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# Three-dimensional soft-tissue and hard-tissue changes in the treatment of bimaxillary protrusion

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**Introduction:** Facial convexity related to bimaxillary protrusion is prevalent in many populations. Underlying skeletal protrusion combined with increased dentoalveolar protrusion contributes to facial muscle imbalance and lip incompetence, which is undesirable for many patients. In this study, we evaluated the relationship between soft-tissue and hard-tissue changes in an orthodontically treated Asian population. **Methods:** Twenty-four consecutive adult Asian patients (mean age, 24 years), diagnosed with severe bimaxillary dentoalveolar protrusion, were evaluated using pretreatment and posttreatment cone-beam computed tomography. The patients were treated with 4 first premolar extractions followed by anterior retraction with either skeletal or intraoral anchorage. Serial cone-beam computed tomography radiographs were registered on the entire cranial base and fossa. Soft-tissue and hard-tissue changes were determined through landmark displacement and color mapping. **Results:** Upper lip retraction was concentrated between the nasolabial folds and commissures. Lower lip retraction was accompanied by significant redistribution of soft tissues at pogonion. Soft-tissue changes correlated well with regional facial muscle activity. Significant retractions (2-4 mm) of the soft tissues occurred beyond the midsagittal region. Use of skeletal anchorage resulted in 1.5 mm greater lower lip retraction than intraoral anchorage, with greater retraction of the maxillary and mandibular incisor root apices. **Conclusions:** Profound soft-tissue changes accompanied retraction of the anterior dentition with both treatment modalities. (Am J Orthod Dentofacial Orthop 2013;144:218-28)

Bimaxillary protrusion is a common dentofacial trait particularly prevalent in Asian and African populations and present in almost every ethnic group.[1-6] Underlying skeletal prognathism and dentoalveolar protrusion produce a convex lower facial profile, procumbent lips, and a protrusive anterior dentition, often resulting in lip incompetence, mentalis strain, and excessive gingival display. This situation is esthetically unacceptable to some patients, and they seek treatment by an orthodontist or oral surgeon. Both orthodontic and surgical treatments can improve facial balance. Orthodontic treatment can correct dentoalveolar protrusion by uprighting and retracting the anterior teeth, typically after the extraction of 4 premolars. Surgical treatment reduces protrusion by repositioning segments of the jaws. Both treatment approaches can reduce facial convexity and improve lip posture significantly.

Improvement of the soft-tissue profile depends on many variables related to the anatomy of the face, including lip thickness, facial muscle activity, and ethnicity.[7-12] The relationship between dentoalveolar movement and soft-tissue change is complex and contingent on soft-tissue relationships in all 3 planes of space.[13-21] Previous studies have focused on lip changes only in the midsagittal plane, using superimposed lateral cephalograms and facial photos.[6] However, the 2-dimensional approach fails to consider the complex 3-dimensional (3D) geometry of the human face.[13,22] In particular, soft-tissue changes in the frontal view are judged more severely by patients but are often

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overlooked in clinical studies.[23] Computer simulations that predict soft-tissue changes from orthodontic and surgical movement rely on relationships derived from the midsagittal plane. Accurate treatment predictions require data on the 3D relationships between hard-tissue and soft-tissue changes. Advances in 3D imaging with cone-beam computed tomography (CBCT) and 3D photography can be used for global evaluation of these changes.[13,14,22,24-27]

This study was designed to evaluate the 3D changes in soft tissues resulting from hard-tissue changes produced by orthodontic treatment of bimaxillary protrusion. The goals were to (1) characterize the 3D changes to the face and skeleton resulting from retraction of the anterior teeth, (2) identify and quantify relationships between incisor and lip movement outside the midsagittal plane, and (3) test differences in results using skeletal and nonskeletal anchorage mechanics in the treatment of bimaxillary protrusion.

