The aesthetic impact of upper lip inclination in orthodontics and orthognathic surgery

Farhad B. Naini*, Martyn T. Cobourne**, Fraser McDonald** and David Wertheim***

*Department of Orthodontics, Kingston and St George’s Hospital and Medical School, **Department of Orthodontics and Craniofacial Development, Kings College London and ***Faculty of Science, Engineering and Computing, Kingston University, London, UK

Correspondence to: Farhad B. Naini, Department of Orthodontics, St George’s Hospital and Medical School, Blackshaw Road, London SW17 0QT, UK. E-mail: farhad.naini@yahoo.co.uk

Summary

Background: The nasolabial angle, particularly its lower component, i.e. the upper lip inclination (ULI), is an important keystone in treatment planning. Normative data for this parameter are not available.

Objectives: A quantitative evaluation of the aesthetic impact of ULI on perceived attractiveness and threshold values of desire for treatment was undertaken.

Methods: The ULI of an idealized silhouette profile image was altered incrementally between 61 and 100 degrees. Images were rated on a Likert scale by pre-treatment orthognathic patients (n = 75), laypeople (n = 75), and clinicians (n = 35).

Results: An ULI between 79 and 85 degrees is viewed as ideal, with a range of 73–88 degrees deemed acceptable. Angles above or below this range, down to 67 degrees and up to 94 degrees are perceived as slightly unattractive, and anything outside the range of 67–94 degrees is deemed very unattractive. For patients the threshold value of desire for treatment was 91 degrees and above and 64 degrees and below, and for both clinicians and lay people the threshold value was 94 degrees and above and 64 degrees and below. Patients appear to be more critical than lay and clinician groups. This stresses the importance of using patients as observers, as well as laypeople and clinicians, in facial attractiveness research.

Limitations: The results are based on an idealized male Caucasian profile.

Conclusions: It is recommended that in treatment planning, the range of normal variability of the ULI, in terms of observer acceptance, is taken into account as well as the threshold values of the desire for treatment.

Introduction

Treatment planning in orthodontics and orthognathic surgery may be ‘occlusion-centred’ or ‘aesthetic-centred’. In the former, facial aesthetics, in particular soft tissue profile aesthetics, are permitted to alter, perhaps detrimentally, at the expense of achieving a Class I incisor relationship and well-interdigitated buccal segment relationships. Therefore, the maxillary incisors may be sometimes excessively retroclined and/or retracted, allowing the upper lip to follow the incisors to a greater or lesser extent depending on the soft tissue thickness and tonicity, and the nasolabial angle to become obtuse in relation to its starting point. In the latter or aesthetic-centred approach, the patient’s soft tissue profile and upper lip to maxillary incisor relationship is considered paramount. Therefore, at times, an increased incisor overjet and Class II occlusion may be accepted or only partially corrected, rather than attempting to achieve a Class I incisor relationship through retroclination/retraction of the maxillary incisors, thereby
avoiding potentially detrimental changes to the facial profile. In short, the teeth are made to fit the face, and not the other way around.

The nasolabial angle, and, in particular, its lower component [i.e. the upper lip inclination (ULI)], is an important keystone in treatment planning, both in orthodontics and in orthognathic surgeries. The change in ULI in orthodontic treatment depends on the degree of retroclination/retraction of the maxillary incisors, the thickness and tonicity of the upper lip (thicker, flaccid lips will alter to a lesser extent), and the size of the space between the anterior dentoalveolus and the inner surface of the upper lip (1). The opening of the nasolabial angle may be beneficial or detrimental, depending on the initial morphological presentation of the patient, though the change in ULI will alter the nasolabial angle independently of the nose (Figure 1).

The change in ULI with Le Fort I type orthognathic surgery depends on the degree of decompensation of the maxillary incisors, the type of maxillary surgery, and its direction and degree of movement. Additionally, soft tissue procedures, such as cinch sutures and VY closures, will affect the ULI (2). However, with orthognathic surgery, both the upper and lower components of the nasolabial angle will alter to varying degrees, whereas in orthodontic treatment, only the inclination of the upper lip is likely to alter (Figure 1). It is important to bear in mind that in some orthognathic patients, a combination of movements, e.g. maxillary advancement and impaction, may be required. The information possessed regarding the above is very important in the treatment-planning process.

