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Aesthetic evaluation of profile incisor inclination

Nathalie Ghaleb, Joseph Bouserhal and Nayla Bassil-Nassif
Department of Orthodontics, Faculty of Dental Medicine, Medical Sciences Campus, Saint-Joseph University, Beirut, Lebanon

Correspondence to: Dr Nayla Bassil-Nassif, Department of Orthodontics, Faculty of Dental Medicine, Medical Sciences Campus, Saint-Joseph University, Damas Street, PO Box 11-5076, Riad El Solh, Beirut 11072180, Lebanon. E-mail: nayla.bassilnassif@usj.edu.lb

SUMMARY The objectives of this study were to evaluate (1) the impact of maxillary incisor inclination on the aesthetics of the profile view of a smile, (2) to determine the most aesthetic inclination in the profile view of a smile and correlate it with facial features, and (3) to determine if dentists, orthodontists, and laypeople appreciate differently incisor inclination in smile aesthetics.

A smiling profile photograph of a female subject (22 years of age) who fulfilled the criteria of soft tissue normative values and a balanced smile was obtained. The photograph was manipulated to simulate six lingual and labial inclinations at 5 degree increments to a maximum of 15 degrees. The seven photographs were randomly distributed in a binder to three groups of raters (30 dentists, 30 orthodontists, and 30 laypeople) who scored the attractiveness of the photographic variations using a visual analogue scale. Comparison of the mean scores was carried out by repeated analysis of variance, univariate tests, and multiple Bonferroni comparisons.

The results showed a statistically significant interaction between the rater's profession and the aesthetic preference of incisor inclination ($P = 0.013$). The profile smile corresponding to an increase of 5 degrees in a labial direction had the highest score among all professions and among male and female raters. Orthodontists preferred labial crown torque; dentists and laypeople did not appreciate excessive incisor inclination in either the lingual or the labial directions. The most preferred smile matched with a maxillary incisor inclined 93 degrees to the horizontal line and +7 degrees to the lower facial third.

Introduction

The smile as an important feature in daily life should be of interest to orthodontists. It is an essential asset for psychosocial adaptation: people with beautiful teeth and smiles are considered more attractive, more intelligent, and more popular with the opposite gender (Shaw *et al.*, 1985; Beall, 2007).

There are a number of reports in the orthodontic literature concerning the frontal view of the smile, whereas the lateral view is still unexplored. Sarver and Ackerman (2003) focused their treatment planning on analysis of the smile in all dimensions: in the profile view, the incisor inclination is of importance. Kerns *et al.* (1997) found that profile and frontal views of the same smile were not similarly rated for aesthetic appeal: the profile views were rated higher than the frontal views of the same smile. These findings suggest that orthodontists should consider both frontal and lateral views when planning and assessing orthodontic treatment (Sarver and Proffit, 2005).

From an aesthetic viewpoint, Schlosser *et al.* (2005) found it preferable to either leave a normally protrusive maxillary dentition in its original position or advance rather than retract the maxillary anterior teeth. On the other hand, among the factors that negatively influence the smile and give the face an 'old' appearance, is lingual inclination of the upper incisors as a result of loss of torque (Lamarque, 1999).

Several cephalometric standards have been introduced to assess the attractiveness of the face; yet it has been shown that good facial harmony can exist within a wide range of cephalometric values (Peck and Peck, 1970; Moss *et al.*, 1995), and even a well-treated orthodontic case in which the final records meet every criterion of the American Board of Orthodontics for successful treatment may not produce an aesthetic smile (Schabel *et al.*, 2008). Beside, professional opinions regarding evaluation of smile aesthetics may not coincide with the perceptions and expectations of laypeople (Johnston *et al.*, 1999; Kokich *et al.*, 1999; Thomas *et al.*, 2003; Roden-Johnson *et al.*, 2005; Parekh *et al.*, 2006). Ideally, the buccal face of the maxillary incisors should be vertical and parallel to the frontal plane of the face (Philippe, 1987).

