European Journal of Orthodontics 34 (2012) 738–746
doi:10.1093/ejo/cjr098
Advance Access publication 16 August 2011

Assessing the influence of mandibular prominence on perceived attractiveness in the orthognathic patient, clinician, and layperson

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SUMMARY The purpose of this investigation was to undertake an objective and quantitative evaluation of how mandibular prominence influences perceived attractiveness. The mandibular prominence of an idealized profile image was altered in 2 mm increments from −16 to 12 mm, in order to represent retrusion and protrusion of the mandible, respectively. These images were rated on a 7-point Likert scale by a preselected group of pre-treatment orthognathic patients, clinicians, and laypeople. A duplicate image was used to assess intra-examiner reliability.

From the results of this study, it is recommended that in treatment planning to alter the sagittal prominence of the mandible in an individual with an otherwise normal soft tissue facial profile, an 'ideal' sagittal position with soft tissue pogonion on or just behind a true vertical line through subnasale may be used. However, mandibular retrusion up to −4 mm or protrusion up to 2 mm was essentially unnoticeable. Surgery was desired from mandibular protrusions of greater than 3 mm (orthognathic patients and laypeople) and 5 mm (clinicians) and retrusions greater than −8 mm. The overall direction of aesthetic opinion appeared to be the same for all the observer groups; the greater the retrusion or prominence of the lower jaw, the less attractive the perceived attractiveness and the greater the desire for surgical correction. Orthognathic patients were found to be more critical than laypeople, suggesting that in future studies, greater emphasis might be put on evaluating the perceptions of patients as opposed to only a lay population.

Introduction

Pleasing facial profile aesthetics result from relative harmony between the morphology and prominence of the various facial structures observed in profile view. Of these structures, the sagittal prominence of the mandible is an important determinant of facial profile attractiveness (Johnston *et al.*, 2005; Kuroda *et al.*, 2009).

Each facial parameter, such as mandibular prominence, will have an 'average' value or 'norm' for a given population, which is specific for age, gender, and ethnicity. Each of these norms will also have a range of variability, with the existence of a facial deformity often resulting from a significant deviation of one or more facial parameters from the accepted norm for a population. It is important to know at what point the deviation of a facial parameter moves from the limits of the acceptable range of variability into being perceived as a facial deformity (Naini *et al.*, 2011).

The magnitude of the deviation, whether it is due to an underlying dentoskeletal discrepancy, the overlying facial soft tissues, or a combination of the two, is an important factor in decision making when orthognathic surgery may be required. If the magnitude of the discrepancy of a facial parameter is great (for example excessive mandibular prominence), then the treatment planning decision may be relatively straightforward. However, there are a significant number of patients who are regarded as 'borderline' in terms of need for surgical treatment. In such patients, the decision-making process may be transferred from subjective clinical judgement to objective evidence-based guidance based on data from studies investigating perceptions of facial attractiveness (Naini *et al.*, 2008). For example, if the degree of mandibular prominence is being assessed, it may be found that a large percentage of observers find that greater than *x* mm of sagittal mandibular prominence is regarded as unattractive and requiring surgical correction. This would provide objective evidence to guide clinicians when planning treatment.

The principle aim of this investigation was to quantitatively evaluate the influence of sagittal mandibular prominence on perceived attractiveness to find objective evidence to aid clinicians in planning the treatment of patients requiring orthognathic surgery. In addition, the relationship between degree of mandibular prominence and attractiveness was recorded to ascertain the range of normal

variability, in terms of observer acceptance, and determine the clinically significant threshold value or cut-off point, beyond which the degree of mandibular prominence is perceived as unattractive and treatment is desired. Finally, the perception of orthognathic patients, clinicians, and laypeople were compared for these different variables.

Materials and methods

Ethical approval was sought and granted for the study [NRES (UK); REC reference: 06/Q0806/46].

The images

Two-dimensional facial profile silhouettes have been routinely used to assess the perceptions of facial profile attractiveness (Barrer and Ghafari, 1985; Ioi *et al.*, 2005; Johnston *et al.,* 2005).

