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USING A STRUCTURED LIGHT SCANNER TO EVALUATE 3-DIMENTIONAL SOFT TISSUE CHANGES AFTER EXTRACTING FOUR PREMOLARS IN YOUNG ADULT FEMALE PATIENTS

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Soft Tissue Alterations, Light Scanner, Orthodontic Treatment

Abstract
Objective: To use structured light-based scanners to assess the three-dimensional (3D) perioral soft tissue alterations following orthodontic treatment in patients with dentoalveolar protrusion. Supplies and Procedures: Examined were forty-four adult Koreans (19 men and 25 women, ages 21.4 and 3.4 years) whose dentoalveolar protrusion was treated by extraction of all four first premolars, followed byen masse retraction using the strongest anchoring. 3D facial scans and lateral cephalograms were taken both prior to treatment (T1) and right after debonding (T2). Following superimposition, 27 perioral landmarks were found. The assessment focused on the three-dimensional alterations in the landmarks and the soft tissue's migration ratio in relation to the horizontal incisal tip. One-way analysis of varianceand paired t-test were used. **Results:** Retraction of the lower incisors was 4.62 mm and that of the upper incisors was 5.76 mm (P,.001). Both the lower and upper lips shifted superoposteriorly and inferoposteriorly, respectively. Movement upward was larger than movement backward in the lower lip (P,.001). The largest bulging area showed the most noticeable modifications. For the upper lip area, the relative ratios were 42%–53% and 22%–82%, respectively. The corners of the lips shiftedsuperoposteriorly (P,.001). The landmarks beneath the nostrils shifted upward and posteriorly (P,.001), while the subnasale moved downwards (P,.05) and posteriorly (P,.001). **Conclusion**; 3D perioral softtissue in individuals with dentoalveolar protrusion was effectively assessed using facial scans obtainedfrom white structured light scanners. There was noticeable vertical lip movement as well as backward
movement. The nasal and lip angle areas showed considerable changes.

Introduction

Because social settings value facial beauty, orthodontic treatment increasingly prioritises the soft tissues of the face, especially the lips. Among Asians, malocclusion and lip procumbency are frequent primary symptoms. Because orthodontic extraction therapy can produce a straighter profile with a mesocephalic face type and a balanced facial look, it is a useful treatment for lip protrusion. The goal of orthodontic therapy is now more focused on the soft tissue of the face than it is on creating optimal interactions between the teeth and skeleton. Improved soft tissue aesthetics have consequently grown in importance as a therapeutic goal.

Asian individuals seeking orthodontic care for cosmetic reasons frequently have dentoalveolar protrusion, which is characterised by protruding and proclined upper and lower incisors as well as increased procumbency of the lips. First premolar extractions are typically scheduled in conjunction with anterior tooth retraction for maximal anchoring.2-4

Previously, lateral cephalometric radiographs were the main tool used to assess soft tissue alterations in individuals with dentoalveolar protrusion after premolar extraction.5–8 Following therapy, the upper and lower lips retreated 2 to 3.2 mm and 2 to 4.5 mm, respectively, according to a systematic study by Leonardi et al. 1. But because of its midsagittal projection, traditional two-dimensional cephalometry has a number of drawbacks when examining perioral soft tissue alterations.9.

As an alternative, gathering information on changes in the soft tissues of the face through pre- and post-treatment photographs is simple and straightforward. However, it still lacks significant information and is subject to several factors, such as the angle and distance at which the photo was taken.10

In an effort to assess facial soft tissue more precisely, three-dimensional (3D) imaging techniques have been created recently.10 Cone beam computed tomography and noncontact optical scanning techniques, such laser- or structured light-based scanners, are the two categories into which 3D imaging acquisition techniques can be separated.11 Cone beam computed tomographic (three-dimensional) scans are frequently utilised in dentistry to obtain information about both deep and superficial

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structures. Nevertheless, the lack of colour value, radiation exposure, and low resolution brought on by the spacing between slices are some of their drawbacks.12

