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Analysis of the soft tissue facial profile by means of angular measurements

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SUMMARY An aesthetically pleasing and balanced face is one of the objectives of orthodontic treatment. An understanding of the soft tissues and their normal ranges enables a treatment plan to be formulated to normalize the facial traits for a given individual. The aim of this study was to evaluate the variables defining the soft tissue facial profile of a Croatian (Caucasian) sample, by means of angular measurements typically used for aesthetic treatment goals. Additionally, gender differences were tested. The soft tissue facial profiles of 110 dental students (52 males and 58 females) between 23 and 28 years of age at the University of Zagreb, Croatia, with a dental Class I occlusal relationship and harmonious soft tissue profile were studied by means of standardized photographs taken in the natural head position (NHP). To compare males and females, a Student's *t*-test was used. The reliability of the method was analysed using Dahlberg's formula.

There were distinct gender differences. All angles were larger in females: nasofrontal (G–N–Nd, females = 139.11 degrees; males 136.38 degrees; $P = 0.030$), nasolabial (Cm–Sn–Ls, females = 109.39 degrees; males = 105.42 degrees; $P = 0.018$), mentolabial (Li–Sm–Pg, females = 134.5 degrees; males = 129.26 degrees; $P = 0.019$), and nasal tip angle (N–Prn–Cm, female = 84.12 degrees; male = 79.85; $P = 0.001$). The greatest variability was found for mentolabial angle.

The findings demonstrate a distinct profile trait for female Croatian patients compared with male subjects.

Introduction

Physical appearance is an important characteristic of the face. It has long been established that self-esteem is strongly influenced by facial appearance (Hershon and Giddon, 1980). The perception of an attractive face is largely subjective, with ethnicity, age, gender, culture, and personality influencing average facial traits (Mandall *et al.*, 2000; Şahin Sağlam and Gazilerli, 2001). Interestingly, facial features are usually studied in profile. Various methods have been used to evaluate facial characteristics, such as anthropometry (Farkas, 1981), photogrammetry (Gavan *et al.*, 1952; Stoner, 1955; Neger, 1959), computer imaging (Guess and Solzer, 1989), and cephalometry (Garner, 1974; Roos, 1977). Czarnecki *et al.* (1993) evaluated the perception of facial balance by varying the length of the nose, lip protrusion, and chin development. They found that the interrelationships of these facial features must be in balance in order to achieve facial harmony.

Different research groups have defined various soft tissue parameters and landmarks of soft tissue facial analysis (Burstone, 1958; Subtenly, 1959; Lines *et al.*, 1978; Holdaway, 1983). The analysis based on photogrammetry has also been extensively described (Stoner, 1955; Peck and Peck, 1970; Powell and Humphreys, 1984; Epker, 1992; Arnett and Bergman, 1993a,b).

Several angles have been used to evaluate facial aesthetics. The H-angle (Holdaway, 1983) is formed by a line tangent to the chin and upper lip with the NB line and, according to the author, the ideal face has an H-angle of 7–15 degrees, which is dictated by the patient's skeletal convexity. Merrifield (1966) reported the Z-angle measurement and profile line to provide an accurate critical description of the relationship of the lower face. This angle is formed by the Frankfort plane and profile line, formed by a line joining the extreme point of the soft tissues of the chin and the more prominent lip, usually the upper. Legan and Burstone (1980) described the angle of convexity which is formed by soft tissue glabella, subnasale, and soft tissue pogonion. The Powell analysis, which is made up of the nasofrontal, nasofacial, nasomental, and mentocervical angles, has been developed to provide an insight into an ideal facial profile (Powell and Humphreys, 1984). Stoner (1955) used soft tissue analysis of the facial profile on photographic records. Arnett and Bergman (1993a,b) defined frontal and lateral analysis from the photographic records taken in the natural head position (NHP). They used the nasolabial angle and the angle of the contour of the maxillary and mandibular sulcus. They also described the facial profile in different malocclusions according to the angle of facial convexity (G–Sn–Pg).

The aim of the present study was to evaluate the average variables that define the soft tissue facial profile of a Croatian sample by means of angular measurements. These would serve as a guide for aesthetic treatment goals.