A facial profile silhouette image was created with computer software (Adobe® Photoshop® CS2 software; Adobe Systems Inc., San Jose, California, USA). The image was then manipulated using the same computer software to construct an 'ideal' facial profile image with proportions (Naini, 2011) and soft tissue measurements (Farkas *et al.*, 1984; Farkas *et al.*, 1985; Farkas *et al.*, 1986; Farkas and Kolar, 1987; Farkas, 1994; Naini, 2011) based on currently accepted criteria:

Facial trisection (facial thirds equal—trichion to glabella, glabella to subnasale, and subnasale to menton); craniofacial tetrasection; lower facial third: upper lip—subnasale to stomion (1/3), lower lip and chin—stomion to menton (2/3); sagittal lip position in relation to E-line; sagittal position of glabella, subnasale, and pogonion to zero degree meridian line; Ideal values for nasofrontal angle; nasofacial angle; nasolabial angle; mentolabial angle; mentolabial depth; lip–chin–throat angle; throat–neck angle; submental length; lips to E-line; lips to S-line.

Contrary to previous studies using cropped profile silhouettes (Johnston *et al.*, 2005) or photographs (Kuroda *et al.*, 2009), it was decided to display the complete profile silhouette image. Cropping the neck would lead to changes in the submental length (Johnston *et al.*, 2005; Kuroda *et al.*, 2009), whereas in the present study, the submental length remained constant throughout the images. It may be reasonable to argue that using the entire profile in this study created a more realistic image, particularly for non-clinical observers.

Profile image manipulation (incremental). The mandibular prominence of the idealized profile image was altered in 2 mm increments from −16 to 12 mm, in order to represent retrusion and protrusion of the lower jaw, respectively (Figure 1).

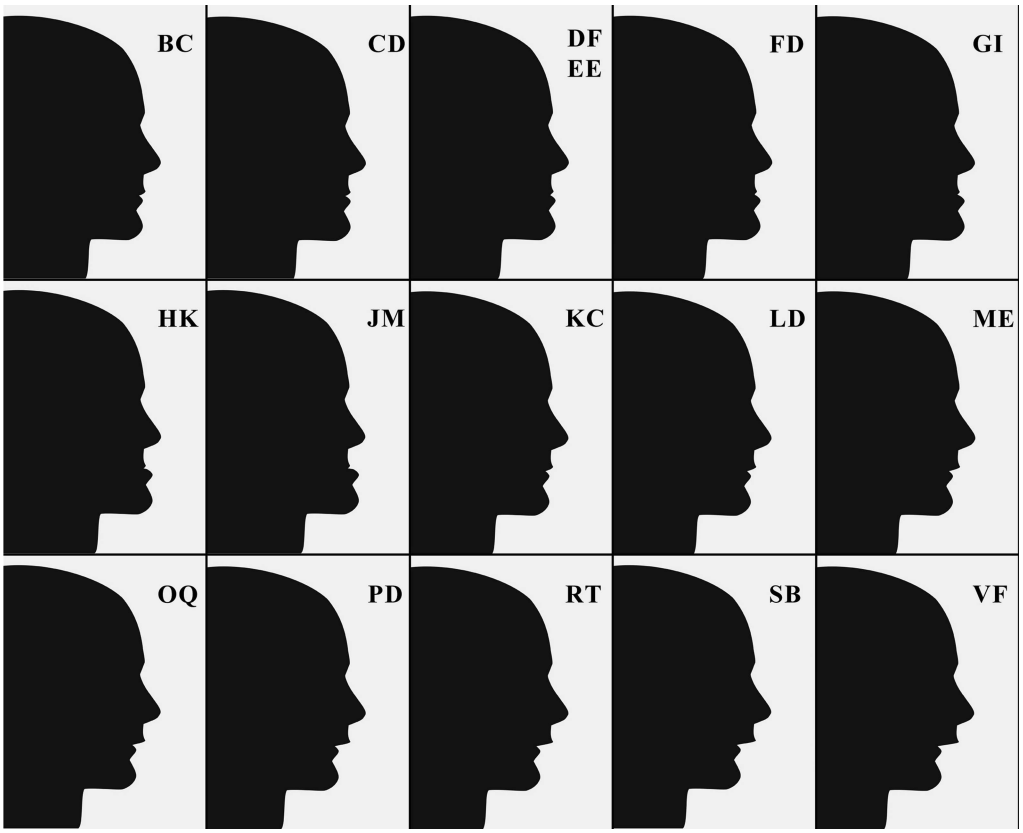

Figure 1 Sagittal mandibular prominence altered in 2 mm increments from −16 to 12 mm.

The observers, questionnaire, and rating method

A pilot study was undertaken in order to perform a power calculation. Based on the results of the pilot study, the anticipated standard deviations of rating were 1.0 in all groups of observers. As such, our study aimed to recruit 75 pre-treatment orthognathic patients, 75 laypeople, and 35 clinicians to guarantee 80 per cent power to detect differences in the mean rating score of approximately 2.5 in the clinician group versus 3.1 in the patient and laypeople groups (this corresponds to a standardized mean difference of 0.6).

