Short communication:
Clinical application of a 3-dimensional morphometric apparatus for diagnosis and treatment of a Class III patient with facial asymmetry: a pilot study

Natsuko Hichijo, DDS[1*], Shingo Kuroda, DDS, PhD[2], Chieko Shiota, DDS[1], Teppei Watanabe, DDS, PhD[3], Eiji Tanaka, DDS, PhD[4].

Author's affiliations and positions

[1] Graduate Student, Department of Orthodontics and Dentofacial Orthopedics, Tokushima University Graduate School of Oral Sciences, Tokushima, Japan

[2] Associate Professor, Department of Orthodontics and Dentofacial Orthopedics, Institute of Health Biosciences, Tokushima University Graduate School, Tokushima, Japan

[3] Clinician, Department of Orthodontics and Dentofacial Orthopedics, Tokushima University Hospital, Tokushima, Japan

[4] Professor and Chair, Department of Orthodontics and Dentofacial Orthopedics, Institute of Health Biosciences, Tokushima University Graduate School, Tokushima, Japan

Key Word: 3-dimensional morphometric apparatus, facial asymmetry, Class III, miniscrew

Correspondence to: Natsuko Hichijo
Department of Orthodontics and Dentofacial Orthopedics, Tokushima University Graduate School of Oral Sciences,
3-18-15 Kuramoto-Cho, Tokushima 770-8504, Japan.
Tel: +81 88 6337357 / Fax: +81 88 6339139.
E-mail: c301251001@tokushima-u.ac.jp

Abstract

This article demonstrated the usefulness of a non-contact 3-dimensional (3D) morphometric apparatus in orthodontic diagnosis and treatment evaluation. A female patient, 23 years 6 months of age, had a Class III malocclusion with mandibular deviation. The 3D images taken by a 3D morphometric apparatus figured out her protrusive chin of 6 mm on the deviation side compared to the non-deviation side, and showed a possibility of orthognathic surgery. Before starting of orthodontic treatment, a diagnostic splint was used for 2 months to determine her proper mandibular position. The 3D images retaken for quantitative evaluation showed decrease of the mandibular protrusion by approximately 3 mm, and improvement of facial asymmetry. Then, we decided to treat the patient without orthognathic surgery. After 18 months of active orthodontic treatment with miniscrew anchorage, the mandibular deviation was improved and an acceptable occlusion was achieved. The 3D images at posttreatment demonstrated significant decrease of chin protrusion on the deviation side, and improvement of facial asymmetry. In conclusion, a 3D morphometric apparatus could provide quantitative data of facial asymmetry and chin protrusion and contributed decision making process of treatment planning in a patient with facial asymmetry.

Introduction

Evaluation of facial proportions is certainly important for orthodontic diagnosis because numerous patients complain of their facial esthetics [1-3]. In general, facial photographs and cephalometric radiographs are taken as diagnostic records, and frontal view and facial profile are evaluated, respectively. However, they have the inherent limitation of aesthetic assessment because of 2-dimensions [4, 5].

Recently, computed tomography (CT) has been widely used to evaluate 3-dimensional (3D) morphology of both maxillofacial skeleton and soft tissue [6, 7]. Images of 3D-CT are quite useful as a diagnostic record but include some concerns, i.e., higher radiation exposure and medical costs compared to traditional radiographs [7]. Moreover, it is difficult to appreciate facial soft tissue in a natural head position because CT images are generally taken under dorsal position.

In medical field, a non-contact 3D morphometric apparatus is often applied for 3D assessment such as evaluation of breast reconstruction surgery and designing an auricular prosthesis [8, 9]. This system is easy to use as it is automated and picture-capturing process is within less than 5 minutes. The 3D photographs are taken in a natural head position. Additionally, these images can be inverted, rotated, translated and zoomed. Therefore, it allows for more precise measurement and analysis of facial soft tissues, particularly in frontal views. Against these background, this device is becoming more acceptable in dental field [10].

In this article, we demonstrate the usefulness of a non-contact 3D

morphometric apparatus for quantitative evaluation of facial soft tissues and orthodontic diagnosis and treatment evaluation in a patient with mandibular deviation.