The inclination of the upper lip (i.e. the lower component of the nasolabial angle), has an ‘average’ value or ‘norm’ for any given population, which is specific for age, gender, and ethnicity. Such normative values also has a range of normal variability, with the existence of a facial deformity often resulting from a significant deviation of the facial parameter in question from the accepted norm for a population. For clinical practice, it is important to know at what point the deviation of a facial parameter moves from the acceptable range of variability to being perceived as a facial deformity (1).

The magnitude of the deviation of the ULI, whether it is due to the sagittal position of the maxilla (prognathic or retrognathic), the inclination of the maxillary incisor teeth (proclined or retroclined), the morphology and thickness of the overlying soft tissues of the upper lip, or any combination of the above, is an important factor in deciding whether orthodontic and/or orthognathic treatment may be required. The ULI is a potentially important factor in the perception of facial profile attractiveness and is the lower component of the nasolabial angle (1, 2). The nasolabial angle is formed by drawing a line tangent to the nasal columella (columella tangent) and a line tangent to the upper lip (upper lip tangent), intersecting at subnasale. This angle will depend on the inclination of the nasal columella and the upper lip. To better evaluate the inclination of the upper lip, the nasolabial angle may be separated into upper and lower component parts using a true horizontal line through subnasale, with the patient in natural head position (1). This will allow the upper lip tangent-true horizontal plane (lower component of the nasolabial angle) and the columella tangent-true horizontal plane angles to be assessed separately, as they vary independently (1). The landmarks and planes used to describe the ULI (i.e. the lower component of the nasolabial angle) are shown in Figure 2.

The principal aim of this investigation was to evaluate quantitatively the influence of the ULI on perceived attractiveness, in order to find objective evidence to aid clinicians in planning the treatment of patients that may lead to alterations in the inclination of the upper lip, e.g. proclination/retroclination and/or protrusion/retrusion of the maxillary incisors, or maxillary advancement/setback procedures. In order to find the ranges of normal variability, in relation to observer-perceived attractiveness scores, and to find the threshold values above and below which treatment may be desired, the relationship between the degree of the ULI and perceived attractiveness was determined. Comparison of the perceptions of the three observer groups was also undertaken.

![Figure 1](image1.png)  
Figure 1. Lateral cephalometric radiographs of a patient desiring orthodontic treatment only with retroclination of the maxillary incisor teeth; A: pretreatment, nasolabial angle: 90 degrees, upper lip inclination to true horizontal through subnasale: 60 degrees, maxillary incisor inclination in relation to maxillary plane: 135 degrees. B: Following orthodontic retroclination of the maxillary incisors to 105 degrees (retroclined by 30 degrees), the nasolabial angle increased to 110 degrees (increase of 20 degrees), though all the increase was in the upper lip inclination (from 60 to 80 degrees). The upper component of the nasolabial angle did not alter, therefore the increase in the nasolabial angle was independent of the nose, and due only to the change in upper lip inclination.
Materials and methods

The National Research Ethics Service, UK, granted ethical approval for this study (REC reference: 06/Q0806/46).

The use of 2D profile silhouettes has been used previously in order to determine facial attractiveness (3, 4). Computer software (Adobe® Photoshop® CS2 software) was used to create an ‘idealized’ profile silhouette image, with proportions (1) and linear and angular soft tissue measurements (1, 5–10) based on currently accepted criteria for an idealized Caucasian male profile, as previously described (4). The ULI (i.e. lower component of the nasolabial angle) of the idealized profile image (image BN: 85 degrees) was altered in 3-degree increments from 61 to 100 degrees in order to represent variations in the angle and morphology of the nasolabial region (Figure 3).

According to the results of a pilot study, 185 observers were recruited in the main study in order to achieve 80 per cent power. The observers were in three groups (Table 1), with the following selection criteria:

- Pre-treatment orthognathic patients (n = 75):
  - Primary concern was with their facial appearance
  - No history of previous orthodontic or facial surgery
  - No severe psychological problems (e.g. body dysmorphic disorder)
- Laypeople (n = 75):
  - No history of previous orthodontic or facial surgery
  - No facial deformities
  - No history of facial trauma
  - Non-healthcare employees
- Clinicians (n = 35):
  - Orthodontists and maxillofacial surgeons involved in the treatment of orthognathic surgery patients.

Every observer was provided with a questionnaire, on which they were asked to provide their age, gender, and ethnic background (White or non-White Caucasian). They were also asked their attractiveness rating of their own facial appearance and how important they felt it was to have an attractive facial appearance.

The observers were asked to rate each individual image on the following rating scale: 1, extremely unattractive; 2, very unattractive; 3, slightly unattractive; 4, neither attractive nor unattractive; 5, slightly attractive; 6, very attractive; 7, extremely attractive.