The purposes of this study were 3-fold: (1) to evaluate the impact of maxillary incisor inclination on the aesthetics of the profile view of a smile, (2) to determine the most aesthetic inclination in the profile view of a smile and to correlate it with facial features, and (3) to determine if dentists, orthodontists, and laypeople appreciate differently incisor inclination in smile aesthetics.

Subject and methods

Subject

An undergraduate female dental student (age 22 years) was chosen from the Faculty of Dental Medicine at Saint-Joseph

University, Lebanon. An informed signed consent form was obtained from the subject. The clinical and lateral cephalometric examinations showed that she met the following criteria: (1) harmonious smile in both frontal and profile views, (2) Class I canine and Class II molar relationship with adequate overjet and overbite, (3) maxillary incisors well positioned according to cephalometric standards (Table 1), and (4) profilometric measurements within the normal range (Table 2). A right smiling lateral profile photograph, with the subject's head horizontal, was taken with a Canon Power Shot Pro1 digital camera (Canon, Oita, Japan) and was used for computer-aided alterations. The use of image alterations of a single subject has been shown to be successful in studying variations in dental appearance (Wagner *et al.*, 1996).

Image alteration

The smiling photograph was altered using a commercially available image editing software program (Adobe Photoshop CS, version 8.0; Adobe Systems Inc., San Jose, California, USA). One parameter was changed: the inclination of the upper incisors. The crowns of the central and lateral incisors were separately cut by this program. Each tooth was considered as an object with a centre of rotation (CRO) at the incisal edge. For the central incisor, the CRO was the incisal tip superimposed from the tracing of lateral cephalogram. For the lateral incisor, the CRO was chosen as the midpoint of the mesio-distal width of the incisal edge for the basis of symmetry. Horizontal tangents to the incisal edges of both maxillary incisors were traced to preserve vertical positions. The vertical tangent medial to the canine was the distal limit for sagittal repositioning of the lateral incisor, followed by the central incisor.

Each simulation was in 5 degree increments: three modifications in the labial direction and three in the lingual or palatal direction were produced. Artistic editing was undertaken when necessary to maintain a natural appearance. Seven final images were obtained (three lingual, three labial, and one unaltered; Figure 1) and printed separately on Digital Royal Paper (Kodak; Rochester, New York, USA) with the Canon Pixma iP5300 printer in a 15 × 20 cm format and then randomly placed in a binder.

Table 1 Values of initial maxillary incisor inclination of the subject compared with the values of Bumann *et al.*, (1994).

Incisor inclination	Norm	Subject
I/SN (°)	102–105	107
I/FH (°)	111 ± 5	112
I/PBS (°)	70 ± 5	64
I/A–Pog (°)	26	28
I/NA (°)	22 ± 4	24

Table 2 Values of facial profile of the subject according to Arnett and Bergman (1993) and Fitzgerald *et al.* (1992). SD, standard deviation.

Measurement	Norm (SD)	Subject
Facial angle (°)	87.85 (1.71)	87
Angle of convexity (°)	0.65 (5.30)	4.5
ANB (°)	2.18 (1.97)	2
SGn/FH (°°)	57.52 (3.32)	58
SGn/Sn (°)	66.32 (4.14)	61
FMA (°)	20.54 (5.59)	24
Naso-labial angle (°)	114.08 (9.58)	113
Profile angle (G′–Sn–Pg′) (°)	165–175	167
Nasal projection (Sn–NT; mm)	16–20	17
Upper lip/Sn–Pg′ (mm)	+3.5 (1.4)	+2
Lower lip/Sn–Pg′ (mm)	+2.2 (±1.6)	+1.5

Judges

Three panels were formed: dentists (22 males and 8 females), orthodontists (21 males and 9 females), and laypeople (9 males and 21 females) to judge the profile photographs. Their mean ages and standard deviations (SD) were dentists (37.27 years, SD = 9.055), orthodontists (35.87 years, SD = 7.523), and laypeople (32.47 years, SD = 9.605).

The dentists and orthodontists had completed their professional training and were in private practice. The lay panel consisted of adult subjects (more than 18 years), college educated but with no link to dentistry. No gender control was made for any group.

