Original article

Antero-posterior and vertical facial type variations influence the aesthetic preference of the antero-posterior lip positions

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Summary

Objectives: The purposes of this study were to investigate whether the antero-posterior and vertical facial type variations influenced the favoured lip positions and to elucidate whether the favoured lip positions differed between orthodontists and laypersons.

Methods: An average profile was constructed from a Japanese female with Class I occlusion and a well-balanced profile, as assessed by several cephalometric analyses. Nine facial types were composed by morphing the chin antero-posteriorly and/or vertically. Thirteen morphed lip profiles were constructed by moving the lips antero-posteriorly in the nine facial types, respectively. Seventy-seven Japanese laypersons and 30 orthodontists were asked to choose the top three most-favoured lip positions for each facial type.

Results: The protruded lip positions were significantly favoured for all the mandibular protrusive facial types. The retruded lip positions were significantly favoured for the short facial type of the antero-posteriorly average and mandibular retrusive-short facial types. Among the mandibular protrusive facial types, the protruded lip positions were significantly favoured for the long facial type. The retruded lip positions were statistically more attractive for orthodontists than laypersons on the antero-posteriorly average-short, mandibular protrusive-short, mandibular retrusive-vertically average, antero-posteriorly average-vertically average, and mandibular retrusive-long facial types.

Limitations: Our data were limited by the specific ethnic groups and variety of facial types.

Conclusion: The favoured antero-posterior lip position was affected by not only the antero-posterior facial disproportion but also by the vertical dimensions. The favoured lip positions differed between orthodontists and laypersons. These results might be helpful in deciding between extraction and non-extraction treatment in borderline cases.

Introduction

Facial attractiveness significantly influences personality development and social interactions as well as a patient’s self-esteem (1–4). An individual’s facial profile is considerably affected by the skeletal components and the positions of the incisors. A primary goal of orthodontic treatment is to achieve balanced and harmonious facial features along with excellent skeletal and dental conformation.
Since E.H. Angle first emphasized the importance of facial aesthetics in orthodontic treatment, many cephalometric analyses have been developed to evaluate skeletal composition and determine the spatial incisor positions. This was followed by the hypothesis that a favourable treatment result, including a desirable facial profile, would be achieved in orthodontic patients who were successfully treated towards a cephalometric standard (5).

Various authors, however, have reported that the reliance on a cephalometric analysis and treatment planning occasionally leads to aesthetics problems (5–8). Burstone warned that correcting dental discrepancies does not necessarily treat the facial imbalance and may even cause facial disharmony (9). Case and Arnett illustrated that the facial outline should be regarded as an important guide in determining orthodontic treatment, whereas cephalometric analyses according to dento-skeletal landmarks, which are not necessarily consistent with good facial aesthetics, have been shown to be unreliable (10). This might be because individuals display great differences in the thickness, length, and postural tone of the soft tissue covering the teeth and bone (9–12) and because the cephalometric analyses have been based on patient populations that exhibited no skeletal disharmony. It could be difficult to adapt these normative measurements to patients who exhibit some skeletal disharmony.

In recent years, it has been suggested that the favoured lip position changes in accordance with facial type variations. Czarnecki et al. (13) suggested that the favoured lip position changed according to the variations in the size of the nose and chin and stated the importance of the balance between the parts composing the face. Ioi et al. (14) reported that the favoured lip position changed according to variations in facial convexity using the silhouette of a morphed facial profile of maxillary and mandibular protrusion with a retracted and protruded mandible. Although several assessments of the favoured antero-posterior lip positions for various antero-posteriorly different facial types have been reported, there have been few reports assessing the relationship between the favoured antero-posterior lip positions and vertically different facial disproportions. Our hypothesis is that the perception of the favoured antero-posterior lip positions might also change according to an increase or decrease in the facial disproportions inherent in individual patients.

It is essential for orthodontists to be aware of the desirable soft tissue profile as an individual treatment goal for each patient’s facial type. The aim of this study was to investigate whether the antero-posterior and/or vertical facial type variations influenced the favoured antero-posterior lip positions and to elucidate whether the favoured lip positions differed between orthodontists and laypersons.

**Materials and methods**

This cross-sectional study was approved by Okayama University and conducted as a part of an education program at Okayama University Dental School. Informed consent was obtained from all subjects.