Systems that use laser scanning offer various benefits. They deliver high-resolution photos rapidly and without causing any harm. Their drawbacks are as follows, though: the apparatus is pricey; technicians must wear safety goggles; the systems are technique-sensitive; and the resulting images are only passably photorealistic.11, 13 Conversely, realistic pictures can be obtained quickly and non-invasively with structured light systems. On the surface of the object, they project an orderly pattern of light that includes stripes, grids, dots, and other designs.11 White light is used in the structured light system and is safe to observe with the unaided eye. This method can be applied to long-term research, as well as those involving children and sizable population samples, due to its fast speed and safe light source.14 Prior research using 3D facial imaging in orthodontic treatment has mostly concentrated on the immediate consequences of debonding or bracket bonding15.16 Although they were all using laser scanner systems, no research has been done to assess 3D soft tissue modifications to different types of malocclusions following active orthodontic therapy. Thus, the goal of the present investigation was to assess, using a structured light-based scanner, the 3D perioral soft tissue alterations following orthodontic therapy that included four-premolar extraction in dentoalveolar protrusion individuals.

Methodology

The primary complaint of the 44 adults in the sample—19 men and 25 women, ages 21.4 and 3.4—was lip protrusion. Each had a Class I dentoalveolar protrusion, with less than 4 mm of crowding. First, all four of the first premolars were extracted, and then they underwent mass retraction with the greatest amount of anchoring. Despite the need for more torque, the working wire was 0.019–3 0.025-inch stainless steel, and the anchor was strengthened with a transpalatal arch. Between the second molar and the hook that is distal to the lateral incisor, 200 g elastic chains were placed. Patients with craniofacial syndromes, such as cleft lip and palate, or severe skeletal disharmony such as facial asymmetry were excluded. This retrospective study was performed under the approval of the Institutional Review Board of Department of Dentistry, Amaltas Medical College, Madhya Pradesh.

Before and right after debonding, lateral cephalograms and 3D facial scans were taken using a light-emitting diode-based white structured light scanner (Morpheus 3D, Morpheus Inc, Seoul, Korea) (scan time: 0.8 seconds, 33 frame rate: 15 frames/s, data accuracy: 6 0.2 mm). Every patient sat in a rotating chair, head in the correct position and lips relaxed, for the scanning procedure. Every patient was simultaneously scanned in three separate viewpoints (Figure 1), and the three images corresponding to these views were then combined using a registration method to create a single 3D image.

Landmarks and Coordinate System

The axial reference plane (x-axis) was established by rotating Camper's plane 7.5 units upward on the axis connecting the left and right tragus and translating it until it encountered soft tissue nasion (N9). The sagittal reference plane (y-axis) was defined as the plane that traversed N9 and was perpendicular to the x-axis. The coronal reference plane (z-axis) was defined as the plane that was perpendicular to the axial and sagittal planes that ran through N9.15 These planes matched the coordinate system where the zero point is N9. Stated differently, a patient's right and left are recorded on the x-axis (left: +, right: 2), their above and below are recorded on the y-axis (above: +, below: 2), and their front and rear are recorded on the y-axis. Superimposition was executed before and after orthodontic treatment with reference to left and right exocanthion, endocanthion, N9, and wide face of forehead using 3D Image Overlay.[15] Therefore, a superimposed 3D image with one coordinate system was obtained from each individual before and after orthodontic treatment (Figure 3).

Figure 1. The structured light scanner (Morpheus 3D) used in this study and equipment setting scanned from three different views simultaneously.

Twenty-seven landmarks were located along the lip border, around the lip, beneath the nostril, at the largest bulge of each section, and along the midline of the face in order to track the changes in the perioral soft tissue (Figure 4). After obtaining the landmarks' 3D coordinate values (x, y, and z), the photos were superimposed onto pre-treatment ones to assess any changes in the landmarks. The vertical reference plane in lateral cephalograms was a plane that is perpendicular to the horizontal reference plane at sella; the horizontal reference plane was found to be a 7u clockwise motion of the sella-N9 plane passing through sella. Points A and B, as well as the vertical and horizontal variations in the upper and lower anterior teeth, were assessed. All measurements were repeated by the same operator after 2 weeks. The second measurements were compared to the first for each variable using the Pearson correlation coefficient, which was above 0.98 at the 95% confidence level. Therefore, the mean of the two data sets was used. The Shapiro-Wilk test was used to confirm the normality of the data distribution for the variables of the facial scans and the lateral cephalograms. Paired t-tests were performed to compare measurements taken before and after the treatment. To compare across axes, a one-way analysis of variance using Duncan's multiple comparison test was carried out. P values indicating a statistically significant difference were less than.05.