Observers. A total of 185 observers took part in the study, separated into three groups (pre-treatment orthognathic patients, laypeople, and clinicians; Table 1). Selection of the three groups of observers followed the selection criteria described below:

- Orthognathic patients:
    - Selection criteria:
        - Pre-treatment
        - Primary concern was facial appearance
        - No previous orthodontic or facial surgical treatment
        - No history of facial trauma
        - No severe psychological issues, e.g. body dysmorphic disorder
- Laypeople:
    - Selection criteria:
        - No previous orthodontic or facial surgical treatment
        - No facial deformities
        - No history of facial trauma
- Clinicians involved in the management of patients with facial deformities.

Questionnaire. Each observer was given a questionnaire and asked to provide the following information: age, gender, ethnic origin, right or left-handedness, how would you rate the attractiveness of your facial appearance, and how important do you think it is to have an attractive facial appearance. An instruction sheet accompanied the questionnaire, asking the observers to rate each image in terms of facial attractiveness using the following rating scale:

1. Extremely unattractive
2. Very unattractive
3. Slightly unattractive
4. Neither attractive or unattractive
5. Slightly attractive
6. Very attractive
7. Extremely attractive

In addition, observers were asked whether they would consider surgery to correct the appearance if this was their facial appearance (yes or no).

The images were placed in random order into the software application Microsoft PowerPoint®. Each image was identified by a randomly assigned double letter in the top right corner of the screen (e.g. BC, CD, DF, etc; Figure 2). A duplicate of one of the images was used in order to assess intra-examiner reliability. Each observer sat undisturbed in the same room in front of the same computer and 17″ flat screen monitor. The presentation and the images were created in such a way that each of the profile silhouette images, when viewed on the 17″ flat screen monitor, had the same dimensions as a normal human head, based around an average lower anterior face height. This would help to reduce

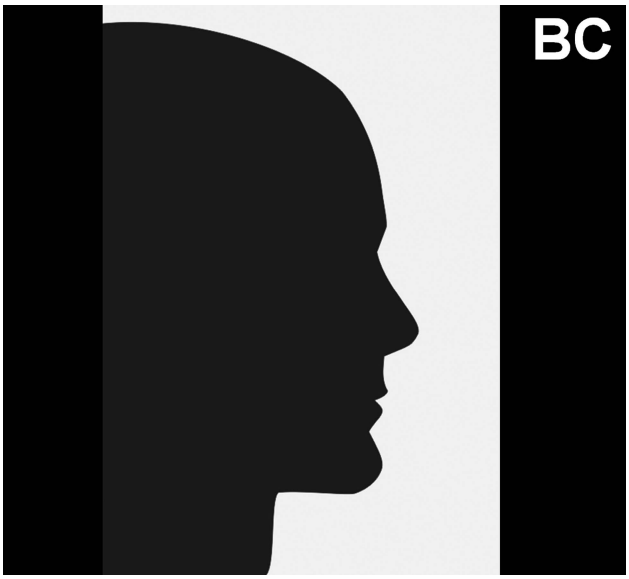

Figure 2 An example of an image viewed by study observers on the monitor during data collection.

Table 1 Observer demographics. CI, confidence interval.

Observer group	Number	Mean age (years)	95% CI	Age range	Gender (% male)	Ethnicity (% white)
Orthognathic patients	75	22	20–24	13–60	42	66
Laypeople	75	31	28–35	16–79	31	49
Clinicians	35	31	30–33	24–39	33	72

the potential effect of image magnification or size reduction on the observer's perception. Each observer examined the images in the PowerPoint® presentation by pressing the 'Page Down' button on the keyboard in their own time.

Rating method. The Likert-type rating scale is largely accepted in the psychology literature as the most useful rating method (Langlois *et al.*, 2000). The 7-point Likert scale described above was used by each observer to rate each image in terms of attractiveness.

Statistical analysis

The observer's ratings were recorded in a Likert scale from 1 to 7. Mixed regression was used to assess the differences in ratings for the three groups (pre-treatment orthognathic patients, laypeople, and clinicians) while adjusting for the concurrent effects of age, gender, ethnicity, and self-rating for facial attractiveness, the importance given to an attractive facial appearance, the observer's antero-posterior jaw relationship (Classes I, II, or III), the observer's vertical face height (average, increased, or decreased), observer's facial asymmetry (yes/no), and the degree of mandibular prominence, i.e. protrusion (mandible forward in position, in millimetres) or retrusion (mandible backward in position, in millimetres). The multivariate regression models are fitted in a stepwise manner, including all those variables that reach a significance below $P = 0.25$ univariately. Given the recognized low power of the relevant test, the benchmark for a significant interaction was set at the 10 per cent level. The mixed regression uses a multilevel approach to take into account the clustering effect by observer. The model was validated using a logarithmic transformation for the rating scale to assess the effect of departure from normality.