A lateral cephalogram and a facial profile photograph of a Japanese woman were used. She had a Class I occlusion and good facial symmetry determined clinically and radiographically. Several analyses indicated that most measurements in her profile were in the normal ranges for current Japanese women using Merrifield’s Z-angle (15); Ricketts’ aesthetic plane analysis: E-plane to the upper lip and E-plane to the lower lip (16); Legan and Burstone analysis: soft-tissue convexity (Gn’-Sn-Pg’), upper lip protrusion (Ls to Sn-Pg’), and lower lip protrusion (Li to Sn-Pg’)) (12); Holdaway’s soft tissue analysis: H-line to N’-Pog (H-angle), H-line to subnasale, and H-line to the lower lip (6); and the soft tissue relationships described by Epker et al.: subnasale perpendicular to the lower lip and subnasale perpendicular to the chin (17). To avoid subjective considerations, facial silhouettes rather than facial photos were chosen for rating of the facial profiles.

Nine facial types were composed by morphing the chin antero-posteriorly and/or vertically using a cephalometric software program in reference to the Sassouni skeletal classification (18). The line parallel to the Frankfort-horizontal plane (FH plane) through point menton (Me) was defined as the X1-axis, and the line perpendicular to the FH plane through point Me was defined as the Y-axis on the cephalogram (Figure 1). Point Me was moved antero-posteriorly and vertically in increments of 10 mm along the x-axis and x1-axis on the WinCeph version 8 cephalometric software program (Rise, Sendai, Japan), and consequently nine silhouette facial types were developed: mandibular retrusive-short facial type, mandibular retrusive-vertically average facial type, mandibular retrusive-long facial type, antero-posteriorly average-short facial type, antero-posteriorly average-vertically average facial type, antero-posteriorly average-long facial type, mandibular protrusive-short facial type, mandibular protrusive-vertically average facial type, and mandibular protrusive-long facial type (Figures 1 and 2).

Subsequently, a total of 13 morphed lip profiles were constructed by moving the lips antero-posteriorly along the line parallel to the FH plane through point stomion (St; X2-axis) in each of the nine facial types (Figures 1 and 3). In the series, the average profile (number 7) was located in the centre. The lips were protruded or retracted in 1 mm increments from the average profile. Profile number 1 was the most retrusive, and number 13 was the most protrusive (Figures 4–6).

The sample size was determined using the results from our pilot study that evaluated the most favoured facial type in nine morphed facial types using the Power and Sample Size Calculation software programs (version 3.1.2, Department of 8Biostatics, Vanderbilt

![Figure 1. The reference lines used for morphing. On the cephalogram, we defined the line perpendicular to the Frankfort-horizontal (FH) plane through point menton (Me) as the Y-axis and the line parallel to the FH plane through point Me as the X1-axis and the stomion (St) as the X2-axis.](https://academic.oup.com/ejo/article-abstract/38/4/414/1748746)
mandibular protrusive facial type groups (short, vertically average, and long). In addition, the evaluations were performed nine times for the attractiveness of the silhouettes as perceived by orthodontists and laypersons for each profile.

**Statistical analysis**

The Tukey–Kramer test was used to compare the attractiveness of the silhouettes in the six groups composed of three facial types. The attractiveness of the silhouettes, as perceived by orthodontists and laypersons for each profile, was compared by a two-sample t-test. A probability of less than 0.05 was considered to be statistically significant. All statistical analyses were performed using the JMP statistical analysis software program (SAS Institute, Inc., Cary, North Carolina, USA).

**Results**

**The comparison of the favoured antero-posterior lip positions among antero-posteriorly different facial types**

Among the short facial types of mandibular retrusive, antero-posteriorly average, and mandibular protrusive facial types, the protruded lip positions were significantly favoured on the mandibular protrusive facial type. Among the vertically average facial types of mandibular retrusive, antero-posteriorly average, and mandibular protrusive facial types, the protruded lip positions were significantly favoured on the mandibular protrusive facial type. Among the long facial types of mandibular retrusive, antero-posteriorly average, and mandibular protrusive facial types, the protruded lip positions were significantly more favoured on the mandibular protrusive facial type (Figures 7 and 8).