RESULTS

There were no statistically significant variations in the vertical dimension across any factors in the lateral cephalograms (Table 1). Point A experienced a substantial retraction (0.76 mm, P,.01), but Point B did not see a significant change. The tip of the lower incisors retracted 4.62 mm (P,.001), while the maxillary central incisor retracted 5.76 mm (P,.001). Both the upper and lower incisors' root locations remained mostly unchanged.

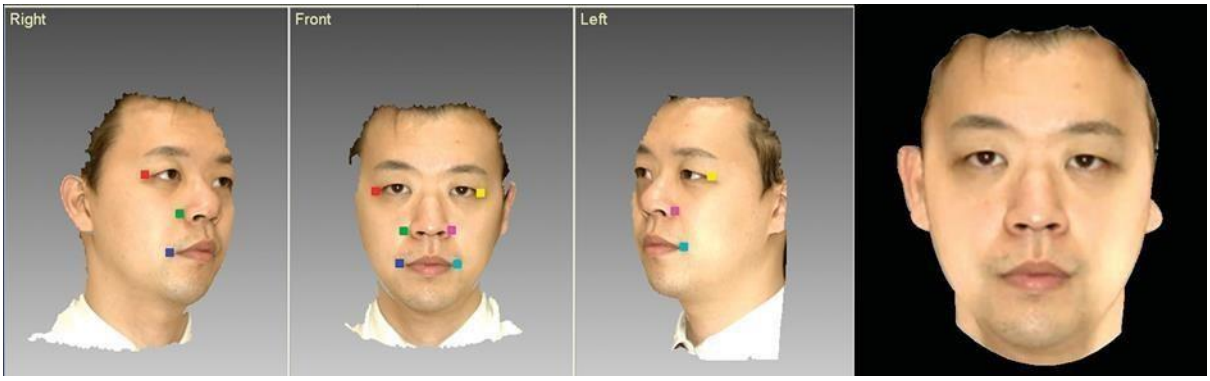

Figure 2. Reconstruction of 3D face by automatic registration analyzing the geometry of six selected circumjacent points.

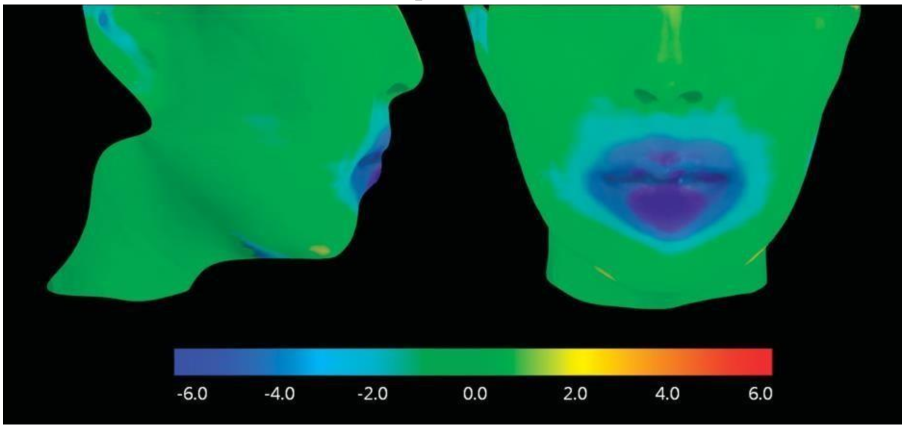

Figure 3. Superimposed color map image, with a unified coordinate system, before and after orthodontic treatment. Increases in the blue colorgradient indicate greater inward displacement after treatment; green indicates no change.