CASE PRESENTATION

A female, 23 years 6 months of age, had a chief complaint of protrusive chin and facial asymmetry (Fig. 1A). Her mandible was deviated 2.5 mm to the left toward the facial midline. For evaluating the soft tissue, we used a non-contact 3D morphometric apparatus (Danae 200, NEC engineering, Yokohama, Japan) and a 3D image analyzing software (3D-Rugle, Medic engineering, Kyoto, Japan). When image analyzing software was applied, we could compare degree of facial asymmetry by the customized color scale (in millimeter) on facial deviation maps. The frontal face was divided at the facial midline and one image (right side) was inverted and superimposed to the other (left side). As the result, her soft tissue chin on the deviated (left) side was protruded 6 mm compared to that on the right side (Fig. 1B). The maxillary arch form was constricted and posterior crossbite was observed on the left side (Fig. 1C). Both overbite and overjet were 1 mm. The patient was diagnosed as having an Angle Class III malocclusion, a skeletal Class I jaw-base relationship with mandibular deviation. Before starting of orthodontic treatment, an occlusal splint was placed in the maxilla for seeking the proper mandibular position (Fig. 2A). After splint wear for about 2 months, mandibular deviation was slightly improved and mandibular dental midline was almost coincident with the facial midline. Quantitative evaluation with 3D morphometric apparatus demonstrated that the chin protrusion degree on the

deviation side was changed to 0.67- 2.0 mm, compared to that at pretreatment (Fig. 2B). Then, we decided to treat her with non-surgical camouflage treatment. After the maxillary expansion with a quad-helix, preadjusted-type multi-bracket appliances were placed in both arches (Figs. 3A and 3B). Then, 4 miniscrews (diameter, 1.4 mm; length, 6 or 8 mm; Absoanchor; Dentos, Daegu, South Korea) were inserted in posterior alveolus to distalize the maxillary and mandibular dentition (Figs. 3C and 3D). After 18 months of active treatment, the occlusion was much more stable, and acceptable intercuspation of the teeth was achieved with Class I canine and molar relationships (Fig. 4C). Dental midlines were coincident with the facial midline. Mandibular deviation was improved compared to pretreatment (Fig. 4A, D). 3D morphometric apparatus still indicated the chin protrusion on the deviated side, but it was significantly decreased to less than 3.3 mm (Fig. 4B).

DISCUSSION

Mandibular deviation is one of the most common problems in facial aesthetics [11]. In severe cases, patients have facial asymmetry and tend to undergo orthognathic surgery [12, 13]. On the other hand, recent development of temporary anchorage devices (TADs) gives these patients more chances to avoid orthognathic surgery because TADs provide various tooth movement including molar intrusion which could not be achieved with traditional orthodontic mechanics [14, 15]. Therefore, accurate evaluation of facial asymmetry and predictable treatment planning are more important in modern orthodontics.

In the present case, we applied a 3D morphometric apparatus for three intended purposes through orthodontic treatment of a patient with mandibular deviation. We should focus on lower face line that mandibular deviation was clearly reflected. In the initial examination, it was used for quantification of facial asymmetry in a frontal view. The patients are taken the images in a natural head position, eye open and relaxed facial musculature. By image analyzing software, a mirror-image analysis is performed to objectively quantify the degree of facial asymmetry. As the result, the color map could graphically show the differences of antero-posterior chin protrusion between deviation side and non-deviation side. The color maps allow precise visualization of condition and are very convenient for clinicians for analysis of facial asymmetry and its explanation for the patient.

Secondary, it was applied for quantitative comparison of soft tissue profile before and after a splint therapy. A diagnostic splint therapy was performed to confirm the proper mandibular position without occlusal interference by posterior crossbite. As the result of 3D image comparison before and after the procedure, we could get quantitative data for diagnosis and evidentially predict the results after removal of occlusal interferences. Mandibular protrusion was definitely decreased and the mandibular dental midline was coincident with the maxillary dental midline and facial midline. According to these results, we decided to treat this patient without orthognathic surgery. In severe mandibular deviation cases, these detailed analyses of facial asymmetry may not mean a great deal; however, it must be much important in mild to moderate cases.