## MATERIAL AND METHODS

The study population consisted of 24 consecutive nongrowing Asian patients with bimaxillary dentoalveolar protrusion treated in the orthodontic clinic at the University of California, San Francisco. All were treated with extraction of 4 first premolars and retraction of the anterior dentition using controlled maxillary anchorage. Institutional review board approval for the study was obtained from the University of California before treatment.

The inclusion criteria for the patients were Class I molar and canine relationships, mild or no crowding, severe dentoalveolar protrusion, and complete pretreatment and posttreatment CBCT radiographs and photos. Only Asian adults were included. The group was mostly female (n = 20), with ages ranging from 20 to 29 years. Initial protrusion was quantified by measuring the distance between the most anterior point on the maxillary and mandibular incisors to the A-point–pogonion along a line parallel to the Frankfort horizontal (Fig 1, *A*). Lip thickness was measured from the cervical aspect of the maxillary and mandibular incisors to the most anterior point on the upper and lower lips (labrale superius and labrale inferius), respectively (Fig 1, *A*). All patients had greater than 2 SD of protrusion of the maxillary and mandibular incisors relative to Asian means (Table I). The degrees of maxillary and mandibular incisor protrusion, skeletal protrusion (defined by SNA and SNB angles), sagittal jaw relationship (defined by ANB angle), lip thickness, and maxillary and mandibular crowding were similar between the treatment groups (Table I). The differences were not statistically significant ($P > 0.05$).

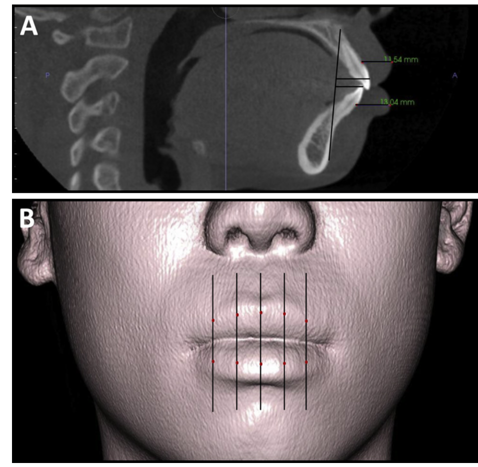


**Fig 1. A,** Initial cephalometric measurements were made using a section centered at the midsagittal plane and aligned to the Frankfort horizontal plane. Dentoalveolar protrusion was quantified by measuring the horizontal distance from the most anterior point on the maxillary and mandibular incisors to the hard tissue A-point–pogonion line. Lip thickness was measured from the most anterior points on the upper and lower lips to the cervical aspects of the maxillary and mandibular incisors, respectively. **B,** Changes to the lips between pretreatment and posttreatment were measured by dividing the intercommissure distance into 5 sagittal planes and placing landmarks at the most anterior point on the upper and lower lips in each plane.

Patients meeting the inclusion criteria were divided into 2 treatment groups based on the type of anchorage used. Both groups were treated with extraction of 4 first premolars and full fixed appliances with an 0.018-in slot and twin brackets (3M Unitek, Monrovia, Calif; or Ensignia; Ormco, Orange, Calif). After the resolution of anterior crowding, the mandibular anterior teeth were retracted en masse in both groups as shown (Fig 2). In the skeletal anchorage group (n = 11), bilateral C-tube temporary skeletal anchorage miniplates[28] were placed mesially to the maxillary first molar (Fig 2). The maxillary anterior teeth were then retracted en masse on a 0.016 × 0.022-in stainless steel archwire using elastomeric chain ligated from the C-tube to a canine retraction arm placed close to the height of the center of resistance. In the nonskeletal anchorage group (n = 13), the maxillary canines were first retracted segmentally on a 0.016 × 0.022-in stainless steel archwire using a soldered 0.032-instainless steel transpalatal archbar or arch between the maxillary first molars for anchorage (Fig 2). After retraction of the canines, the maxillary incisors were retracted en masse using intrusion-retraction loops placed distally to the lateral

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