Figure 5 and Table 2 illustrate the 3D alterations in the perioral soft tissue following orthodontic treatment. There was a significant difference (P,.001) between the pretreatment and posttreatment values for every landmark. With the exception of those that were situated beneath the nostrils or at the midline of the face, most variables on the x-axis showed substantial alterations. But since the amount was less than 1 mm, it was not significant from a clinical standpoint. The lip thinned as a result of the lower lip moving higher (P,.001) and the upper lip, including the

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Cupid's bow, moving downward (P,.01 or.001) in the y-axis. In comparison with the top lip's (less than 1 mm) shift upward, the lower lip's (about 3 mm) movement was noteworthy. In a comparable manner the decreased lip eversion was caused by changes in the greatest bulging points (lower lip [LLP], 14; upper lip [ULP], 13). The only measurements that indicated greater upward movement as opposed to backward movement were those taken at the lower lip boundary (landmarks 4, 8, and 9) and those taken around the lip (landmarks 49, 89, and 99) (P,.001). With the exception of landmark 4, all landmarks had a noticeable rearward shift in the z-axis as a result of the retraction (P,.05 or.01 or.001). Figure 6 displays the relative percentage changes of the soft tissue movements to the incisal tip movement in the z-axis.

The range was 40% to 50% in the top lip, with markers around the midline being higher and progressively decreasing to the outer area. A wide range of percentage changes were seen in the lower lip. The largest bulge points displayed the highest value (up to 80%), whereas LLP displayed the lowest value. Compared to the lip (19–109), there was more retraction along the lip boundary (1–10). Under the nostril, subnasale (Sn), positioned alongthe face midline, moved downward and backward (*P*,.05 and, .001, respectively), whereas landmarks 11 and 12 moved upward and backward (*P*, .001). At the angle of the lips, landmarks 3 and 5 moved upward (*P*, .001) and posteriorly (*P*, .001).

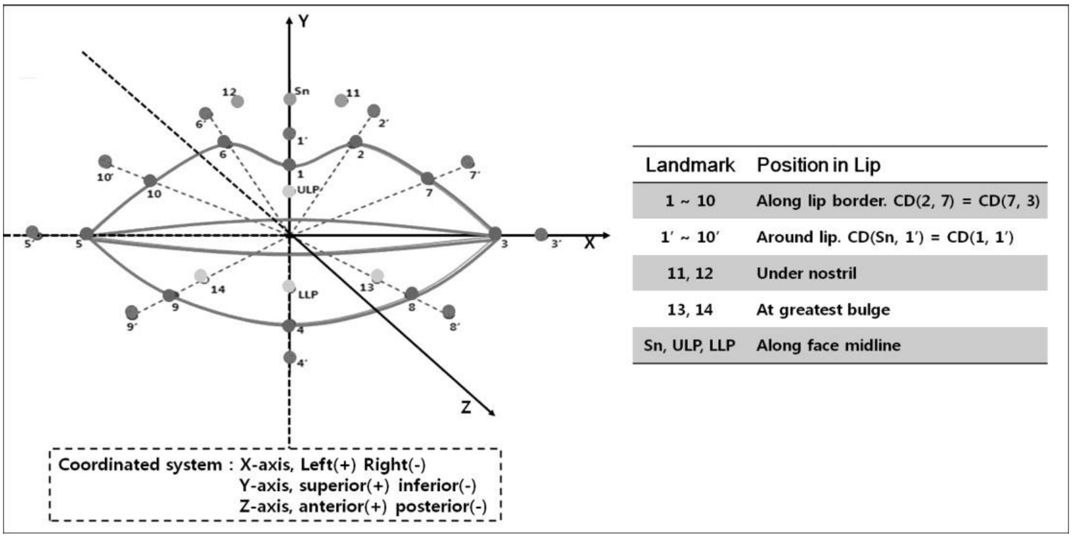

Figure 4. Twenty-seven perioral soft tissue landmarks and their coordinate system. Sn indicates subnasale; ULP, upper lip profile; and LLP,lower lip profile. 1, The lowest point of the middle area of the Cupid's bow; 2 and 6, the highest point of the Cupid's bow; 3 and 5, the most lateral point of vermilion border; 4, the lowest point of vermilion border; 7-10, midpoints of curved vermilion border; 1', midpoint between point 1 and point Sn; and 2'-10',perioral points which are counterparts of each point along the lip border(1-10), being apart by the same distance between point 1 and point 1'.