Incisor inclinations

Incisor inclination is generally measured using linear and angular measurements compared with the cranial base or the maxilla (Bumann *et al.*, 1994). Recently, the antero-posterior position of the maxillary incisor was correlated with the forehead (Schlosser *et al.*, 2005; Andrews, 2008). Since the aim of this study was to determine the aesthetic impact of incisor inclination and knowing that orthodontic treatment can only influence the lower facial third, an attempt to measure it according to the surrounding facial features, such as the horizontal line and the lower facial third, was undertaken.

The profile photograph was taken with the head placed in the 'aesthetic position' as recommended by Bass (2003): it is a corrected natural head position adjusted by the clinician so that the face does not appear to be tilted up or down. The horizontal line ('Hr') is an aesthetic horizontal that is not modified by treatment. It is a reference line if the chin position is modified by orthopaedic or orthognathic correction. The Sn–Pg′ line, joining sub-nasal point (deepest point on the curve where the profile of the nose joins the lip) to facial pogonion, represents the lower facial third, i.e. the nearest reference part of the face to the incisors.

Figure 1 Initial photograph of the subject and the six modifications (three in the lingual direction and three in the buccal direction).

For each photograph, the following steps were carried out to obtain angular measurements:

1. Drawing of the line Sn–Pg′ and of a horizontal line Hr passing through the mid-third.
2. Determining the most anterior point of the labial surface of the maxillary incisor (obtained by the intersection of this surface with the vertical tangent).
3. Drawing the tangent 'Tg' passing through this point.

Two angular measurements for each inclination were obtained (Figure 2): Tg/Hr: angle between incisor inclination and aesthetic horizontal and Tg/Sn–Pg′: angle between incisor inclination and lower facial third. This angle has a positive value when the tangent is forward and a negative value when the tangent is backward.

The angular measurements of the seven photographs are shown in Table 3.

Rating of photographs

To assess aesthetic preference among the three groups, a survey was carried out twice with a minimum interval of 2 weeks, and the order of the seven photographs was randomly changed between the first and second evaluation.

Each judge received a binder containing the photographs and seven scales. The judges were asked to mark, with a vertical line, his or her assessments of smile attractiveness of the subject on the 100 mm visual analogue scales (VAS). The VAS was anchored by the descriptors 'very unattractive', 'unattractive', 'average', 'attractive', and 'very attractive'. A VAS has been

found to provide rapid, valid, and reproducible ratings of dental and facial appearance (Howells and Shaw, 1985). The judges were given specific instructions on the use of the scale but no images with which to practice. No specific information was given regarding the faces they were to see, except that the subject was female and they were appreciating her smile. Each judge was asked to rate the attractiveness of the smiles and to note, when possible, the criteria that lead to this choice. The judges viewed all the photographs first and then began the ratings. They were asked not to return to any previously rated photographs as they progressed through the binder. The same observer gave the instructions for all 90 judges.

Data collection and analysis

The same observer (NG) undertook all measurements to the nearest 0.50 mm with a millimetre ruler. The very unattractive extreme scored 0 and very attractive extreme scored 100.

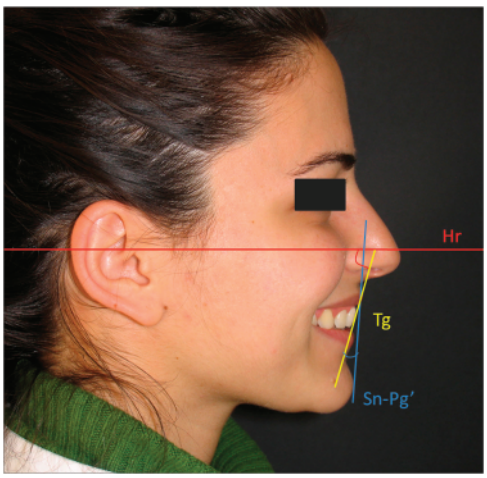

Figure 2 Angular measurements of incisor inclination on a smiling profile photograph. Hr: horizontal line with the profile photograph taken with the head placed in the aesthetic position recommended by Bass (2003) (the face does not appear to be tilted up or down); Tg: tangent to the labial surface of the maxillary central incisor; Sn–Pg′: line joining sub-nasal point Sn (deepest point on the curve where the profile of the nose joins the lip) to facial pogonion Pg′.