Results

The variable 'self-rating of attractiveness' had very few observers in both its border values (very unattractive: seven patients and very attractive: seven laypeople) and therefore was recoded into two levels: attractive ($n = 123$) versus unattractive ($n = 62$). The variable 'vertical face height' was dichotomized into two levels: normal ($n = 166$) versus non-increased/decreased ($n = 19$). Only 11 observers responded that attractiveness was very unimportant (one patient) or unimportant (six patients and four laypeople). As a consequence, this variable was dichotomized as very important versus not very important. There were only 17 left-handed observers in our sample.

All the laypeople and the clinicians were skeletal Class I, while 96 per cent of the patients were skeletal Classes II or III (Table 2). There was no significant difference in perceptions of attractiveness between observer's with skeletal Classes II and III jaw relationships ($P = 0.91$) but they appeared to differ significantly from those with skeletal Class I. When skeletal Class was fitted on the patient group alone, no difference was detected between skeletal Classes II and III ($P = 0.86$).

Reliability analysis

A duplicate of one of the images was used in order to assess intra-examiner reliability. With analysis of variance with random effects for the observers, the variability between observers for replicated images DF and EE was highly significant ($P < 0.0001$): the value of the $F(182,183)$ statistic was 4.3. These results indicate that there was not much variation in the intra-observer ratings for these images. The intra-class correlations was 0.62 [95 per cent confidence interval (CI) 0.53–0.71], representing good reliability.

Perceived attractiveness of images

The univariate and multivariate mixed linear regressions for rating are exhibited in Tables 3 and 4.

On multivariate analysis, the only variable that was found to have a significant effect on rating was the degree and type of mandibular prominence. The mean rating decreased by 0.20 of a level of the Likert scale for each 1 mm increase in the deviation in relation to the normal (95 per cent CI −0.20 to −0.19; $P < 0.001$). Analysis of the entire dataset demonstrated that the mean rating for the 'normal' image (i.e. image BC, with soft tissue pogonion on the true vertical line) was 1.83 levels of the Likert scale (95 per cent CI 1.65–2.02; $P < 0.001$) greater than for those images with negative deviation (mandibular retrusion) and 2.7 levels of the Likert scale greater than for those images with positive deviation (mandibular protrusion). The mean rating for images with positive deviation was 0.86 of a level of the Likert scale less than for images with negative deviation.

Table 2 Observer's jaw relationships.

Jaw relationship (skeletal class)	Orthognathic patients, *N* (%)	Laypeople, *N* (%)	Clinicians, *N* (%)	Total, *N* (%)
Class I	3 (4)	75 (100)	35 (100)	113 (61)
Class II	37 (49.3)	0	0	37 (20)
Class III	35 (46.7)	0	0	35 (19)
Total	75 (100)	75 (100)	35 (100)	185 (100)

Table 3 Univariate mixed linear regression for the outcome rating. CI, confidence interval.

Description	Regression coefficient (gradient)	95% CI for regression coefficient	*P*-value
Age	0.00	0.00 to 0.01	0.47
Gender	−0.17	−0.35 to 0.02	0.07
Ethnicity	−0.04	−0.22 to 0.15	0.70
Handedness (left versus right)	0.06	−0.25 to 0.37	0.70
Self-rating of appearance	0.08	−0.11 to 0.27	0.41
Importance of an attractive appearance	−0.17	−0.37 to 0.02	0.08
Observer's skeletal class (antero-posterior jaw relationship)			0.01
Class II versus I	−0.16	−0.39 to 0.06	0.16
Class III versus I	−0.34	−0.57 to 0.11	0.004
Class I versus II/III	0.25	0.07 to 0.43	0.01
Class I versus II/III (for patients only)	0.32	−0.38 to 1.02	0.37
Observer's vertical lower anterior face height	−0.16	−0.46 to 0.13	0.27
Observer asymmetry (yes versus no)	−0.02	−0.40 to 0.36	0.92
Type of mandibular deviation (protrusion versus 0 versus retrusion)			<0.001
Normal versus retrusion	1.83	1.65 to 2.02	<0.001
Protrusion versus retrusion	−0.86	−0.95 to −0.77	<0.001
Protrusion versus normal	−2.70	−2.90 to −2.50	<0.001
Degree of deviation (mm)	−0.20	−0.20 to −0.19	<0.001
Observer group			0.02
Laypeople versus patients	0.27	0.07 to 0.47	0.01
Clinicians versus patients	0.17	−0.07 to 0.42	0.16
Clinicians versus laypeople	−0.10	−0.34 to 0.14	0.43

Table 4 Multivariate mixed linear regression for rating (n = 185). CI, confidence interval.