Finally, for each image the observers were asked whether they would consider surgery if represented their own appearance.

Observers sat individually in the same room under the same conditions, and went through a PowerPoint® presentation in their own time, running through the randomly ordered images using the ‘Page Down’ button. The images were identified by a randomly assigned double letter in the top right corner of the screen (e.g. BN, GS). Intra-examiner reliability was evaluated using two identical images (DP and EO). In order to reduce the potential effect of the size of the images displayed on the computer screen as compared to a human head, the initial image was created based on the dimensions of an average human head with average lower anterior face height.

The most useful rating method accepted by psychologists in attractiveness perception research is the Likert-type scale (11). The observers in this study used the 7-point rating scale described above in order to rate the attractiveness of each image.

Statistical analysis

In order to assess how perceived attractiveness varies with the ULI, the median and interquartile observer ratings were calculated for each angle and for each observer group; these descriptive statistics were calculated using software that we developed using MATLAB (The MathWorks Inc, Natick, Massachusetts, USA). Additionally, data were modelled by curve fitting performed using MATLAB. Similarly, the software calculated the proportions in each group suggesting a desire for surgery. Additional paired t-tests were performed using Minitab version 16 (Minitab Inc, State College, Pennsylvania, USA) following applying the Ryan-Joiner test in Minitab used to examine if data were consistent with a normal distribution.

Results

Reliability analysis

Analysis of the first and third quartile rankings of the Likert score indicate that there was generally good agreement in the three observer groups, with a maximum interquartile range for all three groups of 1 (Table 2).
Table 1. Observer demographics.

<table>
<thead>
<tr>
<th>Observer group</th>
<th>Number</th>
<th>Mean age (in years)</th>
<th>95% confidence interval</th>
<th>Age range</th>
<th>Gender (% Male)</th>
<th>Ethnicity (% White)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orthognathic patients</td>
<td>75</td>
<td>22</td>
<td>20–24</td>
<td>13–60</td>
<td>42</td>
<td>66</td>
</tr>
<tr>
<td>Lay people</td>
<td>75</td>
<td>31</td>
<td>28–35</td>
<td>16–79</td>
<td>31</td>
<td>49</td>
</tr>
<tr>
<td>Clinicians</td>
<td>35</td>
<td>31</td>
<td>30–33</td>
<td>24–39</td>
<td>33</td>
<td>72</td>
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Table 2. First and third quartile rankings of the Likert score.

<table>
<thead>
<tr>
<th>Image</th>
<th>Angle (°)</th>
<th>Patients</th>
<th>Lay</th>
<th>Clinicians</th>
<th>Patient</th>
<th>Lay group</th>
<th>Clinician</th>
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<td>BN</td>
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<td>4</td>
<td>4</td>
<td>5</td>
<td>5.75</td>
<td>6</td>
<td>6</td>
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<td>CN</td>
<td>82</td>
<td>4</td>
<td>4.25</td>
<td>5</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>DP</td>
<td>79</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>5.5</td>
<td>6</td>
<td>5</td>
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<tr>
<td>EO</td>
<td>79</td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>6</td>
<td>5</td>
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<td>FN</td>
<td>76</td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>6</td>
<td>6</td>
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</tr>
<tr>
<td>GS</td>
<td>73</td>
<td>2.25</td>
<td>3</td>
<td>3</td>
<td>4.1</td>
<td>5</td>
<td>4</td>
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<td>HU</td>
<td>70</td>
<td>2</td>
<td>3</td>
<td>3</td>
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<td>4</td>
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<tr>
<td>JW</td>
<td>67</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>KM</td>
<td>64</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>3</td>
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<td>JK</td>
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<td>4</td>
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<td>PH</td>
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<td>1</td>
<td>2</td>
<td>1</td>
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Table 3. Data in rank order from most to least attractive (clinician ranking first).