Subjects and methods

The sample comprised of 110 subjects (52 males and 58 females), graduate and postgraduate students from the School of Dentistry, University of Zagreb, Croatia. The mean age for males was 28.7 years and for females 25.7 years. The criteria for selection included a pleasing and balanced profile, as judged by two of the authors. All subjects exhibited a dental Class I occlusion with normal overjet–overbite relationships and without previous orthodontic or surgical treatment.

The photographic set-up consisted of a tripod (Soligor, DT-310, Leinfelden-E, Germany) supporting a digital camera (Olympus 3040C). Adjustment of the tripod height allowed the optical axis of the lens to be maintained in a horizontal position during the recording; this was adapted to each subject's body height. In a standing position, each subject was asked to relax, with both arms hanging freely beside the trunk. The subject was positioned on a line marked on the floor, and placed behind the subject was a vertical measurement scale divided into millimetres that allowed measurements at life size. A plumb line, suspending a 0.5 kg weight hung from the scale, held by a thick black thread was used to define the vertical plane [true vertical (TV)] on the photographs. One hundred and twenty centimetres in front of the subject, on the opposite wall was a mirror. The subjects had to look into their eyes in the mirror with their lips relaxed so that the right-side profile records were taken in NHP. Before every recording the operator ensured that the subject's forehead, neck, and ear were clearly visible and their lips were in repose.

The photographic records were analysed with the software for Windows, Microsoft® Visio® 2003, Standard Edition. A millimetric paper gauge was attached on the computer monitor, which produced a universal background. Each photograph was reduced to real size, overlaid over the calibrating gauge, and orientated so that the TV line on the photograph was parallel with the vertical line of the computer monitor. Using the above-mentioned method, all photographic records were scaled to life size and 12 landmarks (Figure 1) were located on the digitized image to obtain all angular measurements (Figures 2–4). All procedures were undertaken by the same operator (SA-M).

Statistical analysis

To compare males and females, a Student's *t*-test was used. Descriptive statistics of the variables are shown in Table 1. The reproducibility of the measurements were analysed using Dahlberg's (1940) formula. The error was calculated from the equation: $\mathrm{ME} = \sqrt{d^2/2n}$, where d is the difference between duplicated measurements and n is the number of replications. To determine the difference between two measurements, made at least 3 months apart, 25 randomly selected records were redigitized (Table 2).

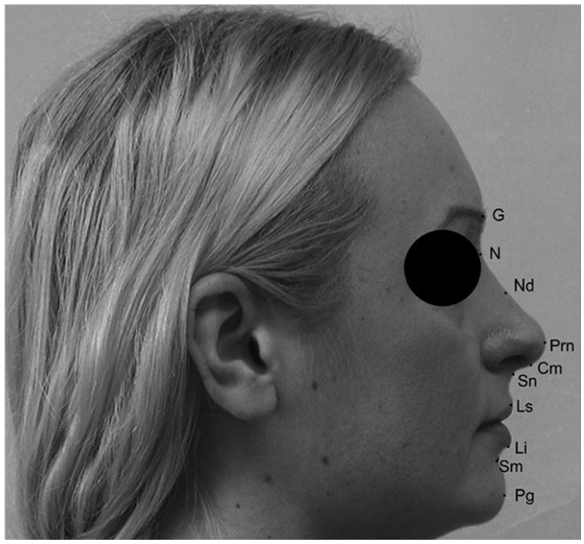

Figure 1 The landmarks used in this investigation: trichion (tri), glabella (G), nasion (N), nasal dorsum (Nd), pronasale (Prn), columella (Cm), subnasale (Sn), labiale superior (Ls), labiale inferior (Li), supramentale (Sm), pogonion (Pg).