Table 3 Angular measurements of incisor inclination of the face, in the seven photographs.

Photograph	Angle Tg/Hr(°)	Angle Tg/Sn–Pg′(°)
−15°	76	−10
−10°	82	−4
−5°	84	−2
Initial	89	+3
+5°	93	+7
+10°	94	+8.5
+15°	97.5	+12

Tg/Hr: angle between incisor inclination and aesthetic horizontal; Tg/Sn–Pg′: angle between incisor inclination and lower facial third (positive value when the tangent is forward and negative value when the tangent is backward).

Every evaluator scored each photograph twice: the mean score was used for statistical comparisons (Table 4).

Data analysis was conducted using the Statistical Package for Social Sciences for Windows version 15.0 (SPSS Inc., Chicago, Illinois, USA). The judgement criterion was the millimetric measurement obtained from the VAS that corresponded with the subjective appreciation of incisor inclination from a profile view of a smile.

Reproducibility among scores between the two evaluations was tested using the intraclass coefficient correlation (ICC) with a 95 per cent confidence interval. One-way between-groups analysis of variance (ANOVA) was used for determination of significant difference in the mean ages between the dentists, orthodontists, and laymen. Mixed between–within-subjects ANOVA (Tabachnick and Fidell, 2001), also referred to as split plot ANOVA, was used for determination of significant differences in the mean scores based on two independent variables: the between-subject variable (profession), the within-subject variable (incisor inclination in each photograph) followed by analyses of simple effects, and Bonferroni multiple comparisons.

These tests were preceded by repeated measures ANOVA based on three independent variables (profession, incisor inclination, and gender) to ensure that the factor 'gender' had not influenced the results.

To determine the criterion that lead the three panel groups to their choice of score for smile attractiveness, chi-square or Fisher's exact tests were conducted to determine significant differences between the frequencies of the evaluators.

The level of significance was set at 0.05 for all statistical tests. The factors were panel (dentist, orthodontist, and laysubject) and photograph (seven variations). Scores were standardized to Z scores to remove interexaminer variation in scale use while preserving any differential effects between panels, as suggested by Johnston *et al.* (1999). The standardization formula (per judge) was as follows:

$$Z \text{ score} = \frac{\text{Attractiveness rating of the photograph -Judge's means rating score}}{\text{Judge's standard deviation}}.$$

Table 4 Attractiveness rating scores [mean and standard deviation (SD)] of the three groups of the panelists in millimetres of the seven photographs.

Photograph	Dentists ($N = 30$)		Orthodontists ($N = 30$)		Laypeople ($N = 30$)	
	Mean (mm)	SD	Mean (mm)	SD	Mean (mm)	SD
−15°	35.30	17.73	25.79	12.39	35.14	16.07
−10°	41.43	16.30	33.57	12.01	41.69	12.95
−5°	55.71	11.91	52.30	14.08	54.07	10.35
Initial	63.03	10.67	61.49	11.61	61.54	13.11
+5°	70.27	13.98	71.67	12.16	65.66	14.29
+10°	56.07	16.79	62.23	13.62	49.99	14.84
+15°	36.74	18.94	41.40	15.31	29.97	19.42

Results

Non-standardized scores were used in this study as no differences were found between the analyses.

Reliability

Since each judge scored every photograph twice, reliability of the ratings was tested using the ICC. For attractiveness, the overall ICC for rating the same photograph was 0.622 (0.57–0.67), with orthodontists, dentists, and laysubjects showing reliability of 0.696 (0.62–0.76), 0.647 (0.56–0.72), and 0.522 (0.41–0.61), respectively. The judge's scores were moderately reliable with a 95 per cent confidence level.