<table>
<thead>
<tr>
<th>Image</th>
<th>Angle (°)</th>
<th>Median score</th>
</tr>
</thead>
<tbody>
<tr>
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<td>5</td>
</tr>
<tr>
<td>CN</td>
<td>82</td>
<td>5</td>
</tr>
<tr>
<td>DP</td>
<td>79</td>
<td>5</td>
</tr>
<tr>
<td>EO</td>
<td>79</td>
<td>5</td>
</tr>
<tr>
<td>FN</td>
<td>76</td>
<td>5</td>
</tr>
<tr>
<td>GS</td>
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<td>5</td>
</tr>
<tr>
<td>HU</td>
<td>70</td>
<td>5</td>
</tr>
<tr>
<td>JW</td>
<td>67</td>
<td>5</td>
</tr>
<tr>
<td>KM</td>
<td>64</td>
<td>5</td>
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<tr>
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<td>OV</td>
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<td>5</td>
</tr>
<tr>
<td>SF</td>
<td>100</td>
<td>5</td>
</tr>
</tbody>
</table>

Perceived attractiveness of images

Table 3 shows the median attractiveness rating of the observers on a Likert scale from 1 to 7, where 1 indicates ‘extremely unattractive’ and 7 indicates ‘extremely attractive’, and demonstrates the data in rank order from most to least attractive, sorted on the basis of responses from the clinician group then lay group. An ULI angle outside the range of 73–88 degrees was associated with a reduction in the median attractiveness scores in all three groups of observers. Repeatability was good, as images DP and EO are identical, with both the lay and patient groups having the same median attractiveness score for these images, with the clinician group only 1 point apart.

Outcome: desire for treatment

Figure 4 demonstrates the proportion expressed as a percentage of each observer group suggesting that treatment is required shown in rank order. The results indicate that clinicians were generally least likely to suggest treatment for varying degrees of ULI. Images DP and EO were identical, and so repeatability of the 35 clinician’s assessment was excellent, in both cases 9 per cent suggesting surgery. For the 75 lay people, the assessment of the two repeated images was also similar (12 and 16 per cent), which is also seen in the group of 75 orthognathic patients (23 and 24 per cent). For many of the images,
there was generally good agreement among clinicians as to whether treatment is required. There was more variability in the assessment for the patient and lay groups as indicated by fewer very low (less than 25 per cent) and very high percentage (greater than 75 per cent) of the groups suggesting treatment. Taking 50 per cent (i.e. majority) of each observer group as a cut-off where the majority suggested treatment, for orthognathic patients the threshold values of desire for treatment were:

- Patient group: ≥91 and ≤64 degrees;
- Lay people: ≥94 and ≤64 degrees;
- Clinicians: ≥94 and ≤64 degrees.

For observers who considered attractiveness to be important (greater than 2), Figure 5 indicates the proportion suggesting treatment. For orthognathic patients 68/75, for laypeople 71/75, and all clinicians considered attractiveness to be important. Thus lower nasolabial angle deviations above 85 degrees and below 68 degrees were again associated with a higher proportion desiring treatment.

**Discussion**

The nasolabial region is the central aesthetic unit of the face, which may be altered significantly by Le Fort I type maxillary surgery and/or movement of the maxillary incisors in the sagittal plane (1). As such, comprehensive treatment planning must involve an accurate analysis of this region and an understanding of the potential aesthetic changes caused by planned orthodontic treatment or orthognathic surgery, which may be desirable or undesirable. The aesthetic appearance of the nasolabial region in profile view may be a particular source of concern for some individuals, with a considerably increased or reduced nasolabial angle being a significant reason for patients seeking rhinoplasty (12). The ULI, which is the lower component of the nasolabial angle, is a significant facial profile parameter in orthodontic and orthognathic surgical treatment planning.

Normative population values for every facial parameter, such as the nasolabial region, are useful for diagnosis and treatment planning, though such data should be age, gender, and ethnicity specific (13). No longitudinal data is available for the nasolabial angle, though there is some cross-sectional data available (10). Additionally, it is important to assess ranges of variability based on observer perceptions and compare the perception of different groups within a population, as detailed in this study.

The results of this investigation demonstrated that increasing the ULI angle deviation in either direction from an angle of 85 degrees (Image BN) was associated with a reduction in the median attractiveness scores in all three groups of observers. The highest attractiveness scores were for image BN (ULI angle of 85 degrees), closely followed by image CN (angle of 82 degrees) and images DP and EO (angle of 79 degrees). An angle of 76 degrees (image FN) was deemed to be neither attractive nor unattractive, i.e. essentially acceptable, even if not attractive. Therefore, within the range of 73–88 degrees, the images were deemed acceptable. Angles above or below this range, down to 67 degrees and up to 94 degrees were perceived as slightly unattractive, and anything outside the range of 67–94 degrees was deemed very unattractive.

