PREDICTION OF SOFT TISSUE PROFILE CHANGES FOLLOWING ORTHODONTIC RETRACTION OF INCISORS IN IRANIAN GIRLS

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***Aim**: To study the relationship between incisor retraction and soft tissue profile alterations and to identify and quantify the parameters that influence it. **Methods**: Pre- and posttreatment lateral cephalograms of 37 Class I and Class II Division 1 Iranian females in whom at least one maxillary premolar was bilaterally extracted were analyzed and compared. **Results**: Significant positive correlations were found between retraction of the maxillary and mandibular incisors and posterior movement of the upper lip (r = 0.53, P < .001), the lower lip (r = 0.63, P < .001), thickness increase of the upper (r = 0.59, P < .001) and lower (r = 0.69, P < .001) lip, increase of the soft tissue lower anterior face height (r = 0.81, P < .001) and lower soft tissue component (r = 0.49, P < .001), and an increase of the nasolabial angle (r = 0.43, P < .01). The ratio of maxillary incisor to upper lip retraction was 2:1. **Conclusion**: In Iranian girls, a strong correlation exists between anterior tooth retraction and the position and configuration of both lips.* World J Orthod 2010;11:262–268.

***Key words**: prediction, profile, incisor retraction, lip position, extraction therapy*

One purpose of orthodontic treatment is to improve the dentoskeletal relationship for good esthetics. The soft tissue of the face is like a mask overlying the skeletal framework, which is affected by changes of the bones and teeth in direct contact with it. Lip positional changes is critical for treatment planning, especially in patients who require premolar extractions.[1] Predicting and quantifying such changes provides important information about treatment alternatives.[2] Hard tissue changes of the lower facial third will affect the lip, nose, and chin,[3] as well as the nasolabial and labiomental angle.[4,5] Such hard tissue changes can be brought about by tooth movements, orthopedic growth modulations, and surgery.[6,7] Changing tooth position and inclination by either protraction or retraction has the potential to directly influence the lips.[8–18] When the main treatment objective is to decrease lower facial convexity and the fullness of the lips, retraction of the maxillary and mandibular anterior teeth becomes necessary, which cannot be accomplished without extraction.

Repositioning of the upper lip in response to maxillary incisor retraction is commonly expressed as a ratio. The reported ratios vary remarkably in relation to sex, ethnicity, and treatment modality. Hershey[9] concluded a 3:1 ratio

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Table 1 Mean, standard deviation (SD), maximum, and minimum of various dental, skeletal, and soft tissue measurements before treatment

Variable	Mean	SD	Maximum	Minimum
Overjet (mm)	2.1	1.5	5.5	0.0
Overbite (mm)	5.3	2.2	12.0	2.0
SNA (degrees)	78.9	3.3	86.0	69.0
SNB (degrees)	74.4	3.6	82.0	63.0
ANB (degrees)	4.4	1.6	8.0	0.0
FMA (degrees)	30.3	6.1	47.0	20.0
Sum angle (degrees)	401.9	6.5	424.0	393.0
Facial plane angle (degrees)	86.4	3.1	93.5	81.0
Nasolabial angle (degrees)	106.1	10.2	125.0	73.0
Mentolabial angle (degrees)	134.1	17.5	170.0	94.0
U1-SN (degrees)	107.8	7.5	122.0	85.0
L1-MP (degrees)	96.3	9.4	128.0	75.0

in adult white females. In a study involving 60 preadolescent boys, Wisth[11] reported a 2:1 ratio for nonextraction patients and a 3:1 ratio for patients with extractions. Rains and Nanda[14] stated a ratio of 1.6:1.0 for 15- to 23-year-old white females, while Rudee[19] noted a 2:1 ratio after studying 85 individuals between 6 and 22 years of age. Kokodynski et al[20] studied individuals of both sexes 16 years and older and described this ratio as 1.5:1.0 for females and 1.6:1.0 for males.