	Regression coefficient (gradient)	95% CI for regression coefficient	*P*-value
Gender	−0.14	−0.32 to 0.04	0.13
Importance of an attractive appearance	−0.15	−0.35 to 0.05	0.14
Degree of deviation from normal (mm)	−0.20	−0.20 to −0.19	<0.001
Type of mandibular deviation			<0.001
Normal (zero) versus retrusion	1.83	1.65 to 2.02	<0.001
Protrusion versus retrusion	−0.86	−0.95 to −0.77	<0.001
Protrusion versus normal	−2.70	−2.89 to −2.51	<0.001
Observer group			0.05
Laypeople versus patients	0.24	0.04 to 0.43	0.02
Clinicians versus patients	0.19	−0.05 to 0.43	0.13
Clinicians versus laypeople	−0.05	−0.30 to 0.20	0.70

A significant difference between the observer groups was found ($P = 0.05$). Laypeople gave on average 0.24 of a level of the Likert scale (95 per cent CI 0.04–0.43; $P < 0.001$) greater rating than patients. No significant differences are found between clinicians and patients ($P = 0.13$) or clinicians and laypeople ($P = 0.70$).

Including the observer's skeletal Class in the model, considering just the orthognathic patient group, the most influential variable on rating was the degree of mandibular prominence. The ratings decreased by 0.21 of a level of the Likert scale for each unit increase in the deviation (unit deviation) in the mandible in relation to normal ($P < 0.0001$). Although there was a tendency for skeletal Classes II and III patients to give lower ratings, no significant differences in the rating between the different skeletal Classes were detected ($P = 0.20$).

Outcome: desire for surgery

The univariate and multivariate logistic regressions for the binary outcome 'desire for surgery' are exhibited in Tables 5 and 6. On multivariate logistic regression, observer age, gender, consideration of the importance of an attractive appearance, and the degree of mandibular prominence featured as statistically significant factors on the desire for surgery. The odds of desire for surgery:

- decreased by 2 per cent for each year increase in age of the observer

- was 50 per cent greater for men than for women
- was 48 per cent greater for those who thought attractiveness was very important in relation to those that did not
- was 45 per cent greater for each mm change in the deviation of the mandible from normal
- Increased 3-fold for a positive deviation (protrusion) in relation to a negative deviation (retrusion)

None of the other variables were shown to have any effect. In particular, no significant differences in the desire to have surgery were found between patients, laypeople, and clinicians ($P = 0.39$). No significant effect of skeletal Class was found in the orthognathic patient group (coefficient = 0.34; 95 per cent CI 0.09–1.32; $P = 0.12$).

Mandibular retrusion became noticeable at −4 mm, and mandibular protrusion became noticeable at 2 mm. The results were the same for the three observer groups. The extent of sagittal mandibular prominence above which observers began to desire surgery depended on whether the deviation was protrusive or retrusive but did not differ much between the groups of observers. For mandibular retrusion, the values from which surgery was desired were −8.3 mm for patients, −9 mm for laypeople, and −8.4 mm for clinicians. For mandibular prominence, the values from which surgery was desired were 3.4 mm for patients, 3.1 mm for laypeople, and 4.7 mm for clinicians.

Table 5 Univariate mixed logistic regression for binary outcome: desire for surgery. CI, confidence interval; OR, odds ratio.

Description	OR	95% CI	*P*-value
Age	0.99	0.98 to 1.00	0.004
Gender	1.30	1.01 to 1.67	0.05
Ethnicity	1.17	0.91 to 1.50	0.22
Handedness (left versus right)	0.91	0.59 to 1.38	0.65
Self-rating of appearance	1.01	0.78 to 1.32	0.91
Importance of an attractive appearance	1.28	0.97 to 1.67	0.08
Observer's skeletal class (antero-posterior jaw relationship)			0.44
II versus I	1.09	0.79 to 1.50	0.59
III versus I	1.24	0.89 to 1.71	0.20
Observer's skeletal class (II and III versus I; patients only)	0.34	0.09 to 1.32	0.12
Observer's vertical lower anterior face height	0.89	0.59 to 1.33	0.57
Degree of mandibular prominence (mm)	1.45	1.40 to 1.49	<0.001
Type of mandibular deviation (Protrusion versus. 0 versus. Retrusion)			<0.001
Retrusion versus normal	18.1	10.0 to 32.6	<0.001
Protrusion versus retrusion	2.9	2.4 to 3.4	<0.001
Protrusion versus normal	52.13	28.69 to 94.7	<0.001
Observer group			0.57
Laypeople versus patient	0.94	0.71 to 1.24	0.66
Clinician versus patient	0.83	0.59 to 1.17	0.29
Clinician versus laypeople	0.88	0.63 to 1.24	0.48