**The relationship between the favoured lip position for different skeletal patterns and orthodontic expertise**

Orthodontists showed a significantly higher preference for the retruded lip positions than laypersons on the antero-posteriorly average-short, mandibular protrusive-short, mandibular retractive-vertically average, antero-posteriorly average-vertically average, and mandibular retrusive-long facial types. There were no differences between orthodontists and laypersons in the aesthetic preference on the mandibular retrusive-short, mandibular protrusive-vertically average, antero-posteriorly average-long, and mandibular protrusive-long facial types (Figures 9 and 10).

**Discussion**

This study demonstrated that the judgment of a favoured antero-posterior lip position was dependent on the antero-posterior and/or vertical facial type variations. The null hypothesis was that the perception of...
of facial beauty might change according to both the antero-posterior and vertical facial proportions in each patient. In recent years, it has become possible to treat cases of moderate skeletal disproportion with severe dentoalveolar discrepancies who are ‘borderline’ in the decision between surgical treatment and orthodontic camouflage treatment options, such as an open bite with clockwise rotation of the mandible by intruding molars and anti-clockwise rotation of the mandible, with the use of temporary anchorage devices and without the need for surgical procedures (19, 20). However, if the open bite case had a large mandibular body length with a straight profile, such camouflage treatment by anti-clockwise rotation of the mandible for correcting the open bite without consideration of suitable lip position might worsen the facial aesthetics, and vice versa. Steiner proposed the innovative concept that a desirable incisor position could depend on unique skeletal variations of individual patients (21). Steiner’s novel idea was invaluable in the decision-making process regarding the suitable incisor position for providing camouflage treatment in clinical practice. However, the soft tissue treatment goal of the desired antero-posterior lip position for such camouflage cases is not clear. Although several assessments of favoured antero-posterior lip positions for various antero-posteriorly different facial types have been reported, the suitable soft tissue profiles have not been well investigated in regard to the vertically different facial disproportions and the combination of antero-posterior and vertical facial disproportion that individuals exhibit.

In this study, among vertically average facial types (antero-posteriorly average-vertically average, mandibular retrusive-vertically average, and mandibular protrusive-vertically average facial types), lip protrusion was statistically favoured on the mandibular protrusive facial type. It is generally conceivable that lip protrusion could camouflage a concave profile with a protruded chin position. This finding may be in line with the traditional concept that in a patient with a tendency towards a protruded chin, a more forward lower incisor position would be preferred to keep the lip curves within that profile. Alternatively, in a patient with a tendency towards a retruded chin with lip strain, one may well decide to extract teeth to reduce the lip strain. Modarai et al. (22) also previously reported that lip prominence was more acceptable when there is concomitant chin prominence and vice versa. However, in the Japanese subjects of our study, there were no statistically significant differences in the favoured antero-posterior lip position between the antero-posteriorly average and mandibular retrusive facial types among the vertically average facial types. These findings for general preferences agree with other Japanese studies, which indicate that Japanese laypersons find mandibular protrusion less attractive than mandibular retrusion (14, 23–25). These results might be related to the cephalometric norm for Japanese people, which is more convex than for Caucasians (26–28). Alcalde et al. (28) reported that though significant differences were found in the Japanese sample when compared with the white norms of cephalometric radiographs, the soft tissue mean values of the Japanese supernormal group were similar to the white norms, with the exception of the nasolabial angle and the lip prominence. Some studies of Caucasian subjects showed that mandibular retrusive facial types were rated, overall, to be less attractive than mandibular protrusive facial types (13, 29, 30). Therefore, this tendency for the acceptance of convex profiles might be a particular characteristic of Japanese laypersons.

These results were similar among short facial types (antero-posteriorly average-short, mandibular retrusive-short, and mandibular protrusive-short facial types) and long facial types (antero-posteriorly average-long, mandibular retrusive-long, and mandibular protrusive-long facial types). Regardless of the vertical dimension, lip protrusion was favoured on all mandibular protrusive facial types (mandibular protrusive-short, mandibular protrusive-vertically average, and mandibular protrusive-long facial types), and there were no differences
in the perception of the favoured lip position on antero-posteriorly average and mandibular retrusive facial types. These results were partially supported by the previous studies of Cox and van der Linden (31) who showed that there were no differences in the aesthetic preference according to the vertical facial dimensions, while definite differences were found regarding the antero-posterior dimensions.
In the comparison of the three vertically different mandibular protrusive facial types (mandibular protrusive-short, mandibular protrusive-vertically average, and mandibular protrusive-long facial types), protruded lip positions were only significantly more favoured for the long facial type. Among the mandibular protrusive facial types (mandibular protrusive-short, mandibular protrusive-vertically average, and mandibular protrusive-long facial types), long facial types could be more emphasized by mandibular prognathism than in both short and vertically average facial types. Therefore, a greater degree of lip protrusion might be advantageous in easing the unfavourable perception of mandibular prognathism.