Finally, treatment results were reassessed after active orthodontic treatment. In the frontal cephalogram, the mandibular deviation to the left was

improved, but it was difficult to evaluate quantitatively. The mirror image at posttreatment showed significant decrease of chin protrusion on the deviation side. Superimposition of 3D images at pre- and posttreatment also showed significant improvement of facial asymmetry with decrease of the volume at left buccal region and increase of chin protrusion on the right side. These quantitative assessments are also useful to verify the treatment results for further advancement of orthodontic treatment.

In conclusion, a 3D morphometric apparatus could provide quantitative data of facial asymmetry and chin protrusion and contributed decision making process of treatment planning in a patient with facial asymmetry.

Conflict of Interest Statement

The authors declare that there is no conflict of interest.

REFERENCES

[1] Daniels AS, Seacat JD, Inglehart MR. Orthodontic treatment motivation and cooperation: a cross-sectional analysis of adolescent patients' and parents' responses. Am J Orthod Dentofacial Orthop 2009;136:780-7.

[2] Bos A, Hoogstraten J, Prahl-Andersen B. Towards a comprehensive model for the study of compliance in orthodontics. Eur J Orthod 2005;27:296-301.

[3] Pabari S, Moles DR, Cunningham SJ. Assessment of motivation and psychological characteristics of adult orthodontic patients. Am J Orthod Dentofacial Orthop 2011;140:263-72.

[4] Schendel SA, Duncan KS, Lane C. Image fusion in preoperative planning. Facial Plast Surg Clin North Am 2011;19:577-90.

[5] Smith JD, Thomas PM, Proffit WR. A comparison of current imaging programs. Am J Orthod Dentofacial Orthop 2004;125:527-36.

[6] Schendel SA, Jacobson R, Khalessi S. 3-dimensional facial simulation in orthognathic surgery: is it accurate? J Oral Maxillofac Surg 2013;71:1406-14.

[7] Aboul-Hosn Centenero S, Hernandez-Alfaro F. 3D planning in orthognathic surgery: CAD/CAM surgical splints and prediction of the soft and hard tissues results-our experience in 16 cases. J Craniomaxillofac Surg 2012;40:162-8.

[8] Ahcan U, Bracun D, Zivec K, Pavlic R, Butala P. The use of 3D laser imaging and a new breast replica cast as a method to optimize autologous breast reconstruction after mastectomy. Breast 2012;21:183-9.

[9] Liacouras P, Garnes J, Roman N, Petrich A, Grant GT. Designing and manufacturing an auricular prosthesis using computed tomography, 3-dimensional photographic imaging, and additive manufacturing: a clinical report. J Prosthet Dent 2011;105:78-82.

[10] Choi JW, Lee JY, Oh TS, Kwon SM, Yang SJ, Koh KS. Frontal soft tissue analysis using a 3 dimensional camera following two-jaw rotational orthognathic surgery in skeletal class III patients. J Craniomaxillofac Surg 2014;42:220-6.

[11] Severt TR, Proffit WR. The prevalence of facial asymmetry in the dentofacial deformities population at the University of North Carolina. Int J Adult Orthodon Orthognath Surg 1997;12:171-6.

[12] Lee ST, Mori Y, Minami K, An CH, Park JW, Kwon TG. Does skeletal surgery for asymmetric mandibular prognathism influence the soft tissue contour and thickness? J Oral Maxillofac Surg 2013;71:1577-87.

[13] Proffit WR, White RP, Sarver DM. Contemporary treatment of dentofacial deformity. St. Louis: Mosby; 2003. p. 574-644.

[14] Kuroda S, Tanaka E. Application of temporary anchorage devices for the treatment of adult Class III malocclusions. Semin Orthod 2011;17:91-7.

[15] Yanagita T, Kuroda S, Takano-Yamamoto T, Yamashiro T. Class III malocclusion with complex problems of lateral open bite and severe crowding successfully treated with miniscrew anchorage and lingual orthodontic brackets. Am J Orthod Dentofacial Orthop. 2011;139:679-89.