Statistical analysis

Age comparison showed no statistical difference between the three groups of panelist ($F = 2.376$, $P = 0.099$). The analysis of scores showed that photograph +5 degrees was scored highest by all groups (53.33 per cent of dentists, 60 per cent of orthodontists, and 53 per cent of laypeople).

While exploring the impact of incisor inclination on smile aesthetics, a significant interaction effect was found between incisor inclination and panel profession (Wilk's Lambda, $F = 2.224$, $P = 0.013$), which was the same among male and female raters ($P = 0.643$, Wilk's Lambda). Figure 3 shows the interaction profile plot in which the *y*-axis represents the scores in millimetres and the *x*-axis the photographs. It shows that the modification of incisor inclination can be differently perceived according to the judge's profession.

Follow-up tests to explore this relationship were carried out using analyses of simple effects. The intrasubject effect (photograph) for each group was tested using repeated measure ANOVA of variance followed by pairwise comparisons using Bonferroni adjustment. The intersubject effect (profession) for each group of photographs: (−15 and −10 degrees), (−5, initial, and +5 degrees), and (+10 and +15 degrees) was tested using the mixed between–within subjects ANOVA followed by pairwise comparisons using the Bonferroni adjustment.

A statistically significant difference between the appreciations of photographs by each profession was found ($P < 0.01$) which was not different between male and female raters ($P = 0.09$, Wilk's Lambda). For each profession, additional multiple comparisons detected whether judges appreciate differently the smile aesthetics: the photograph +5 degrees was the most appreciated by the dentists and orthodontists, whereas photographs +5 degrees and initial ($P = 1.00$) were aesthetically preferred by the lay panel. On the other hand, photographs −15, −10, and +15 degrees were not appreciated by dentist and lay panels, while only −15 and −10 degrees had the lowest scores in the orthodontist panel. The image +15 degrees was aesthetically acceptable but only by orthodontists (Figure 4).

When comparing the scores of statistically different inclinations between the three groups of judges; for extreme lingual inclinations (−15 and −10 degrees), orthodontists gave significantly lower scores than dentists ($P = 0.04$) and laypeople ($P = 0.04$), whereas dentists and laypeople gave similar scores ($P = 1.00$). For moderate inclinations (−5, initial, and +5 degrees), no statistical difference was found between the three professions ($P = 0.53$). For extreme labial inclinations (+10 and +15 degrees), the scores of orthodontists were statistically higher than those of laypeople ($P = 0.01$) while the scores of dentists were intermediate.

When the evaluators were asked what criteria lead to their choice of smile attractiveness, despite incisor inclination, which was the principal criterion among the three groups, other characteristics were also mentioned (Table 5). The

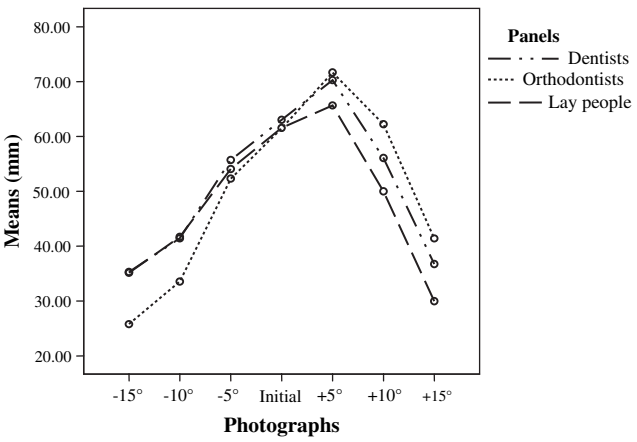

Figure 3 Profile plots of the sample mean of the photograph for the three groups of panelists.