Contrarily, in the comparison of the three vertically different mandibular retrusive facial types (mandibular retrusive-short, mandibular retrusive-vertically average, and mandibular retrusive-long facial types), retruded lip positions were only significantly more favoured on the short facial types. Short facial types could be comparatively more emphasized by mandibular retrognathia than on either long or vertically average facial types. It has generally been suggested that lip retraction could be advantageous in easing the unfavourable perception of a mandibular retrusive facial type. Even in the Japanese raters, a mandibular retrusive-short facial type could be recognized as an excessively convex profile and an unfavourable facial proportion. The same result was recognized among antero-posteriorly average facial types (antero-posteriorly average-short, antero-posteriorly average-vertically average, and antero-posteriorly average-long facial types). These results are partially supported by previous investigations by Sassouni and Paulton, which indicated that vertical skeletal disproportion is often associated with a displeasing facial appearance (32–34).

Consequently, the results of this study indicate that the favoured antero-posterior lip positions might change not only according to the antero-posterior or vertical facial proportions but also based on the combination of antero-posterior and vertical dimensions. In this light, a more protruded incisal position might be recommended for a patient who has a relatively protruded chin position and long lower face height. In a borderline decision between non-extraction and extraction treatment, non-extraction might thus be selected in such cases. In addition, in patients who show a long facial type with a protruded chin position, non-extraction with a protruded lip position would be strongly recommended. Conversely, a retruded incisal position might be recommended for Japanese patients with a short facial type corresponding to antero-posteriorly average and mandibular retrusive facial patterns.

Figure 8. The comparison of the aesthetic preferences in six groups composed of three facial types: (1) short facial type group (mandibular retrusive, antero-posteriorly average, and mandibular protrusive facial types); (2) vertically average facial type group (mandibular retrusive, antero-posteriorly average, and mandibular protrusive facial types); (3) long facial type group (mandibular retrusive, antero-posteriorly average, and mandibular protrusive facial types); (4) mandibular retrusive facial type group (short, vertically average, and long facial types); (5) antero-posteriorly average facial type group (short, vertically average, and long facial types); (6) mandibular protrusive facial type group (short, vertically average, and long facial types). A = mandibular retrusive-short facial type; B = antero-posteriorly average-short facial type; C = mandibular protrusive-short facial type; D = mandibular retrusive-vertically average facial type; E = antero-posteriorly average-vertically average facial type; F = mandibular protrusive-vertically average facial type; G = mandibular retrusive-long facial type; H = mandibular protrusive-vertically average facial type; I = mandibular protrusive-long facial type. An asterisk indicates a significant difference among the three profiles ($P < 0.05$). Values without asterisks denote a lack of statistical significance.

Figure 9. The distribution of the most-favoured profiles of laypersons and orthodontists.
Figure 10. The comparison of aesthetic preferences of laypersons and orthodontists for each profile type. A = mandibular retrusive-short facial type; B = antero-posteriorly average-short facial type; C = mandibular protrusive-short facial type; D = mandibular retrusive-vertically average facial type; E = antero-posteriorly average-vertically average facial type; F = mandibular protrusive-vertically average facial type; G = mandibular retrusive-long facial type; H = mandibular protrusive-vertically average facial type; I = mandibular protrusive-long facial type. An asterisk indicates a significant difference among the three profiles (P < 0.05). Values without asterisks denote a lack of statistical significance.

With regards to the vertical dimension of facial types, Naini et al. (35) previously elucidated that a lower anterior face height (LAFH) influenced the perceived attractiveness using frontal face image manipulation. They reported that with an increase in the LAFH, the desire for surgery became significant at 15–16 mm for male faces and 13–14 mm for female faces. With a reduction in the LAFH, the desire for surgery became significant at ~14 to ~17 mm for male faces; a smaller reduction of ~6 to ~8 mm led to a significant desire for surgery for female faces.