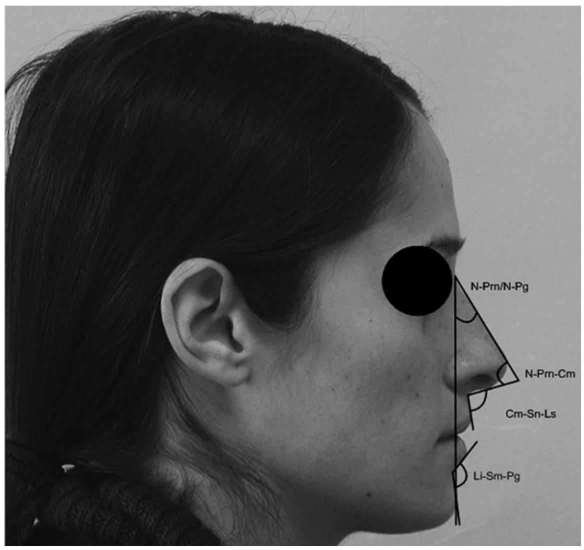

Figure 2 Angular measurements: nasomental angle (N–Prn/N–Pg); nose tip angle (N–Prn–Cm); nasolabial angle (Cm–Sn–Ls); mentolabial angle (Li–Sm–Pg).

Results

The average measurement values for males and females are shown in Table 1 and the average values for the whole sample in Table 3. Four angles showed gender differences: nasofrontal (G–N–Nd, $P=0.030$), nasolabial (Cm–Sn–Ls, $P=0.018$), mentolabial (Li–Sm–Pg, $P=0.019$), and nasal tip (N–Prn–Cm, $P=0.001$).

All angles that suggested gender differences were wider in females: nasofrontal (G–N–Nd females = 139.11 ± 6.35

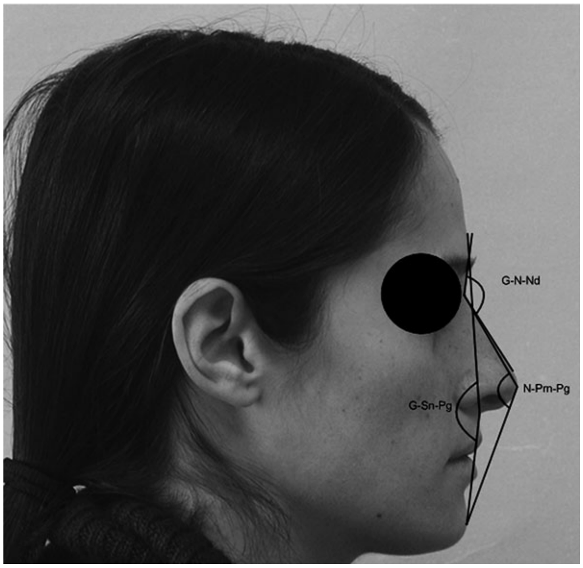

Figure 3 Angular parameters of the nasofrontal angle (G–N–Nd); total facial angle or facial convexity including the nose (N–Prn–Pg); facial angle or angle of facial convexity excluding the nose (G–Sn–Pg).

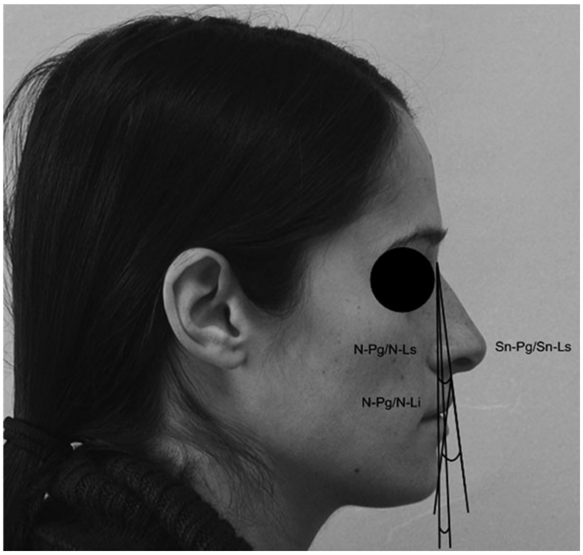

Figure 4 Projection of the upper lip to chin (N–Pg/N–Ls); upper lip angle (Sn–Ls/Sn–Pg); projection of the lower lip to chin (N–Pg/N–Li).

degrees, males = 136.38 ± 6.71 degrees), nasolabial (Cm–Sn–Ls females = 109.39 ± 7.84 degrees, males = 105.42 ± 9.52 degrees), mentolabial (Li–Sm–Pg females = 134.50 ± 9.08 degrees, males 129.26 ± 9.55 degrees), and nasal tip (N–Prn–Cm females = 84.12 ± 5.20 degrees, males 79.85 ± 6.36 degrees). The greatest variability was found for mentolabial angle, which had the highest standard deviation. The nasolabial and mentolabial angles showed the highest method error (1.5–2.5 degrees).