FIGURE LEGENDS

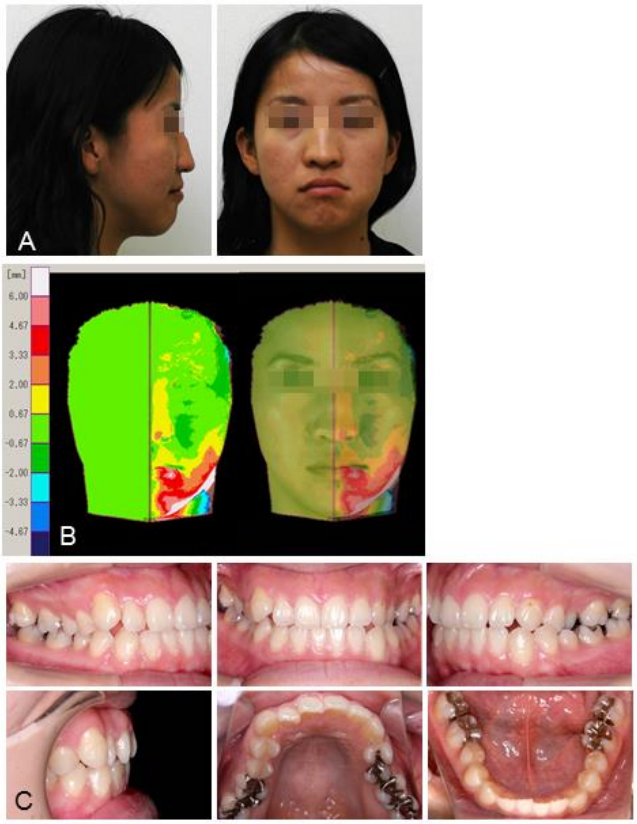

Fig. 1 Pretreatment: A, facial photographs; B, 3D color mapping image showed remarkable chin protrusion on the left side (light red areas indicated 4.67 to 6.0 mm protrusion); C, intraoral photographs.

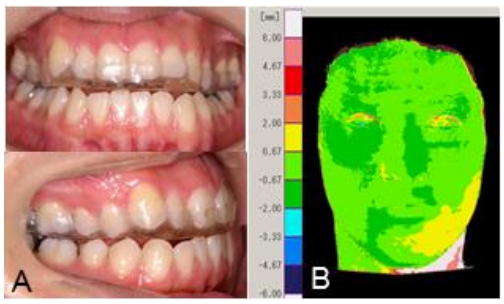

Fig. 2 Diagnostic splint therapy: A, intraoral photographs; B, 3D color mapping image after the therapy; Superimposition of images at pretreatment and post-

splint therapy demonstrated significant reduction of chin protrusion on the left side (yellow areas indicated 0.67 to 2.0 mm protrusion, which meant approximately 4 mm setback of the mandible compared to pretreatment).

