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Authors: T. M. Perović, Z. Blažej, I. Jovanović

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The influence of antero-posterior dentoskeletal pattern on the value of nasal soft tissue angles: a cephalometric study

Running title: Facial pattern and nasal angles

T. Perović[1], Z. Blažej[1], I. Jovanović[2]

[1]Dental Clinic, Department for Orthodontics and Dentofacial Orthopedics, Niš, Serbia

[2]Faculty of Medicine, Department for Anatomy, University of Niš, Serbia

Address for correspondence: Tatjana Perović, Sestre Baković 16/22, 18000 Niš, Serbia, tel: +381 18 520 763, fax: +381 18 453 67 36, e-mail: tatjana.tanic@gmail.com

ABSTRACT

The aim of this study was to examine the influence of sagittal dentoskeletal pattern on the value of profile nasal soft tissue angles and estimate the significance of examined differences for each angle. Lateral cephalograms were used to examine the nasofrontal angle, nasofacial angle, nasal tip angle, and nasolabial angle of 120 adult Caucasian subjects (60 male and 60 female) from the central Balkan area. Subjects were divided into four groups according to the ANB angle and incisors inclination: Class I as the control group, Class II division 1, Class II division 2 and Class III. By evaluating the influence of sagittal dentoskeletal relationships on the values of examined angles, significant differences were found among subjects with Class I and Class II/2 (p=0.028), so as Class III (p=0.002) for nasal tip angle. The nasofacial angle was found to differ among subjects with Class I and Class II/1 (p=0.002), so as Class III (p=0.001). Different dentoskeletal patterns have significant influence on values of the nasal tip angle and nasofacial angle, and don't have influence on the values of the nasofrontal and nasolabial angle.

Key words: cephalometry, nose, dentoskeletal pattern

INTRODUCTION

The nose is central and most prominent part of the middle segment of the face, which is crucial for assessing facial harmony and attractivness. The nasal pyramid plays a notable cosmetic role in the appearance of the whole face; providing harmony and balance to the face [22]. This segment as well as shape of the nose represents a "signature" indicating ethnicity, race, age, and gender [18,19,22,23,31,32]. Farkash was the first who began to apply selective anthropometric parameters that later researchers standardized and created “ideal nose” (cited by Lazovic)[15]. Some of the shapes are purely racial-specific [22], so as angles that nose create with the nearby profile contours [33].

Are changes in the nasal profile angles correlated with different antero-posterior dentofacial pattern and to what extent? Since the midfacial segment and nose form the nasomaxillary complex, each antero-posterior jaw discrepancy is expected to influence the profile angles of this facial segment. Contours of the facial soft tissue differ from the contours of basic skeletal structures in certain areas, especially in the nasal third of the profile [12,24,28,29]. Therefore, facial profile angles are influenced by composite effect of skeletal and soft tissue profile. This fact indicates a possibility of difficult facial reconstruction based on the skull, because nose can have any shape. Likewise, angles that nose makes with nearby facial components can have any value inside the range of variations (racial, age and gender).

Dentoskeletal patterns highly influence the facial profile and facial aesthetics [24], especially the lower part of the face profile. However, some of the dentoskeletal patterns can imply a certain shape of the nose [23].

According to Angle, Class I dentoskeletal pattern is usually related to normal anteroposterior jaw relationship (Fig 1.), the straight profile and pleasant face.

Class II division 1 pattern present retroposition of the lower jaw in relation to the upper jaw (Fig. 2) and indicates a convex profile with the chin set posterior, therefore the dominant nose.

Class II division 2 pattern indicates a convex profile with characteristically emphasized tip of the nose and chin, having the tendency of mutual convergency (Fig. 3)[23]. This specific facial profile morphotype exists due to retropositioned dentoalveolar segment.

Class III pattern indicates overdeveloped lower jaw (Fig. 4) that is dominant in relation to other facial features (nose, forehead, lips). Persons with Class III have a concave profile This pattern is considered the least aesthetic [2,24].

The aim of this study is to determine the values of facial profile angles of the midfacial (nasal) segment in subjects with Class I, Class II division 1, Class II division 2, and Class III, in order to, examine, in this way, the influence of dentoskeletal pattern on the value of angular profile parameters of the nose region, as well as to examine the significance of the established variations for each angle individually.