Table 1 Average values for angular measurements in males (n=52) and females (n=58) and application of a Student's t-test relating to gender.

Variable	Gender	Value of the parameters			t-test	
		$\bar{x}$*	s†	$s_{\bar{x}}$‡	t§	P¶
G–Sn–Pg	M	168.78	4.97	0.69	–0.292	0.771
	F	169.05	4.69	0.62		
N–Prn–Pg	M	130.47	3.73	0.52	0.407	0.685
	F	130.19	3.47	0.46		
G–N–Nd	M	136.38	6.71	0.93	–2.193	**0.030**
	F	139.11	6.35	0.83		
Cm–Sn–Ls	M	105.42	9.52	1.32	–2.402	**0.018**
	F	109.39	7.84	1.03		
Li–Sm–Pg	M	129.26	9.55	1.32	–2.947	**0.019**
	F	134.50	9.08	1.19		
N–Pg/N–Ls	M	6.98	2.29	0.32	–0.490	0.625
	F	7.17	1.71	0.22		
N–Pg/N–Li	M	3.27	1.79	0.25	–1.387	0.168
	F	3.69	1.39	0.18		
N–Prn–Cm	M	79.85	6.36	0.88	–3.868	**<0.001**
	F	84.12	5.20	0.68		
N–Prn/N–Pg	M	29.53	2.51	0.35	–1.787	0.077
	F	30.36	2.38	0.31		
Sn–Ls/Sn–Pg	M	11.70	6.20	0.86	–1.143	0.256
	F	12.90	4.82	0.63		

*Mean; †Standard deviation; ‡Standard error; §t-value; ¶Statistically significant differences are in bold.

Table 2 Method error of the angular measurement according to Dahlberg's formula.

Variable	Method error (º)
G–Sn–Pg	1
N–Prn–Pg	0.75
G–N–Nd	0.52
Cm–Sn–Ls	2.5
Li–Sm–Pg	1.5
N–Pg/N–Ls	0.43
N–Pg/N–Li	0.58
N–Prn–Cm	0.8
N–Prn/N–Pg	0.48
Sn–Ls/Sn–Pg	0.5

Discussion

The aim of this investigation was to evaluate the average angular variables that define the soft tissue facial profile of a Caucasian sample. Standardized photogrammetric records taken in NHP were analysed. Several authors have also used NHP in their studies (Yuen and Hiranaka, 1989; Arnett and Bergman, 1993a,b; Fernández-Riveiro *et al.*, 2002, 2003). It should be noted, however, that the present study was based on the photographs of aesthetically pleasing and balanced soft tissue profiles.

Nasolabial angle (Cm–Sn–Ls) can be altered by orthodontic or surgical treatment and depends on the

Table 3 Average values for angular measurements for the whole sample ($n = 110$) and application of a Student's t-test.

Variable	Value of the parameters			t-test	
	$\bar{x}$*	s†	$s_{\bar{x}}$‡	t§	P¶
G–Sn–Pg	168.92	4.80	0.46	–0292	0.771
N–Prn–Pg	130.32	3.58	0.34	0.407	0.685
G–N–Nd	137.82	6.63	0.63	–2.193	**0.030**
Cm–Sn–Ls	107.51	8.86	0.84	–2.402	**0.018**
Li–Sm–Pg	132.02	9.63	0.92	–2.947	**0.019**
N–Pg/N–Ls	7.08	2.00	0.19	–0.490	0.625
N–Pg/N–Li	3.49	1.60	0.15	–1.387	0.168
N–Prn–Cm	82.10	6.14	0.59	–3.868	**<0.001**
N–Prn/N–Pg	29.97	2.47	0.24	–1.787	0.077
Sn–Ls/Sn–Pg	12.33	5.52	0.53	–1.143	0.256

*Mean; †Standard deviation; ‡Standard error; §t-value; ¶Statistically significant differences in bold.