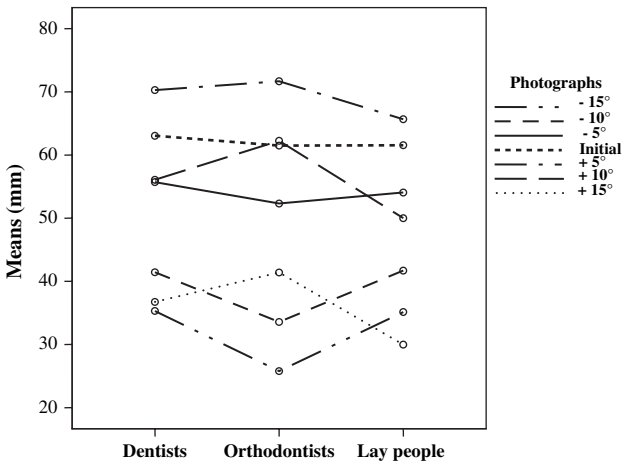

Figure 4 Profile plots of the sample mean for all photographs.

Table 5 Descriptive and significance of most cited criteria that lead the three groups of panels to their choice of score for smile attractiveness.

Panel \ Criteria	Incisor inclination, *n* (%)	Relationship of incisor inclination with lips and face, *n* (%)	Harmonious smile, *n* (%)	Parallelism of the central and lateral incisor axes, *n* (%)	Gingival display, *n* (%)	Other, *n* (%)
Orthodontists ($N = 30$)	30 (100)	7 (23.33)	0 (0)	3 (10)	1 (3.33)	2 (6.66)
Dentists ($N = 30$)	30 (100)	13 (43.33)	7 (23.33)	6 (20)	8 (26.66)	6 (20)
Laysubjects ($N = 30$)	29 (96.66)	5 (16.66)	16 (53.33)	7 (23.33)	2 (6.66)	6 (20)
P value	1.00	0.06	<0.01	0.37	0.02	0.29

pleasantness and harmony of the smile significantly influenced 53.33 per cent of laysubjects' scores ($P < 0.01$, chi-square test), and the gingival display affected 26.66 per cent of dentists' scores ($P = 0.02$, Fisher's exact test).

Regarding smile aesthetics in total facial concept, the preferred smile matched with an upper incisor angulated 93 degrees to the horizontal line and +7 degrees to the lower facial third.

Discussion

Enhancing smile attractiveness relies on a multifactorial process: one that can easily be controlled is maxillary incisor position. These teeth should be angulated and also positioned favourably in their antero-posterior and vertical relationships to all facial structures to ensure maximum facial harmony (Janzen, 1977).

The vertical dimension of incisors is mostly determined by lip contour: at rest, the lower edge of the upper incisors should touch the upper vermillion of the lower lip (Zachrisson, 1998; Frindel, 2001). When smiling, most orthodontists and dentists prefer that the elevation of the lip stops at the gingival margins of the maxillary incisors; some amount of gingival display is certainly acceptable and, in many cases, is even aesthetic and results in a youthful appearance (Sarver, 2001; Sarver and Ackerman, 2003; Sarver and Proffit, 2005). The absence of alignment between the lower lip and the edge of the maxillary incisors detracts from the beauty of the smile in both the frontal and lateral views (Sarver, 2001).

Moreover, bucco-lingual inclination of the maxillary incisors has a major effect on profile smile attractiveness (Sarver and Ackerman, 2003; Sarver and Proffit, 2005). Lingual inclination, characterized by torque loss, was found to be one factor leading to an unpleasant smile and to an 'old' appearance (Mackley, 1993; De Brondeau *et al.*, 2001). When comparing smile aesthetics in treated (with and without extractions) and untreated subjects, Işiksal *et al.* (2006) reported a statistical difference between the inclinations of the maxillary central incisors (measured to the SN line): it seems that the maxillary incisors needed more labial crown torque after retraction in the extraction group. However, the difference did not affect smile aesthetics in their three groups (extraction, non-extraction, and control). Furthermore, their results indicated that increasing the U1–SN (the angle between the upper central incisor and SN line) would cause deterioration of smile aesthetics.

The advance in the present study was to emphasize the importance of incisor inclination in smile attractiveness. When the judges were asked to specify which criteria led to their appreciations, the majority was susceptible to incisor modifications (Table 5), with the orthodontists being more sensitive. The most criticized factors of unattractive smiles were: exaggerated retrusion and protrusion of the incisors, lack of parallelism between the crown axes of the central and lateral incisors, 'rabitting', gingival display, tipping of the lateral incisor, increased overjet, and disharmony between incisor position and lip contour. It is important to note that the morphology of the lateral incisor (distal-incisal edge angulated) might negatively have influenced smile aesthetics, especially in the labial modifications (+10 and +15 degrees), simulating tipped angulations. Thus, greater consideration should be given to the choice of incisor morphology in similar aesthetic studies.