According to Brock et al,[21] any soft tissue changes in blacks occur generally more downward, whereas in whites, they occur in a more backward direction. Garner conducted two studies on blacks and found a 3.7:1.0 ratio for both sexes and a 2.0:1.0 ratio for only females.[22] Also, for black females, Diels et al[23] and Caplan et al[24] reported ratios of 3.2:1.0 and 1.6:1.0, respectively. For an Asian population, Lew[25] delineated a 2.1:1.0 ratio, whereas also for Asians, Yogosawa[26] stated this ratio to be 2.5:1.0 (for maxillary incisor retraction to lower lip retraction, it amounted to 1.4:1.0). In an Indonesian population, Kusnoto and Kusnoto[27] observed 0.4 mm of upper and 0.6 mm of lower lip retraction per millimeter of mandibular incisor retraction.

Talass et al[16] stated more generally in their study of 80 white females that retraction of the maxillary incisors causes a retraction of the upper lip and an increase of the lower lip length and the nasolabial angle. Similarly, other studies described changes in lip position, length, and width.[28,29] Because there are little relevant data for Iranians, this study was initiated.

MATERIAL AND METHODS

The material consisted of cephalograms with good midfacial soft tissue resolution from 37 females before (T1) and after (T2) orthodontic therapy. All individuals were treated in two orthodontic practices and chosen at random. The mean age at pretreatment was 13.9 years (range 10 to 18 years), whereas at the end of treatment, it was 16.0 years. On average, the treatments lasted 25 months. The six inclusion criteria for the patients were:

- Bilateral extraction of at least one maxillary premolar
- Class I or Class II division 1 occlusion
- Treatment with Edgewise appliances and maximum anchorage
- No vertical facial configuration as defined by the mandibular plane angle
- No syndromes, asymmetries, or congenitally missing teeth
- No previous orthognathic surgery.

In 10 patients, the maxillary first premolars had been extracted; in 17 others, all four first premolars had been removed. Measurements of the sample are summarized in Table 1.

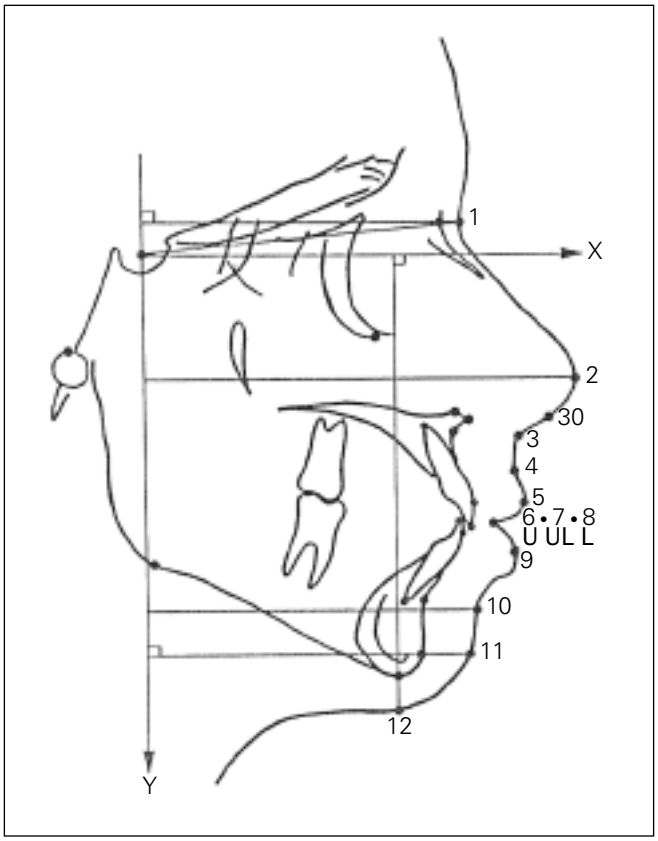

Fig 1 Soft tissue landmarks. See Table 2a.