Table 6 Multivariate mixed logistic regression for binary outcome: desire for surgery. CI, confidence interval.

	Odds ratio	95% CI	*P*-value
Age	0.98	0.96 to 0.99	0.003
Gender	1.50	1.02 to 2.19	0.04
Importance of an attractive appearance	1.48	0.98 to 2.24	0.06
Degree of prominence (mm)	1.45	1.40 to 1.49	<0.001
Observer group			0.39
Laypeople versus patient	1.26	0.81 to 1.94	0.30
Clinician versus patient	0.91	0.54 to 1.54	0.73
Clinician versus laypeople	0.72	0.43 to 1.21	0.22

Most attractive and least attractive images

The highest rated and thereby most attractive perceived image was BC, representing the idealized facial profile with soft tissue pogonion on the true vertical line (Table 7). Other highly rated images exhibited minor degrees of lower jaw retrusion (KC and LD) or very minor lower jaw prominence (CD). The lowest rated images (JM, HK, and VF) demonstrate the most severe degrees of lower jaw protrusion and retrusion.

Discussion

Physical attractiveness is recognized as an important attribute in psychosocial well-being. The facial profile may be a particular source of concern for some individuals, with a considerably prominent or retrusive lower jaw being a significant reason for patients seeking orthognathic surgery. The appearance of the mandible in profile view is a potentially important determinant of perceived attractiveness and thereby knowledge of perceptions of attractiveness, in addition to average population values, is important for clinicians correcting facial deformities.

Table 7 Mean observer ratings and confidence intervals (CIs), ordered from worse to best rating (positive values represent mandibular protrusion and negative values represent mandibular retrusion).

Image	Mandibular prominence (mm)	Mean	95% CI	Median
JM	12	1.7	1.5 to 1.8	2
HK	10	1.8	1.7 to 2.0	2
VF	−16	2.0	1.9 to 2.1	2
GI	8	2.1	2.0 to 2.3	2
SB	−14	2.4	2.2 to 2.5	2
FD	6	2.5	2.3 to 2.6	2
RT	−12	2.7	2.5 to 2.8	3
EE	4	2.8	2.6 to 2.9	3
PD	−10	2.8	2.6 to 2.9	3
DF	4	2.9	2.8 to 3.0	3
OQ	−8	3.4	3.2 to 3.6	3
ME	−6	4.0	3.9 to 4.2	4
CD	2	4.0	3.9 to 4.2	4
LD	−4	4.9	4.7 to 5.0	5
KC	−2	5.3	5.1 to 5.4	5
BC	0	5.3	5.2 to 5.5	6

A large number of studies have been undertaken to assess the psychological factors involved in perceptions of facial attractiveness (Langlois *et al.*, 2000). However, the purpose of the present investigation was to provide clinically relevant data by evaluating the perceptions of attractiveness for mandibular prominence, in order to provide objective evidence to guide clinicians involved in the treatment planning of patients requiring orthognathic surgery.

In order to determine and validate the correct facial proportions with which to plan clinical treatment, two sources of information are required (Naini *et al.*, 2008). Firstly, population averages, which permit comparison of an individual's facial measurements and proportions to the population norms. Such data must be age, gender, and ethnicity specific. Such data are available from anthropometric studies (Farkas *et al.*, 1985) and long-term cephalometric growth studies of normal individuals (Broadbent *et al.*, 1975). Secondly, the perceived attractiveness of the proportions must be confirmed by the judgement of patients and the lay public and ideally compared to the judgement of treating clinicians. This was the main purpose of this investigation.

A potential limitation of the present study is that a type of observer bias may occur when Likert scales are used, where observers may have an unconscious tendency to avoid extreme categories, thereby essentially constricting the range of possible responses. However, if the worded categories are described clearly, the spectrum of genuine responses should be preserved, which is why the Likert scale is the preferred option in such studies (Langlois *et al.*, 2000).