To quantify innate feelings about the impact of incisor inclination on smile aesthetics, an anchored scale (VAS) was used. This method has been endorsed by many investigators for use in attractiveness ratings because of its simplicity and ease of use (Tedesco *et al.*, 1983; Howells and Shaw, 1985). It avoids the bias towards preferred values that is found with numeric or interval scales and allows a better examination of the amount and significance of differences (Howells and Shaw, 1985).

Complete profile photographs, not dental views only, have been used to obtain a true evaluation of attractiveness (Flores-Mir *et al.*, 2004). Beside the notion of facial distractions such as nose, hair, eyebrows, etc. with full profile photographs, the variety of professions led to a wide range of aesthetic opinions and subsequently large standard deviations especially in the lay panel.

As mentioned previously, Schlosser *et al.* (2005) in a similar study, but with antero-posterior movements without any torque variations, found higher aesthetic scores for protrusive maxillary incisors. There is unquestionably a very close relationship between smile aesthetics and orientation of the teeth: the present results showed that the best smile corresponded to a well-angulated maxillary incisor. Not only the anterior position of the maxillary incisor is preferred but also its labial crown torque (Mackley, 1993; Lamarque, 1999; De Brondeau *et al.*, 2001; Işıksal *et al.*, 2006). Aesthetically, the preferred smile was of the modification of 5 degrees augmentation in the labial direction, i.e. a supernormal or, in this case, an increased inclination is the most accepted for optimal smile aesthetics. This finding is contrary to the results of Işıksal *et al.* (2006) who stated that increasing incisor inclination, to the SN line, would cause smile aesthetics to deteriorate and that incisor inclination does not affect smile attractiveness. This contradiction might be caused by the difference in the nature of the photographs since the present study used lateral facial coloured photographs while the sample of Işıksal *et al.* (2006) consisted of lower face frontal and three-quarter black and white photographs.

Furthermore, an additional aim in the present study was to correlate incisor inclination with facial profile in order to create an aesthetic outcome for the patient without restriction to cephalometric values. In the lateral photographic position, the aesthetically desired smile had an upper incisor inclined 93 degrees to the horizontal line and +7 degrees to the lower facial third, represented by the Sn–Pg′ line. As bucco-lingual incisor inclination can differ according to the vertical growth pattern of each subject (Ross *et al.*, 1990), the use of torque values related to the occlusal plane were avoided with this method.

Cephalometric standards should not be the main goal of orthodontists: they must be a general guide and a complement to visual aesthetic appreciation. This is in agreement with the results of Schabel *et al.* (2008) who suggested that additional criteria might be incorporated into the assessment of overall orthodontic treatment outcome, including variables evaluating the smile. In the present investigation, incisor inclination above normal standard values was preferred by the three panel groups for optimal smile aesthetics in the profile view. Some authors have reported torque loss with age (Crétot, 1997; Devreese *et al.*, 2007) and since achievement of adequate maxillary incisor inclination or torque is necessary for both function and aesthetics, orthodontists should be careful to avoid movements causing torque loss.

Further investigations in which a male subject is chosen, taking into account sexual dimorphism, could strengthen the results and provide additional conclusions regarding the contribution of incisor inclination to smile attractiveness.

Conclusions

1. Upper incisor inclination affects smile aesthetics in the profile view.
2. There is significant interaction effect between appreciation of incisor inclination and the judge's profession.
3. Incisor inclination above normal standard values was preferred by all panels for optimum smile aesthetics.
4. In the aesthetic photographic position, the preferred incisor is angulated 93 degrees to the horizontal line and +7 degrees to the lower facial third.
5. Orthodontists tend to prefer labial crown torque in comparison with lingual crown inclination.

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