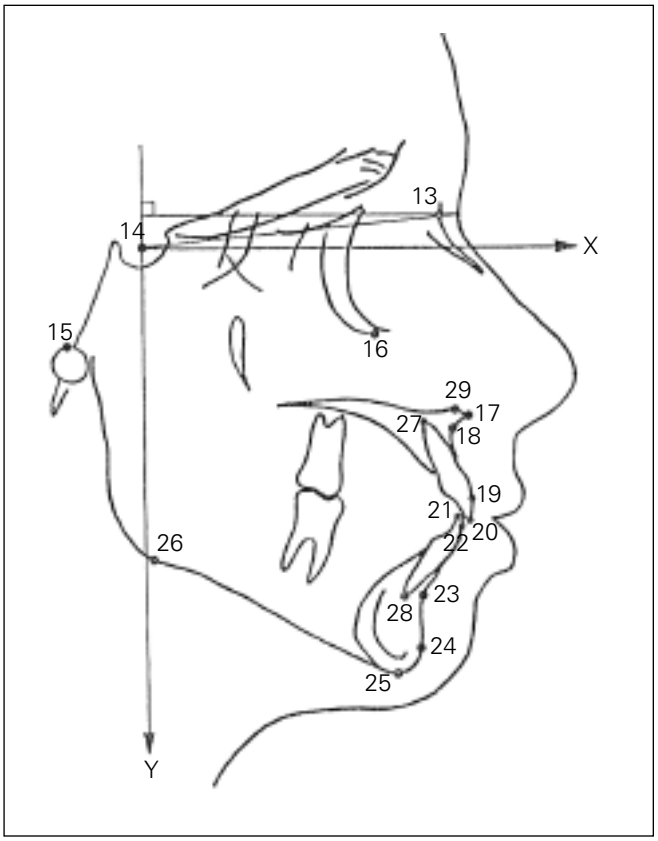

Fig 2 Hard tissue landmarks. See Table 2a.

All pre- and posttreatment cephalograms were traced twice by one operator on acetate paper with a 0.5 mm fine-tip pencil. The magnification of each cephalostat was known, and the appropriate corrections were performed for each data entry. All soft and hard tissue landmarks and reference lines are depicted and described in Figs 1 and 2 and Tables 2a and 2b. Due to difficulties in locating the landmarks for Frankfort horizontal, a horizontal reference line (X) was constructed that ran 7 degrees below the SN plane; the (vertical) Y reference line was perpendicular to the X line from S.[16]

Standard statistical evaluation was performed with SPSS 13.0. The Pearson correlation coefficient was used to compare incisor retraction and subsequent soft tissue changes, and a stepwise multiple regression analysis was performed to evaluate the predictability of any soft tissue changes following incisor retraction.

RESULTS

All 15 linear and angular measurements comparing the soft tissue changes as a result of treatment and growth are summarized in Table 3. Overall, average 4.5 ± 1.9 mm maxillary incisor retraction resulted in an average 1.6 ± 2.0 mm upper lip retraction (r = 0.53, P < .001). The correlation coefficient between maxillary incisor and upper lip retraction amounted to decreased overjet to r = 0.60 (P < .01), vertical facial configuration to r = 0.66 (P < .001), increased FMA to r = 0.78 (P < .001), lip competency to r = 0.60 (P < .05), increased upper lip thickness to r = 0.69 (P < .001), and increased lower lip thickness to r = 0.63 (P < .001).