Influence of the degree and type of mandibular prominence of the image

On multivariate analysis, the only variable that is found to have a significant effect on rating is the degree and type of mandibular prominence. The mean rating decreased by 0.20 of a level of the Likert scale for each 1 mm increase in the deviation in relation to the normal. Analysis of the entire dataset demonstrated that the mean rating for the 'Normal' image (i.e. image BC, with soft tissue pogonion on the true vertical line) was 1.83 levels of the Likert scale greater than for those images with negative deviation (mandibular retrusion) and 2.7 levels of the Likert scale greater than for those images with positive deviation (mandibular protrusion). The mean rating for images with positive deviation was 0.86 of a level of the Likert scale less than for images with negative deviation.

At what degree of prominence does the mandibular profile become so noticeable that patients want (or clinicians or laypeople recommend) surgery to correct it?

The results of this study demonstrate that mandibular retrusion up to −4 mm and protrusion of up to 2 mm is essentially unnoticeable for all three observer groups.

The extent of sagittal mandibular prominence above which observers began to desire surgery depended on whether the deviation was protrusive or retrusive but did not differ much between the groups of observers. For mandibular retrusion, the values from which surgery was desired were approximately −8 mm for patients and clinicians and −9 mm for laypeople. For mandibular prominence, the values from which surgery was desired were approximately 3 mm for patients and laypeople but almost 5 mm for clinicians.

Influence of observer group and professional status

Previous studies have found significant differences between the perceptions of facial profile attractiveness of orthodontists and maxillofacial surgeons compared with laypeople (Cochrane *et al.,* 1999).

In the present study, a significant difference between the observer groups was found ($P = 0.05$), with laypeople giving on average 0.24 of a level of the Likert scale greater rating than patients. No significant differences were found between clinicians and patients ($P = 0.13$) or clinicians and laypeople ($P = 0.70$). The very existence of a mandibular discrepancy may lead to patients developing a greater sensitivity to noticeable differences in facial appearance from the ideal, which may explain their greater critical perception of mandibular prominence in comparison with the lay public. Although clinicians may develop enhanced critical faculties as a result of their training, it appears that in terms of mandibular prominence, their perceptions are similar to the other groups. Previous attractiveness studies on mandibular prominence have not used orthognathic patients as observers (Johnston *et al.*, 2005; Kuroda *et al.*, 2009). The finding that orthognathic patients were more critical than laypeople, suggests that in future studies, greater emphasis might be put on evaluating the perceptions of patients as opposed to only a lay population.

Taking into account the orthognathic patient's skeletal Class, it was found that the most influential variable on rating was the degree of mandibular prominence. The ratings decreased by 0.21 of a level of the Likert scale for each unit deviation (2 mm) in the mandible in relation to normal ($P < 0.0001$). Although there was a tendency for patients with skeletal Classes II and III to give lower ratings, no significant differences in the rating between the different skeletal Classes were detected ($P = 0.20$). Interestingly, although patients were more critical in terms of attractiveness perception, no significant differences in the desire to have surgery were found between the three observer groups.

Desire for surgery

On multivariate logistic regression, observer age, gender, consideration of the importance of an attractive appearance, and the degree of mandibular prominence featured as statistically significant factors on the desire for surgery. The

odds of desire for surgery decreased by 2 per cent for each year increase in observer age, was 50 per cent greater for men, 48 per cent greater for those who thought attractiveness was very important in relation to those that did not, and was 45 per cent greater for each mm change in the deviation of the mandible from normal. A difference was detected comparing mandibular protrusion and retrusion, with a 3-fold increase in desire for surgery for protrusion in relation to retrusion.

None of the other variables were shown to have any effect. In particular, no significant differences in the desire to have surgery were found between patients, laypeople, and clinicians ($P = 0.39$). No significant effect of skeletal Class was found in the orthognathic patient group.

Most attractive and least attractive images

The highest rated and thereby most attractive perceived image was BC, representing the idealized facial profile with soft tissue pogonion on the true vertical line and with the lower lip just posterior to the upper lip. Other highly rated images exhibited minor degrees of lower jaw retrusion of up to −4 mm or very minor lower jaw prominence of 2 mm. The lowest rated images demonstrated the most severe degrees of lower jaw protrusion (JM and HK) and retrusion (VF). The overall trend demonstrates that milder degrees of lower jaw retrusion and protrusion were rated as more attractive and greater degrees of deviation were rated as progressively less attractive, though the tendency was for lower jaw protrusion to be perceived as less attractive than retrusion.