Table 1. Vertical and Horizontal Changes of Hard Tissue During Retraction on Lateral Cephalograms

		Vertical			**Horizontal**	
Measurements[a]	Mean	SD[b]	*P* Value[c]	Mean	SD[b]	*P* Value[c]
A point	20.24	1.00	.2447	20.76	1.07	.0020**
B point	20.08	2.03	.8440	20.45	1.19	.0765
Mx1Crown	20.40	1.63	.2462	25.76	1.99	.0000****
Mx1Root	0.19	1.17	.4392	20.47	1.47	.1325
Mn1Crown	0.22	1.93	.5871	24.62	1.89	.0000****
Mn1Root	20.73	2.11	.1046	0.20	1.62	.5556

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[a] Mx1Crown indicates incisor tip of maxillary central incisor; Mx1Root, root apex of maxillary central incisor; incisor tip of mandibular centralincisor; and Mn1Root, root apex of mandibular central incisor.

[b] SD indicates standard deviation.

[c] Paired *t*-test.

** *P*, .01; ****P*, .0001.

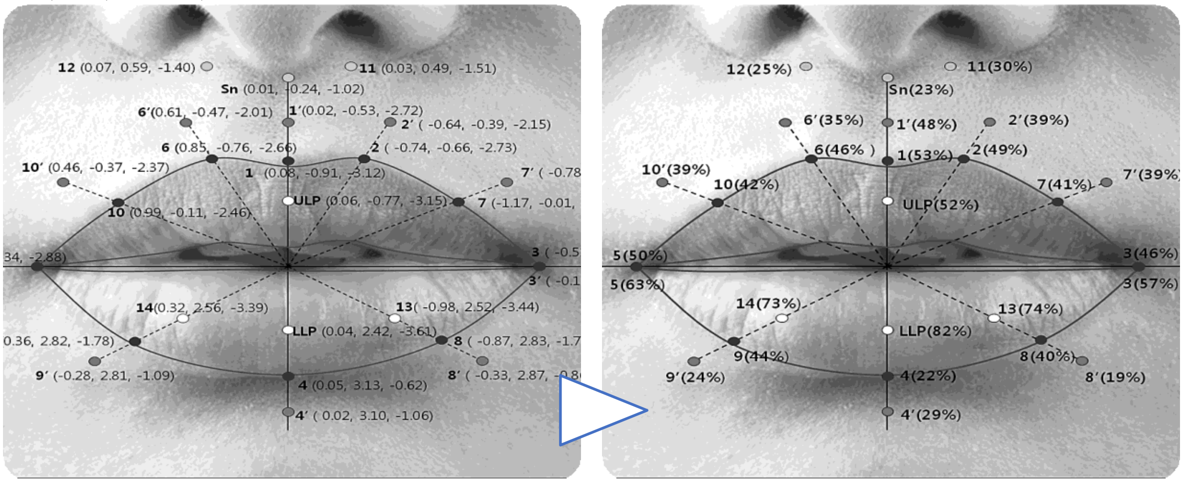

Figure 5. Overall 3D changes of soft tissue landmarks after orthodontic treatment with extraction of all four first premolars. Shown as: (changes in the *x*-axis, *y*-axis, and *z*-axis

Table 2. Three-Dimensional Changes of Soft Tissue During Retraction on the Facial Scan Images