In general, an average 1.9 ± 2.0 mm mandibular incisor retraction caused on average a 1.5 ± 2.1 mm lower lip retraction (r = 0.63, P < .001). The lower lip was

Table 2a Names, abbreviations, and definitions of the soft and hard tissue cephalometric landmarks used in this study

Landmark	Abbreviation	Definition
1. Soft tissue nasion	N'	Most posterior point between nose and forehead
2. Nasal tip point	Pn	Most anterior point of the nose
3. Subnasale	Sn	Intersection of nasal septum and upper lip
4. Sulcus superior	Ss	Most posterior point between Ls and Sn
5. Labrale superius	Ls	Most anterior point on the upper lip
6. Stomion superius	Sts	Most inferior point on the upper lip vermilion
7. Stomion	St	Conjunction of upper and lower lip
8. Stomion inferius	Sti	Most superior point on the lower lip vermilion
9. Labrale inferius	Li	Most anterior point on the lower lip
10. Sulcus inferius	Si	Most posterior point between Li and soft tissue pogonion
11. Soft tissue pogonion	Pg'	Most anterior point on the soft tissue chin
12. Soft tissue menton	Me'	Most inferior point on the soft tissue chin
13. Nasion	N	Most anterior point of the nasofrontal suture
14. Sella	S	Center of the pituitary fossa
15. Porion	Po	Most superior point of the external auditory tube
16. Orbitale	Or	Most inferior point on the lower border of the orbit
17. Anterior nasal spine	ANS	Most anterior point of the nasal floor
18. Subspinale	A	Most posterior point below ANS
19. Maxillary incisor labial crown		Most anterior point of labial surface of most anterior maxillary incisor
20. Incisor superius	Is	Maxillary incisor incisal edge
21. Incisor inferius	Ii	Mandibular incisor incisal edge
22. Mandibular incisor labial crown point		Most anterior point on labial surface of most anterior mandibular incisor
23. Supramentale	B	Most posterior point between Pog and Infradentale
24. Pogonion	Pog	Most anterior point of chin
25. Menton	Me	Most inferior point of mandibular symphysis
26. Gonion	Go	Conjunction of tangents to the mandibular corpus and ramus
27. Maxillary incisor apex	Isa	Root tip of maxillary incisor
28. Mandibular incisor apex	Iia	Root tip of mandibular incisor
29. Structured anterior nasal spine		Most anterior point of nasal floor at 3 mm thickness
30. Columella tangent point		Midpoint between Pn and Sn
31. Prosthion	Pr	Most inferior and anterior point on maxillary alveolar process between central incisors

Table 2b Definition of the cephalometric variables investigated in this study

Variable	Definition
U1 – upper lip relationship	Pr–Sts on Y plane
U1 – lower lip relationship	Is–Sti on Y plane
Upper lip width	Ls to most anterior point of maxillary incisors on X plane
Lower lip width	Li to most anterior point of mandibular incisors on X plane
Interlabial gap	Sts–Sti on Y plane
Upper lip length	Sn–Sts on Y plane
Lower lip length	Si–Sti on Y plane
Lower anterior face height (LAFH)	ANS–Me on X plane
Lower soft tissue component (LSTC)	Sti–Me' on Y plane
Upper vermilion length	Ls–St on Y plane
Lower vermilion length	Li–St on Y plane
Total vermilion length	Ls–Li on Y plane
Soft tissue thickness at Pog	Pog–Pog' on X plane
Horizontal growth of nasal tip	Initial to final Pn on Y plane

also retracted with maxillary incisor retraction, but this correlation was not as strong as the previous one ($r = 0.38$, $P < .05$). Again, the correlation coefficient between maxillary incisor retraction and lower lip retraction amounted to decreased overjet to $r = 0.68$ ($P < .001$), vertical facial configuration to $r = 0.43$ ($P < .01$), lip competency to $r = 0.57$ ($P < .05$), increased upper lip thickness to $r = 0.52$ ($P < .05$), and decreased lower lip thickness to $r = 0.44$ ($P < .05$).