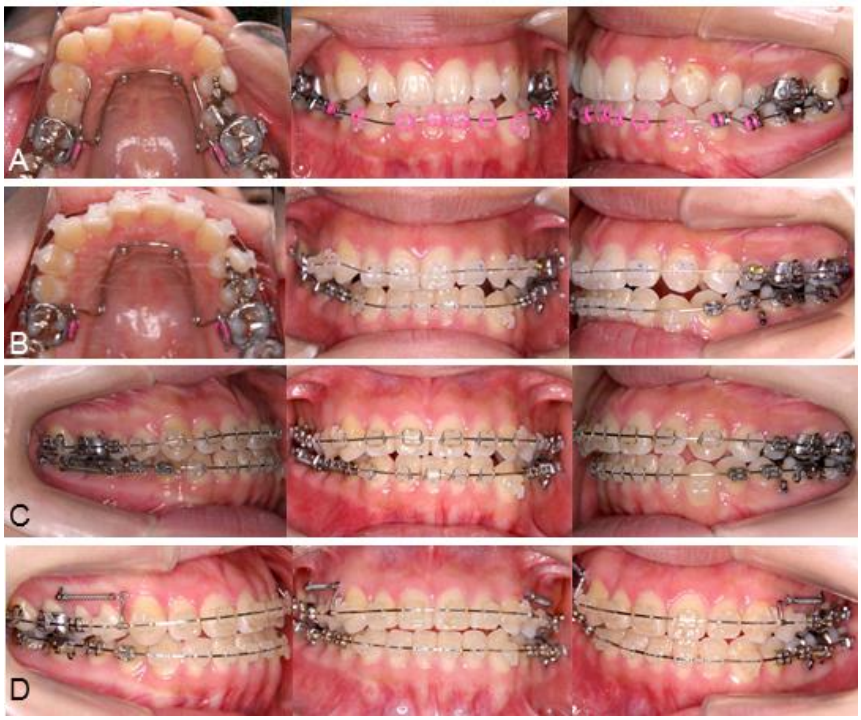

Fig. 3 Treatment progress: A, 1 month after the start of treatment; leveling and alignment were initiated in the mandible and a quad-helix was placed for the maxillary lateral expansion; B, 4 months later, after the improvement of posterior crossbite, leveling was started in the maxilla; C, 8 months later, miniscrews were implanted in the mandible, and the molar distalization was started with 200 g nickel-titanium closing coil springs; D, 15 months later, miniscrews were inserted in the maxilla and group distalization of the maxillary dentition was started.

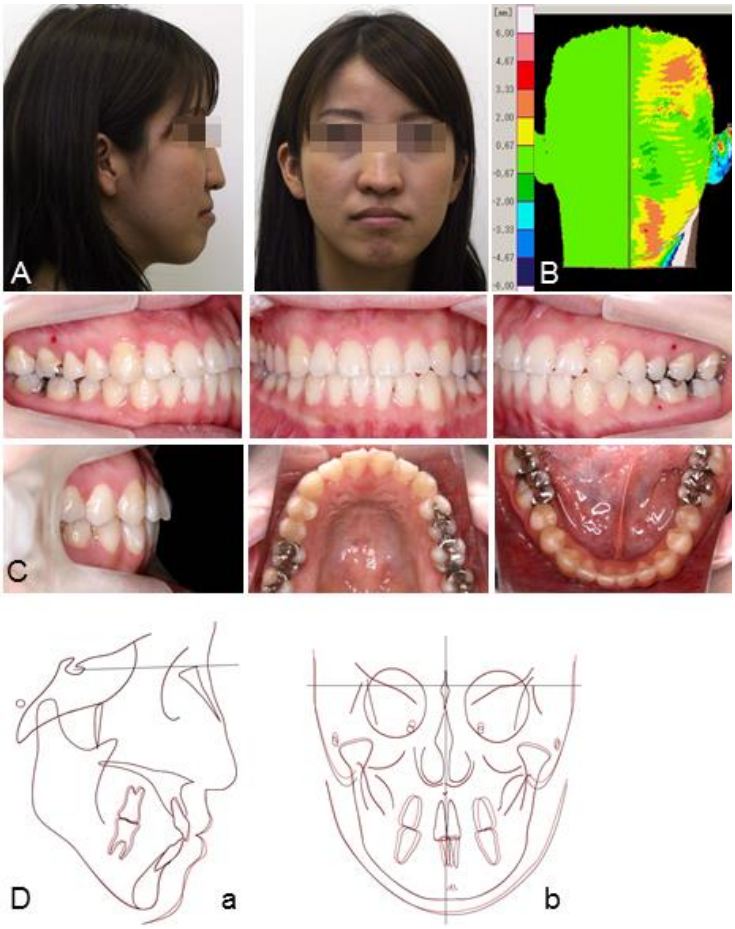

Fig. 4 Posttreatment: A, facial photographs; B, 3D color mapping image showed remarkable decrease of chin protrusion on the left side compared to pretreatment (orange areas indicated 2.0 to 3.3 mm protrusion); C, intraoral photographs; D, Cephalometric tracing at pretreatment (black line), posttreatment (red line) superimposed on (a) sella-nasion plane at sella, (b) latero-orbitale line at Crista galli.