		***X*-axis[a]**			***Y*-axis[a]**	
Variables[c]	**Mean**	**SD[d]**	***P* Value**	**Mean**	**SD[d]**	***P* Value**
Along lip border1	0.08	0.46	.2687	20.91	1.44	.0001***
2	20.74	0.94	.0000****	20.66	1.32	.0017**
3	20.51	1.31	.0132*	1.58	1.36	.0000****
4	0.05	0.47	.4593	3.13	1.96	.0000****
5	20.02	1.01	.8776	1.34	1.35	.0000****
6	0.85	0.95	.0000****	20.76	1.38	.0007***
7	21.17	0.96	.0000****	20.01	1.08	.9557
8	20.87	1.11	.0000****	2.83	1.75	.0000****
9	0.36	0.94	.0164*	2.82	1.57	.0000****
10	0.99	0.90	.0000****	20.11	0.97	.4725
Around lip border						
19	0.02	0.46	.7899	20.53	0.92	.0004***
29	20.64	1.46	.0056**	20.39	1.16	.0296*
39	20.18	1.57	.4431	1.68	1.53	.0000****
49	0.02	0.50	.8417	3.10	2.03	.0000****
59	20.39	1.12	.0243*	1.34	1.48	.0000****
69	0.61	1.33	.0039**	20.47	1.08	.0063**
79	20.78	1.30	.0003***	20.17	0.99	.2654
89	20.33	1.36	.1184	2.87	1.94	.0000****
99	20.28	1.09	.0933	2.81	1.72	.0000****

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109	0.46	1.12	.0092**	20.37	1.08	.0278*
Under nostril						
11	0.03	0.79	.8332	0.49	0.79	.0002***
12	0.07	0.94	.6118	0.59	0.89	.0001***
At greatest bulge						
13	20.98	0.92	.0000****	2.52	1.63	.0000****
14	0.32	0.94	.0017**	2.56	1.52	.0000****
Along face midline						
Sn	0.01	0.47	.8677	20.24	0.63	.0160*
ULP	0.06	0.43	.3803	20.77	1.54	.0020**
LLP	0.04	0.45	.5773	2.42	1.82	.0000****

DISCUSSION

The authenticity of the facial scanning data must be established in order to support the usage of the 3D surface scanner as a therapeutic and research tool. Reproducibility between multiple observers at the same time or by the same observer at different times is referred to as precision. Three different kinds of 3D surface scanners—laser scanners, stereophotogrammetry, and structured light systems—all demonstrated a variation of less than 1 mm between landmarks, according to earlier research. Reproducibility with the structured light system was reported to be 0.2 mm, while with the laser scanning system, it was claimed to be mm with varied times17.14 Bhatia et al.18 used a structured light scanner to quantify changes in the face surface and found minimal differences. However, accuracy can be assessed by contrasting the results of a 3D facial scan with those of direct anthropometric measurements. For a laser scanning system, Marmulla et al. (19) found a mean accuracy of 1.1 mm, while Ma et al. (2014) reported 0.93 mm for a structured light system. Precision and accuracy have increased as a result of the recent rapid evolution of procedures. Our study's scanner claimed to have an accuracy of 0.2 mm. Previous investigations have found that many structured light scanning methods are nonmodular,20,21 meaning that many captures from different perspectives are required to get data for the entire face. There is intrinsic inconsistency when left and right views are scanned consecutively because there could be changes in the subject's posture or expression in between scan points.21 In this investigation, a newly constructed, specifically built structured light-scanning system was employed to address this issue. In less than a second, the subject's face could be simultaneously scanned from three different angles thanks to the placement of the three scanners. Any alterations in the subject's expression or movements might be prevented in this way. In addition, to confirm that the hard and soft tissue data matched, a computed tomogram can be taken using the scanner equipment at the same location. In terms of vertical mobility, the lip thinned as the lower lip moved higher by roughly 3 mm and the upper lip moved downward by less than 1 mm. According to Lee et al., there is a considerable increase in lip stability and the upper lip moved superiorly, whereas the lower lip moved inferiorly.15 The reverse movement is anticipated following the extraction of the premolars since the lower lip's upward migration tends to preserve lip competency. Fascinatingly, the largest bulge area in the lower lip moved backward by nearly twice as much as what was observed at the lip boundary. This indicates that the lower lip's vermilion border shifted upward rather than backward, and that the alteration in the largest bulge area was the main factor for the lip eversion to be reduced. The amount of retraction between the corresponding left and right landmarks did not differ significantly. This indicates that during orthodontic treatment with premolar extraction, the posterior displacement of the left and right teeth is nearly symmetrical. The upward movement of the lip angle and downward movement of ULP contributed to a more attractive lip curvature by resolving the reverse upper lip line.[27] Remarkably, there was also a posterior movement of the soft tissue beneath the nostril. Additionally, Solem et al. demonstrated that the lip alteration encompassed the columella region.26 It is imperative to ascertain if this occurred due to a shift in the lip's mobility or an adaptive alteration in the underlying hard tissue (retraction of A point). Lee et al. showed that if the lips moved following bracket bonding, Sn would also have changed positions.[15]