Table 3 Mean, standard deviation (SD), minimum, maximum, correlation coefficient with maxillary incisor retrusion (*r*) and *P* value of upper and lower lip retraction and amount of increase and decrease of various cephalometric parameters as a result of treatment and growth

Variable	Mean	SD	Maximum	Minimum	*r*	*P*
Upper lip retraction (mm)	1.1	2.0	5.0	−3.0	0.53	< .001
Lower lip retraction (mm)	0.5	2.1	5.5	−4.0	0.63	< .001
Increase in upper lip thickness (mm)	2.1	2.0	8.5	−1.5	0.59	< .001
Increase in lower lip thickness (mm)	0.6	1.6	5.0	−3.0	0.69	< .001
Decrease in interlabial gap (mm)	1.9	2.5	1.0	−9.5	0.68	NS
Increase in upper lip length (mm)	0.9	1.6	5.5	−1.5	0.52	< .01
Increase in lower lip length (mm)	1.8	1.7	6.0	−0.5	0.37	< .01
Increase in LAFH (mm)	2.8	2.5	8.0	−2.0	0.81	< .001
Increase in LSTC (mm)	2.8	2.3	10.0	−1.0	0.49	< .01
Increase in nasolabial angle (degrees)	3.9	8.6	26.0	−10.0	0.43	< .01
Increase in mentolabial angle (degrees)	3.4	11.4	27.0	−25.0	0.46	NS
Decrease in upper vermilion height (mm)	0.4	1.6	5.0	−4.0	0.40	NS
Increase in lower vermilion height (mm)	0.2	1.2	2.0	−2.0	0.34	NS
Decrease in total vermilion height (mm)	1.9	3.5	6.0	−9.0	0.49	NS
Increase in soft tissue thickness at Pog (mm)	0.4	1.1	3.0	−2.0	0.37	NS

NS = not significant.

A significant increase of 2.1 ± 1.9 mm in upper lip thickness (r = 0.59, P < .001) and of 1.1 ± 1.6 mm in lower lip thickness (r = 0.69, P < .001) occurred with incisor retraction. Maxillary incisor retraction led to an average increase of 0.9 ± 0.6 mm in upper lip length (r = 0.52, P < .01) and of 1.8 ± 1.7 mm in lower lip length (r = 0.37, P < .01). Lower lip length increase correlated with initial lower lip length (r = 0.35, P < .05), initial SNB (r = 0.33, P < .05), and initial overjet (r = 0.32, P < .05).

Also, lower anterior face height (LAFH) and lower soft tissue component (LSTC)[16] were increased following maxillary incisor retraction (r = 0.81, P < .001 and r = 0.49, P < .01, respectively). The ratio between the increase in soft and hard tissue lower facial height was 0.7:1.0; both were strongly correlated. Finally, maxillary incisor retraction produced an average nasolabial angle increase of 3.9 degrees (r = 0.43, P < .01).

The overall ratio of maxillary incisor retraction to upper lip retraction was 2:1.

DISCUSSION

A reliable method for predicting changes in the soft tissue profile in response to tooth movement could be valuable to all orthodontists. However, this response varies largely among ethnicities. Most studies regarding soft tissue profiles have been carried out on white individuals.[9,14,16,20] Aside from this, a recent study on adults emphasized a pronounced variability among patients that may explain why it seems impossible to accurately predict the behavior of soft tissue following maxillary incisor movements.[30]

The pretreatment age span (10 to 18 years) of the sample of this study appears appropriate because most patients seeking orthodontic treatment are of this age. All subjects were females to avoid variations between sexes that, as demonstrated in previous studies, would jeopardize an interpretation of the results.[13,31]

To assess the dental, skeletal, and soft tissue changes, a horizontal reference line (X) was introduced, which runs 7 degrees below SN through S. This reference is commonly applied to approximate the true horizontal line and minimize the variability of the intracranial structures.[16,24]