anteroposterior position or inclination of the upper anterior teeth. According to Bergman (1999), no matter if orthodontic or surgical correction is indicated, this angle should be 102 ± 8 degrees. This is important in assessing the upper lip position and is used as part of the extraction decision. In the study of Talass and Baker (1987) of Class II malocclusion subjects where premolars were extracted, the upper incisors were retracted 6.7 mm on average and the angle increased on average 10.5 degrees with orthodontic treatment (1.6 degrees for each millimetre of incisor retraction). In the present study the nasolabial angle was the most significant angular variable of the soft tissue profiles between the genders. The mean nasolabial angle value for males was 105.4 ± 9.5 degrees and for females 109 ± 7.8 degrees. Legan and Burstone (1980) found no gender difference for this angle; an average of 102 ± 8 degrees for both genders. Burstone (1967) reported a nasolabial angle of 74 ± 8 degrees in a Caucasian adolescent sample with a normal facial appearance. Genecov *et al.* (1989) found that the angular parameters of the nasal complex between the ages of 7 and 17 years remained relatively constant. Despite few findings of differences in growth of the nasal complex, the whole nasal contour increased by an average of 3–4 degrees (3.9 degrees in boys; 3.1 degrees in girls), in agreement with the studies of Nanda *et al.* (1990), Prahl-Andersen *et al.* (1995), and Ferrario *et al.* (1999). In the present study, in addition to gender differences, the measurement error for nasolabial angle 2.5 degrees.

Mentolabial angle (Li–Sm–Pg) also showed great variability. A more pronounced mentolabial angle can be seen in Class II and vertical maxillary deficiency cases. The uprighting of the lower incisors tends to enlarge the angle (Bergman, 1999). The mean value according to Burstone (1967) is 122.0 ± 11.7 degrees. In the present sample there was a great gender difference for this angle. For the males the value was 129.3 ± 9.5 degrees, which is similar to the findings of Fernández-Riveiro *et al.* (2003) and McNamara *et al.* (1993), but greater than the values found by Zylinski *et al.* (1992). In the present research, females had a measured value of 134.5 ± 9 degrees, while Fernández-Riveiro *et al.* (2003), using a similar photogrammetric technique, reported values that were 3 degrees lower on average, but with a higher standard deviation (131.4 ± 11 degrees). Lines *et al.* (1978), in a study of silhouettes, reported that the mentolabial angle ranged between 120 and 130 degrees. They found that a deeper mentolabial sulci was preferred in males. In the current investigation the females had a shallower mentolabial angle than the males. This is in accordance with the profile preferences published by Lines *et al.* (1978). The ideal face of historical beauties, both male and female, according those authors had deeper and more pronounced mentolabial sulci (around 122 degrees), which gave them a more uniform or similar appearance.

Another angle that reflects the position of the upper incisors and the thickness of the soft tissue overlying these teeth is the upper lip angle (Arnett *et al.*, 1999). The upper and lower lip angle (N–Ls/N–Pg and N–Li/N–Pg) was measured from nasion. The upper lip was also measured from subnasal (Arnett *et al.*, 1999). In the present study the upper lip angle, measured from subnasal (Sn–Ls/Sn–Pg), showed no gender differences, while Arnett *et al.* (1999) found this angle to be greater in females. Burstone (1958) used an angle called 'total facial contour' defined as the intersection of the upper facial (G–Sn) and anterior lower facial (Sn–Pg) components. The mean value was 11.3 ± 4 degrees from a sample of lateral and frontal photographs of 40 young Caucasians with aesthetically pleasing faces. The profile angle was used to assess convexity or concavity of the facial profile. According to Bergman (1999), a Class I subject presented an angle range of 165–175 degrees. This decreased in Class II and increased in Class III.

In the study of Bishara *et al.* (1998), in subjects between 5 and 25 years of age, the angle increased by 3.0 degrees in males and 1.9 degrees in females. After 25 years, the angle of convexity decreased by 2.8 degrees in males and 2.6 degrees in females, which points to a certain degree of stability in this angle (Subtenly, 1959; Mauchamp and Sassouni, 1973). It remains relatively constant in individuals who experience normal growth as subnasale and pogonion move forward with growth (Bergman, 1999).