With regards to the sagittal dimension, Modarai et al. (22) previously reported that laypeople perceived a borderline decision between surgical treatment and orthodontic camouflage treatment options at ±8 to ±12 mm changes in the chin position. Therefore, we moved the chin position and length in increments or decrements of 10 mm sagittally and vertically from the original position in camouflage cases.

On the other hand, orthodontic expertise affects orthodontic treatment needs and the perception of facial attractiveness (36, 37). McKoy-White et al. (38) reported that orthodontists preferred flatter profiles than laypeople. Other studies have found obvious differences in the perception among groups of laypersons, dental students, and orthodontists (24, 39, 40). The professional opinions of orthodontists regarding dentofacial aesthetics are made more objective by guidelines, norms, ideal ratios and angles. However, the perceptions of laypersons are largely motivated by subjective feelings in their culture groups (41, 42).

In comparison between orthodontists and laypersons regarding the favoured lip positions among each of the skeletal patterns, orthodontists significantly favoured the retruded lip position on antero-posteriorly average-short, mandibular protrusive-short, mandibular retrusive-vertically average, antero-posteriorly average-vertically average, and mandibular retrusive-long facial types. These results were also explained by previous studies that indicated that convex profiles were more acceptable and that concave profiles were less attractive among Japanese laypersons (14, 23–25). On the mandibular retrusive-short facial type, however, there was no significant difference between the ratings of orthodontists and laypersons. Because a mandibular retrusive-short face could be recognized as an excessive convex profile and unfavourable profile even for Japanese laypersons, the retruded lip position might be preferred.

With the exception of the mandibular retrusive-short facial type, as the face height became shorter, and facial convexity became more pronounced, orthodontists tended to favour the retruded lip position more than Japanese laypersons. Conversely, as the face height became longer, and facial concavity became more pronounced, the perceptions of Japanese orthodontists and laypersons tended to be similar. These results indicated that the perception of the favoured lip position for specific facial proportions could change in line with orthodontic expertise. It is important for orthodontists to be aware of the differences of perceptions regarding a patient’s antero-posterior and vertical facial disharmony.

To avoid subjective considerations, we used facial silhouettes rather than facial photos for rating of the facial profiles. Although the use of silhouettes could avoid some confusing factors (such as hairstyle, make-up, and skin complexion), laypeople are accustomed to seeing and evaluating real faces and not drawings of silhouettes. Torsello et al. and Agostino et al. previously reported that similar modifications in cases of nose or chin protrusion were performed on photographs instead of silhouettes with similar conclusions to the present study that compensatory lip protrusion improves the profile attractiveness (43, 44).

As orthodontists have increased their ability to change facial profiles, it has become necessary to understand what is and is not desirable in a facial profile. Orthodontists have to not only objectively judge the dental and skeletal conditions in a comprehensive manner, but they must also consider the skeletal type variations, soft tissue profiles and the desires of individual patients, as well as the differences in perception based on orthodontic expertise. This study attempted to simplify and quantify facial balance as a guideline for treatment planning and the assessment of treatment outcomes. In respect to the individual goals of soft tissue treatment, we proposed a new concept that may provide a tool to promote organization, understanding and communication between orthodontists, prosthodontists, maxillofacial/plastic surgeons, and patients. These results should also be helpful in the decision-making process in borderline cases where it is difficult to decide between extraction and non-extraction treatment and in treatment planning for camouflage cases involving individual skeletal disproportions. With this investigation, cosmetic problems might thus become predictable and orthodontic tooth movements that produce aesthetic decline might thereby be avoided.

Limitations
Our data were limited by the specific ethnic groups and variety of facial types. The subjects of this study were restricted to Japanese subjects. There might be differences in the preference of facial profile among different ethnic backgrounds. In addition, in this study, chin position and length were moved only in increments or decrements of 10 mm of sagittal and vertical dimension from the original position. However, actual patients have more complicated facial types. Therefore, our future studies will focus on evaluating different ethnic subjects and various facial types.

Conclusion
1. The most-favoured antero-posterior lip position was affected by not only the antero-posterior facial type disproportion but also the vertical dimension of the facial pattern.
2. The most-favoured lip positions differed between orthodontists and laypersons.
3. Consequently, orthodontists should realize the individualized soft tissue treatment goals for patients of various facial patterns.

References