Johnston *et al.* (2005) carried out an attractiveness study of mandibular prominence using profile silhouettes. They found that their image based on an SNB angle of 78 degrees was considered by the lay judges as the most attractive. Interestingly, the use of a cephalometric value such as the SNB angle to analyse a facial soft tissue variable such as mandibular prominence is open to debate, particularly as the SNB angle alters with changes in the S–N plane and has no influence on the sagittal position or morphology of the lower lip or soft tissue chin. However, analysis of the silhouette image they described as rated highest demonstrates an almost straight profile, with the lower lip in line with a vertical line through subnasale, and the chin only just posterior to this line.

There is previous evidence that Class II profiles are regarded as less attractive than Class III profiles in some western countries (Czarnecki *et al.*, 1993; Michiels and Sather, 1994; Cochrane *et al.*, 1999; Johnston *et al.*, 2005), but the results of the present study do not provide confirmation as overall mandibular protrusion appeared to be less attractive than mandibular retrusion. Perhaps, a patient's ability to posture the mandible forwards to disguise a Class II discrepancy may explain why Class II discrepancies may be better tolerated than Class III, though this is merely conjecture.

There is also evidence that the Class I profile is more attractive than Class II or Class III profiles (Kerr and O'Donnell, 1990; Phillips *et al.*, 1995; Hönn et al., 2005; Ioi et al., 2007). The results of the present study confirm this, as the ideal orthognathic (straight) profile, with soft tissue pogonion on the true vertical line (image BC), was rated as the most attractive image. Interestingly, in a Japanese population, Ioi *et al.* (2007) found that although observers tended to choose Class II profiles as more acceptable than Class III profiles for both males and females, patients with Class III profiles tended to seek surgical orthodontic treatment more often. The results of the present study demonstrate that although lower jaw deviations from the ideal are noticeable from greater than approximately −4 mm retrusion or 2 mm protrusion, surgery is desired with relatively smaller protrusive deviations (from 3 to 5 mm) compared to retrusive deviations (from −8 to −9 mm).

The results of this investigation support previous empirical evidence that mild mandibular deviation in the sagittal plane is compatible with an attractive facial appearance, and an orthognathic profile is 'ideal'. For example, the zero degree meridian (Gonzalez-Ulloa and Stevens, 1968) is an aesthetic profile line, proposing that soft tissue pogonion should be on this vertical line dropped from soft tissue nasion, perpendicular to the Frankfort Horizontal plane, with subnasale on or close to this line. However, there is evidence that the zero degree meridian line is based on facial profile analyses previously described in the Renaissance by Leonardo da Vinci (c. 1490) and Albrecht Dürer (c. 1528), both of whose work was based on anthropometric measurements of attractive individuals rather than merely empirical (Naini, 2011).

Objective evidence from normative population samples (Subtelny, 1959; Worms *et al.*, 1976; Farkas *et al.*, 1985; Bhatia and Leighton, 1993) demonstrates that the angle of soft tissue profile convexity of the lower face tends to be with the lower jaw slightly retrusive; none of the normative population data demonstrates mandibular protrusion or a Class III profile as within normal limits. Such population data corroborate the results of the present study, in that mandibular protrusion appears to be less attractive and also leads to a greater desire for surgical correction than mandibular retrusion. An attractiveness study in a lay Japanese population, using a cropped profile photograph of a Japanese woman, also found that mandibular retrusion was generally more favoured than mandibular protrusion (Kuroda *et al.*, 2009). However, it contradicts previous findings that Class II profiles are regarded as less attractive than Class III profiles (Czarnecki *et al.*, 1993; Michiels and Sather, 1994; Cochrane *et al.*, 1999; Johnston *et al.*, 2005).

Conclusions

1. From the results of this study, it is recommended that in treatment planning to alter the sagittal prominence of the mandible in an individual with an otherwise normal soft

tissue facial profile, an ideal sagittal position with soft tissue pogonion on or just behind a true vertical line through subnasale may be used, with the lower lip just posterior to the upper lip, although mandibular retrusion up to −4 mm or protrusion up to 2 mm were essentially unnoticeable.
2. Surgery was desired from mandibular protrusions of greater than 3 mm (orthognathic patients and laypeople) and 5 mm (clinicians) and retrusions greater than approximately −8 mm.
3. The overall direction of aesthetic opinion appeared to be the same for all the observer groups; the greater the retrusion or prominence of the lower jaw, the less attractive the perceived attractiveness and the greater the desire for surgical correction.
4. Orthognathic patients were found to be more critical than laypeople, suggesting that in future studies, greater emphasis might be put on evaluating the perceptions of patients as opposed to only a lay population.

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