In the present investigation the value for the facial angle (G–Sn–Pg) for males was 168.8 ± 4.96 degrees, in agreement with the findings of Fernández-Riveiro *et al.* (2003) of 168 ± 5 degrees and Arnett and Bergman (1993a,b) of 169.4 ± 3.2 degrees, who also used NHP. The facial angle for females was 169.07 ± 4.72 degrees, in accordance with Arnett and Bergman (1993a,b; 169.3 ± 3.4 degrees), also with no significant gender differences. The measurement for total facial angle or facial convexity including the nose (N–Prn–Pg) in the current study was males = 130.5 ± 3.7 degrees and females = 130.2 ± 3.5 degrees, indicating no significant gender difference. These are similar to the findings reported by others (Subtenly, 1959; Cox and Van der Linden, 1971; Nanda *et al.*, 1990; Arnett *et al.*, 1999). Fernández-Riveiro *et al.* (2003) found higher values for males (140 ± 5 degrees) than females (139 ± 4.5 degrees) because they measured from glabella, not from nasion; however, there were no significant gender difference. Yuen and Hiranaka (1989) also found no gender dimorphism (males = 135 ± 4 degrees; females 135 ± 3 degrees). Bishara *et al.* (1998) measured the angle from glabella, and stated that between 25 and 45 years of age, the angle increased by 2.1 and 1.3 degrees in males and females, respectively, reflecting either a more vertical growth of the tip of the nose or a more forward movement of soft tissue pogonion.

According to Lines *et al.* (1978), the nasomental angle (N–Prn/N–Pg) is aesthetically most acceptable within a range of 20–30 degrees. Statistically significant gender differences showed that a less prominent nose in relation to the chin is preferable in females and the opposite in males (Lines *et al.*, 1978). Clements (1969) stated that in most faces illustrated in art throughout history, the nasal prominence angle (nasomental angle) was around 30 degrees or less. In addition it was also reported that this angle (if measured from glabella) was within the range of 30–40 degrees, and the average value was approximately 36 degrees. According to Hinds and Kent (1972), the normal value is between 23 and 37 degrees, with an average of approximately 30 degrees. In the present study (males = 29.5 ± 2.5 degrees; females = 30.4 ± 2.4 degrees), no gender differences were found. The nasal tip angle (N–Prn–Cm) showed gender dimorphism ($P < 0.001$; males = 79.85 ± 6.36 degrees; females = 84.1 ± 5.2 degrees). According to Lines *et al.* (1978) this angle is most acceptable between 60 and 80 degrees. The values found in the present study are within that range. McNamara *et al.* (1993) found gender differences in the nasal tip angle on cephalograms in a study of 141 adult Caucasians with pleasing facial aesthetics and a dental Class I occlusion. The nasofrontal angle (G–N–Nd) in this investigation showed gender dimorphism ($P = 0.030$; males = 136.38 ± 6.7 degrees; females = 139.1 ± 6.35 degrees), while Epker (1992) in a study on frontal and lateral facial views of Caucasians found no gender differences in this angle (130 degrees).

Various studies (Burstone, 1958, 1967; Legan and Burstone, 1980; Farkas, 1981; Yuen and Hiranaka, 1989; Fernández-Riveiro *et al.* 2003) of the soft tissue facial profile, showed various values for the angles. There could be many reasons for the inconsistency between different study norms such as racial origin, malocclusions, head orientation, measurement methodology, age. Some studies were performed anthropometrically or photogrammetricaly, others cephalometrically, while some examined immature subjects.

The normative data for any population, including the sample in this study, are used as a guide for comparison during diagnosis and treatment planning. Clearly, orthodontists should consider each patient's beauty perception in order to establish an individualized treatment plan. The higher values (Table 1) for the females in this study could be explained by the fact that in general the facial contours of female subjects were softer than those of males, especially in the area of the nose, lips, and chin.

Conclusions

The soft tissue values obtained from this sample can be used as standards in comparisons of subjects with the same ethnic characteristics, a dental Class I occlusion and good soft tissue profile. Therefore, the values can be used for comparison of subjects with malocclusions, indicating areas of facial disharmony. Gender differences were observed for four of the 10 measurements: nasofrontal, nasolabial, mentolabial, and nasal tip angle. All these angles were wider in females. Another important finding was the relatively high method error and large variability for the nasolabial angle. Consequently, the results of this measurement should be viewed with caution.

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