Conclusions

- Three-dimensional imaging using a structured light

scanner showed significant changes in the lip and perioral soft tissues of patients with dentoalveolar protrusion after orthodontic treatment with extraction of all four first premolars.

- Both backward and vertical movements of the lips were observed.
- There were considerable changes, even in the nasal area and around the angles of the lip.

References

1. Leonardi R, Annunziata A, Licciardello V, Barbato E. Soft tissue changes following the extraction of premolars in nongrowing patients with bimaxillary protrusion. A system- atic review. *Angle Orthod*. 2010;80:211–216.
2. Lew K. Profile changes following orthodontic treatment of bimaxillary protrusion in adults with the Begg appliance.*Eur J Orthod*. 1989;11:375–381.
3. Tan TJ. Profile changes following orthodontic correction of bimaxillary protrusion with a preadjusted edgewise appli- ance. *Int J Adult Orthod Orthognath Surg*. 1996;11:239– 251.
4. 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.
5. Bravo LA. Soft tissue facial profile changes after orthodontic treatment with four premolars extracted. *Angle Orthod*. 1994;64:31–42.
6. Bills DA, Handelman CS, BeGole EA. Bimaxillary dentoal- veolar protrusion: traits and orthodontic correction. *Angle Orthod*. 2005;75:333–339.
7. Caplan MJ, Shivapuja PK. The effect of premolar extractionson the soft-tissue profile in adult African American females. *Angle Orthod*. 1997;67:129–136.
8. Diels RM, Kalra V, DeLoach N Jr, Powers M, Nelson SS. Changes in soft tissue profile of African-Americans following extraction treatment. *Angle Orthod*. 1995;65:285–292.
9. Fuhrmann RA, Schnappauf A, Diedrich PR. Three-dimensionalimaging of craniomaxillofacial structures with a standard personal computer. *Dentomaxillofac Radiol*. 1995;24:260–263.
10. Lane C, Harrell W Jr. Completing the 3-dimensional picture. *Am J Orthod Dentofacial Orthop*. 2008;133:612–620.
11. Kau CH, Richmond S, Incrapera A, English J, Xia JJ. Three-dimensional surface acquisition systems for the study of facial morphology and their application to maxillofacial surgery. *Int J Med Robot*. 2007;3:97–110.
12. Miracle AC, Mukherji SK. Cone-beam CT of the head and neck, part 1: physical principles. *AJNR Am J Neuroradiol*. 2009 Jun;30(6):1088–1095. doi:10.3174/ajnr.A1653. Epub 2009 May 13.
13. Bush K, Antonyshyn O. Three-dimensional facial anthro- pometry using a laser surface scanner: validation of the technique. *Plast Reconstruct Surg*. 1996;98:226–235.
14. Ma L, Xu T, Lin J. Validation of a three-dimensional facial scanning system based on structured light techniques. *Comput Methods Programs Biomed*. 2009;94:290–298.
15. Lee WJ, Lee KY, Yu HS, Baik HS. Lip and perioral soft tissue changes after bracket bonding using 3-D laser scanner. *Korean J Orthod*. 2011;41:411–422.