The ratio of upper lip retraction to maxillary incisor retraction obtained in this study was 2:1. The correlation coefficient between these two variables was increased in patients with decreased overjet, a long face tendency (increased FMA) before treatment. This finding is coincident with the results of previous studies.[9,11,14,16,20,22–25,31] Lower lip retraction was more strongly correlated with mandibular incisor retraction than upper lip retraction with maxillary incisor retraction. This correlation was higher in patients with small overjet and thin lower lips at pretreatment, which is confirmed by the study of Conley et al.[32] Besides this, several earlier studies have emphasized that only retraction of the mandibular incisors is correlated with a change of the upper and lower lip.[5,24,26,33] Other studies, however, stated that all soft tissue changes are more strongly correlated with maxillary than mandibular incisor retraction[34] or even that mandibular incisor movements do not change the position of either the upper or lower lip.[14] Kasai remarked in this context that the lower lip is more adaptable than the upper one.[35] One study found only minor changes and concluded that the pretreatment lip morphology is the best predictor of the posttreatment configuration.[36]

Increase in upper and lower lip width is also verified by previous investigations.[16,21,27] The increase in upper lip length was smaller in patients with a decreased overbite. Lower lip length increase had a positive correlation with pretreatment lip length. Increase in LSTC was also significant, although it had less clinical significance.[16]

In the current study, no significant increase in the mentolabial angle was shown after incisor retraction, which is in accordance with the study of Talass et al[16]; however, in yet another study, this angle as the nasiolabial angle increased significantly.[26]

Whether the observed changes are a result of the extraction of the first premolars cannot easily be answered. At a minimum, the influence of growth has to be included. Surprisingly, a recent study stated that in patients with a Class II relationship, a treatment protocol with extraction of two maxillary premolars provides similar soft tissue results as treatment without extraction.[37]

CONCLUSION

There was a strong correlation between anterior tooth retraction and the anteroposterior position of both lips in Iranian girls, and the ratio of maxillary incisor retraction to upper lip retraction was 2:1.

REFERENCES

1. Hodges A, Rossouw PE, Campbell PM, Boley JC, Alexander RA, Buschang PH. Prediction of lip response to four first premolar extractions in white female adolescents and adults. Angle Orthod 2009;79:413–421.
2. Mirabella D, Bacconi S, Gracco A, Lombardo L, Siciliani G. Upper lip changes correlated with maxillary incisor movement in 65 orthodontically treated adult patients. World J Orthod 2008;9:337–348.
3. Morris W. An orthodontic view of dentofacial esthetics. Compendium 1994;15:378–389.
4. Kusnoto H. Soft tissue profile changes after orthodontic treatment in Class III malocclusion. Ind Dent Assoc J 1994;43:72–76.
5. Roos N. Soft tissue profile changes in Class II treatment. Am J Orthod 1977;72:165–175.
6. Proffit WR, Fields HW, Ackerman JL, Sinclair PM, Thomas PM, Tulloch JF. Contemporary Orthodontics. St Louis: Mosby, 1993.
7. Graber TM, Vanarsdall RL. Orthodontics: Current principles and techniques. St Louis: Mosby, 2000.
8. Bloom LA. Perioral profile changes in orthodontic treatment. Am J Orthod 61;47:371–379.
9. Hershey HG. Incisor tooth retraction and subsequent profile change in postadolescent female patients. Am J Orthod 1972;61:45–54.
10. Anderson JP, Joondeph DR, Turpin DL. A cephalometric study of profile changes in orthodontically treated cases 10 years out of retention. Angle Orthod 1973;43:324–336.
11. Wisth J. Soft-tissue response to upper incisor retraction in boys. Br J Orthod 1974;2:199–204.
12. Haynes S. Prevalence of upper lip posture and incisor overjet. Comm Dent Oral Epidemiol 1977;5:87–90.