In terms of threshold values of desire for treatment, for orthognathic patients the threshold value was 91 degrees and above and 64 degrees and below, and for both clinicians and lay people the threshold value was 94 degrees and above and 64 degrees and below. In terms of desire for correction, the results of this investigation indicate that clinicians were generally least likely to suggest treatment for varying degrees of ULI angle. In addition, there appears to be a high degree of agreement among clinicians, with the repeatability of the clinician group’s assessment being excellent. The reason for this may be conjectured to be that clinicians develop higher critical capabilities because of their training. The patient group also demonstrated relatively good reliability and agreement, which again may be conjectured to be that the very existence of a facial deformity may lead to patients developing a greater sensitivity to noticeable differences in facial appearance from the norm.

It is generally acknowledged that, as with most facial parameters, the nasolabial angle has a range of normal individual variability. A number of authorities have provided ‘ideal’ values for the nasolabial angle, based on anecdotal evidence and the ‘good eye’ of the respective surgeon. For example, Powell and Humphreys (14) described a range of 90–120 degrees, though in their ‘aesthetic triangle’ they provided a range of 90–105 degrees. Davidson and Murakami (15) provided an angle of 90 degrees in men as ideal, with a range of 100–105 degrees in women. Guyuron (16) described a range of 90–100 degrees in men and 100–108 degrees in women. Rohrich et al. (17) described a range of 90–95 degrees in men and 95–100 degrees in women. Orten and Hilger (18) described a range of 90–95 degrees men and 95–115 degrees in women. Papel and Capone (19) described a range of 90–100 degrees in men and 100–110 degrees in women. Average values, based on anthropometric studies by Farkas et al. (8), for adult Caucasians are 100±12 degrees in males and 104±10 degrees in females. There is ethnic variability, and average values for a Chinese population have been provided as 87±12 degrees in males and 89±11 degrees in females, and in an African-American population as 72±13 degrees in males and 74±15 degrees in females (10). None of the authorities provided separate values for the upper and lower components of the nasolabial angle. However, without this separation, it is not known which of the adjoining aesthetic units, i.e. the upper lip or nasal columella, is outside normal limits and potentially the result of an aesthetic aberration.

The interplay between the inclination of the upper lip and the inclination of the nasal columella is an important determinant in clinical diagnosis and treatment planning. The inclination of the upper lip will depend on both the sagittal position of the anterior maxilla and the inclination of the maxillary incisor teeth. Alteration in either parameter may affect the inclination of the upper lip and nasolabial angle. For example, proclination of the maxillary incisors tends to increase

![Figure 5](image.png)

*Figure 5. Proportion of observers desiring surgery who considered attractiveness to be important.*
the forward inclination of the upper lip, reducing the lower compo-
nent of the nasolabial angle, while not affecting the upper compo-
nent of the nasolabial angle. Conversely, retroclination of proclined
maxillary incisors will reduce the ULI, thereby increasing the lower
component of the nasolabial angle. However, maxillary advancement
at the Le Fort I level will increase the forward inclination of the upper
lip, reducing the lower component of the nasolabial angle, and also
has a tendency to elevate the nasal tip. The impact of such changes on
the upper component of the nasolabial angle suggests that rhinoplast-
ic correction is, more often than not, preferentially undertaken after
orthodontic treatment that will alter maxillary incisor inclination and/or
orthognathic procedures involving the anterior maxillary region.

As the main soft tissue changes induced by maxillary ortho-
nathic surgery are located in the nasolabial region, and as the soft
tissue changes induced by proclination or retroclination of the maxi-
llary incisors primarily affect the inclination of the upper lip, the
results of this study may be valuable both for initial clinical diagno-
sis and for treatment-planning purposes.

However, it should be borne in mind that the profile silhouette
image created was based on white Caucasian proportions and norma-
tive values. Therefore, it is not generalizable to different ethnic
groups and populations. As such, it may not be directly relevant to
other ethnic groups, through it does provide an insight into how dif-
ferent ethnic groups view white Caucasian faces. It would be inter-
esting to repeat the study using images from different ethnic groups.

Conclusions

The results of the present investigation demonstrate that an ULI
between 79 and 85 degrees is viewed by observers as ideal, with a
range of 73–88 degrees deemed acceptable. Angles above or below
this range, down to 67 degrees and up to 94 degrees, are perceived
as slightly unattractive, and anything outside the range of 67–94
degrees is deemed very unattractive.

In terms of threshold values of desire for treatment, for orthog-
nathic patients the threshold value was 91 degrees and above and
64 degrees and below, and for both clinicians and lay people the
threshold value was 94 degrees and above and 64 degrees and below.

Patients appear to be more critical than lay and clinician groups.
This stresses the importance of using patients as observers, as well as
laypeople and clinicians, in facial attractiveness research.

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None.

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