protrusion of incisor and lips with slower incisor retraction in the elastic group. Sliding mechanics with elastics to generate light forces achieved better torque control albeit incisor retraction distance is similar. Light force achieved better skeletal effect and more upper lip retraction.

Financial support and sponsorship
This work was supported by grants from Nanjing Commission of Health and Family Planning (YKK15155).

Conflicts of interest
There are no conflicts of interest.

References

1. Bills DA, Handelman CS, BeGole EA. Bimaxillary dentoalveolar protrusion: Traits and orthodontic correction. Angle Orthod 2005;75:333-9.
2. Melsen B, Bosch C. Different approaches to anchorage: A survey and an evaluation. Angle Orthod 1997;67:23-30.
3. Meling TR, Ødegaard J. The effect of second-order couple on the application of torque. Am J Orthod Dentofac Orthop 1998;113:256-62.
4. Chung K-R, Choo H, Lee J-H, Kim S-H. Atypical orthodontic extraction pattern managed by differential en-masse retraction against a temporary skeletal anchorage device in the treatment of bimaxillary protrusion. Am J Orthod Dentofac Orthop 2011;140423-32.
5. Yao C-CJ, Lai EH-H, Chang JZ-C, Chen I, Chen Y-J. Comparison of treatment outcomes between skeletal anchorage and extraoral anchorage in adults with maxillary dentoalveolar protrusion. Am J Orthod Dentofac Orthop 2008;134:615-24.
6. McLaughlin RP, Bennett JC. Evolution of treatment mechanics and contemporary appliance design in orthodontics: A 40-year perspective. Am J Orthod Dentofac Orthop 2015;147:654-62.
7. Pasha A, Vishwakarma S, Narayan A, Vinay K, Shetty SV, Roy PP. Comparison of Frictional Forces Generated by a New Ceramic

Bracket with the Conventional Brackets using Unconventional and Conventional Ligation System and the Self-ligating Brackets: An *In Vitro* Study. J Int Oral Health 2015;7:108.
8. Tominaga J-y, Ozaki H, Chiang P-C, Sumi M, Tanaka M, Koga Y, *et al*. Effect of bracket slot and archwire dimensions on anterior tooth movement during space closure in sliding mechanics: A 3-dimensional finite element study. Am J Orthod Dentofac Orthop 2014;146:166-74.
9. Chen M, Li Z-M, Liu X, Cai B, Wang D-W, Feng Z-C. Differences of treatment outcomes between self-ligating brackets with microimplant and headgear anchorages in adults with bimaxillary protrusion. Am J Orthod Dentofac Orthop 2015;147:465-71.
10. Tan T. Profile changes following orthodontic correction of bimaxillary protrusion with a preadjusted edgewise appliance. Int J Adult Orthodon Orthognath Surg 1995;11:239-51.
11. Cao L, Zhang K, Bai D, Jing Y, Tian Y, Guo Y. Effect of maxillary incisor labiolingual inclination and anteroposterior position on smiling profile esthetics. Angle Orthod 2011;81:121-9.
12. Ghaleb N, Bouserhal J, Bassil-Nassif N. Aesthetic evaluation of profile incisor inclination. Eur J Orthod 2010:cjq059.
13. Najafi HZ, Oshagh M, Khalili MH, Torkan S. Esthetic evaluation of incisor inclination in smiling profiles with respect to mandibular position. Am J Orthod Dentofac Orthop 2015;148:387-95.
14. Javaheri H. The side effects of orthodontic mechanics in orthodontic treatments. Int J Orthod (Milwaukee, Wis) 2007;19:11-2.
15. Sangcharearn Y, Ho C. Effect of incisor angulation on overjet and overbite in class II camouflage treatment: A Typodont Study. Angle Orthod 2007;77:1011-8.
16. Gioka C, Eliades T. Materials-induced variation in the torque expression of preadjusted appliances. Am J Orthod Dentofac Orthop 2004;125:323-8.
17. Barlow M, Kula K. Factors influencing efficiency of sliding mechanics to close extraction space: A systematic review. Orthod Craniofac Res 2008;11:65-73.
18. Parashar A, Aileni KR, Rachala MR, Shashidhar NR, Mallikarjun V, Parik N. Torque loss in en-masse retraction of maxillary anterior teeth using miniimplants with force vectors at different levels: 3D FEM study. J Clin Diagn Res 2014;8:ZC77.
19. McLaughlin R, Bennett J. The transition from standard edgewise to preadjusted appliance systems. J Clin Orthod 1989;23:142.
20. Dixon V, Read M, O Brien K, Worthington H, Mandall N. A randomized clinical trial to compare three methods of orthodontic space closure. J Orthod 2002;29:31-6.
21. Nightingale C, Jones S. A clinical investigation of force delivery systems for orthodontic space closure. J Orthod 2003;30:229-36.
22. Samuels R, Orth M, Rudge S, Mair L. 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;103:464-7.
23. Burstone C, Groves M. Threshold and optimum force values for maxillary anterior tooth movement. J Dent Res 1961;39:695.
24. Lu TC, Wang WN, Tarng TH, Chen JW. Force decay of elastomeric chain—a serial study. Part II. Am J Orthod Dentofac Orthop 1993;104:373-7.
25. Sonis AL. Comparison of NiTi coil springs vs. elastics in canine retraction. J Clin Orthod 1994;28:293-5.
26. Oliver BM. The influence of lip thickness and strain on upper lip response to incisor retraction. Am J Orthod 1982;82:141-9.
27. Kusnoto J, Kusnoto H. The effect of anterior tooth retraction on lip position of orthodontically treated adult Indonesians. Am J Orthod Dentofac Orthop 2001;120:304-7.
28. Diels RM, Kalra V, DeLoach Jr N, Powers M, Nelson SS. Changes in soft tissue profile of African-Americans following extraction treatment. Angle Orthod 1995;65:285-92.
29. O'Reilly MT. Integumental profile changes after surgical orthodontic correction of bimaxillary dentoalveolar protrusion in black patients. Am J Orthod Dentofac Orthop 1989;96:242-8.