13. Oliver BM. The influence of lip thickness and strain on upper lip response to incisor retraction. Am J Orthod 1982;82:141–149.
14. Rains MD, Nanda R. Soft-tissue changes associated with maxillary incisor retraction. Am J Orthod 1982;81:481–488.
15. Holdaway RA. A soft tissue cephalometric analysis and its use in orthodontic treatment planning: Part I. Am J Orthod 1983;84:1–28.
16. Talass MF, Talass L, Baker RC. Soft-tissue profile changes resulting from retraction of maxillary incisors. Am J Orthod Dentofacial Orthop 1987;91:385–394.
17. Ricketts RM. Influence of orthodontic treatment on facial growth and development. Angle Orthod 1960;30:103–133.
18. Park S, Kudlick EM, Abrahamian A. Vertical dimensional changes of the lips in the North American black patient after four first-premolar extractions. Am J Orthod Dentofacial Orthop 1989;96:152–160.
19. Rudee DA. Proportional profile changes associated with maxillary incisor retraction. Am J Orthod 1964;50:421–434.
20. Kokodynski RA, Marshall SD, Ayer W, Weintraub NH, Hoffman DL. Profile changes associated with maxillary incisor retraction in the postadolescent orthodontic patient. Int J Adult Orthod Orthognath Surg 1997;12:129–34.
21. Brock RA 2nd, Taylor RW, Buschang PH, Behrents RG. Ethnic differences in upper lip response to incisor retraction. Am J Orthod Dentofacial Orthop. 2005;127:683–691.
22. Garner LD. Soft-tissue changes concurrent with orthodontic tooth movement. Am J Orthod 1974;66:367–377.
23. Diels RM, Kalra V, DeLoach N, Powers M, Nelson SS. Changes in soft tissue profile of African-Americans following extraction treatment. Angle Orthod 1995;65:285–292.
24. Caplan MJ, Shivapuja PK. The effect of premolar extractions on the soft-tissue profile in adult African-American females. Angle Orthod 1997; 67:129–136.
25. Lew KK. Changes in lip contour following treatment of maxillary protrusion with esthetic orthodontic appliances. J Esthetic Dent 1992; 4:16–23.
26. Yogosawa F. Predicting soft tissue profile changes concurrent with orthodontic treatment. Angle Orthod 1990;60:199–206.
27. Kusnoto J, Kusnoto H. The effect of anterior tooth retraction on lip position of orthodontically treated adult Indonesians. Am J Orthod Dentofacial Orthop 2001;120:304–307.
28. Steyn CL, Maritz JS, du Preez RJ, Harris AM. Facial profile changes with various orthodontic premolar extraction sequences during growth. SADJ. 2004;59:139–141, 143–145.
29. Valentim ZL, Capelli Júnior J, Almeida MA, Bailey LJ. Incisor retraction and profile changes in adult patients. Int J Adult Orthodon Orthognath Surg 1994;9:31–36.
30. Mirabella D, Bacconi S, Gracco A, Lombardo L, Siciliani G. Upper lip changes correlated with maxillary incisor movement in 65 orthodontically treated adult patients. World J Orthod 2008;9:337–348.
31. Baum AT. Age and sex differences in dentofacial changes following orthodontic treatment and their significances in treatment planning. Am J Orthod Dentofacial Orthop. 1961;47:355–369.
32. Scott Conley R, Jernigan C. Soft tissue changes after upper premolar extraction in Class II camouflage therapy. Angle Orthod 2006;76:59–65.
33. Assuncao ZLV, Cappelli J, Almeida MA, Bailey LJ. Incisor retraction and profile and profile changes in adult patients. Int J Adult Orthod Orthognath Surg 1994;9:31–36.
34. Ozaki T, Ozaki S, Kuroda K. Premolar and additional first molar extraction effects on soft tissue. Effects on high Angle Class II division 1 patients. Angle Orthod 2007;77:244–253.
35. Kasai K. Soft tissue adaptability to hard tissues in facial profiles. Am J Orthod Dentofacial Orthop 1998;113:674–684.
36. Bokas J, Collett T. Effect of upper premolar extractions on the position of the upper lip. Aust Orthod J 2006;22:31–37.
37. Janson G, Fuziy A, de Freitas MD, Henriques JFC, de Almeidac RR. Soft-tissue treatment changes in Class II Division 1 malocclusion with and without extraction of maxillary premolars. Am J Orthod Dentofacial Orthop 2007;32: 729.e1–729.e8