MATERIALS AND METHODS

The study was conducted at the Faculty of Medicine Niš, Serbia. Before the commencement of the study, each volunteer gave an informed consent as to the purpose and nature of the study. All work was performed in accordance with the Declaration of Helsinki and was approved by the Faculty`s Ethics Committee, (General project title of Clinical and Experimental Examination of the Stomatognathic System and Modern Therapeutic Procedures, Project Number 11, March 8th, 2017, Niš, Republic of Serbia). This study included the examination and the analyses of cephalometric radiography data (lateral cephalograms) obtained from the profile angles of 120 adult Caucasian subjects (60 male and 60 female) from the central Balkan area (Serbia). The cephalograms were taken from the archives of the subjects. Lateral cephalograms were recorded during the routine diagnostic procedures for subjects who were examined at the Department of Dentofacial Orthopedics at the Clinic of Dentistry in Niš, aged between 18–30 years, and who underwent orthodontic therapy for the first time. The subjects with a history of trauma, craniofacial anomalies, cleft lip and palate, and previous orthodontic, prosthetic or orthognathic treatment were excluded from the study. Cephalometric radiographs of the

head were done using a cephalostat (head-holding device). All subjects included in the study underwent a detailed clinical assessment and analyses of their dental and skeletal profiles, as well as soft tissue profiles on cephalometric radiography. The equipment used for the imaging analyses was the Rotograf Plus (20090 Buccinasco MI Italy) (Number and series: 00036045), and the CEI-OPX/105 X-ray tube (CEI, Bologna) with a protective filter (2.5mm aluminum- equivalent). Lateral cephalometric films were taken from a distance of 165 cm away from the tube, using a cephalostat to ensure rigid head fixation. The subjects were placed in the cephalostat in such a way that the sagittal plane of the head was at a 90° angle to the path of the X-rays. The Frankfort horizontal plane (from the lower edge of foramen orbitale and upper rim of the external auditory canal) was parallel to the ground, the teeth were in the central occlusion position, and the lips were in relaxed position. No corrections of the magnification factors were required, since all the radiographs were taken with the same equipment and the same proportions. Each cephalogram was fixed on the viewing box with the profile to the right, and the acetate tracing paper was fixed by a tape at the top. The soft tissue and skeletal features were traced manually in a darkened room, using a 0.5 mm lead pencil. All the image tracing was done by the main investigator. Subjects were divided into four groups. The size of the ANB angle according to Steiner and the angle inclination of the upper incisors was the criteria used to categorize the subjects in this study. The cephalometric ANB angle was the parameter that defined the sagittal relationship between the upper and lower jaw as orthognathic, distal, or mesial (Fig. 5).

The points that determined the ANB angle included, point (N), the nasion, located on the suture between the frontal and nasal bones; point (A), the deepest point on the line between the anterior nasal spine and the prosthion (alveolar point); and point (B), the deepest point from the line between the infradentale and the pogonion (midline of the chin).

The first group was with an eugnathic dentoskeletal relationship (Class I) and the ANB angle between 2–4°. The second group was with a distal dentoskeletal pattern, an ANB angle >4°, and the inclination angle of the upper incisor >22° (Class II, division I, or Class II/1). The third group was with a distal pattern, an ANB angle >4° and the inclination angle of the upper incisors inclination <22° (Class II, division 2, or Class II/2). The fourth group was with a mesial pattern and an ANB angle <1° (Class III). Each group consisted

of 30 subjects (15 males, 15 females). Since subjects with Class I generally had a harmonic facial profile due to the eugnathic jaw relationship, this group was taken as the control and then compared to the other three groups.

Then, on the radiograph of each patient, the following anthropometric soft tissue points were determined (Tab. I, Fig. 6).

By pulling the lines from these points, the following profile angles were formed (Fig. 7):

- Nasofrontal angle (G-N-Nd) - angle between glabella (G) to nasion (N) line and nasion to nasal dorsum (Nd) line;
- Nasofacial angle or nasal projection angle (Prn-N-Pg) - angle between nasion (N) to pogonion line (Pg) and nasion to tip (Prn) line;
- Nasal tip angle (N-Prn-Cm) - angle between nasion (N) to tip/pronasale line (Prn) and tip to columella (Cm) line;
- Nasolabial angle (Cm-Sn-Ls) - angle between columella point (Cm) to subnasale (Sn) line and subnasale to labiale superior (Ls) line.

Since these were angular measures, all results were expressed in degrees (^{o}).

Statistical analysis

Statistical analysis of obtained morphometric data was performed by IBM SPSS Statistics (version 25). Results of the Kolmogorov-Smirnov test showed that majority of the morphometric parameters were not normally distributed. Consequently, significance of detected differences was evaluated by non-parametric Mann-Whitney U test.

In the statistical assessment, the following levels of significance were used: Not significant $P>0.05$; Significant $0.05 \geq P>0.01$(*); Highly significant $0.01 \geq P>0.001$(**); Very highly significant $P \leq 0.001$(***); P= probability value.

RESULTS

Descriptive statistics of average angular values for different parameters in four groups with different dentoskletal pattern (Class I, Class II/1, Class II/2, Class III) were

shown in Table II. The statistical differences of average values of the examined angles between the group with Class I and the other three groups were shown in Table III:

Nasofrontal angle: The average value for subjects in current study with Class I was 138.80 ± 9.39˚,that was similar to other groups without significant differences.

Nasofacial angle: The average value for subjects with Class I was 29.63±3.61˚, and for the group with Class II/1 (33.13±4.61˚) that's significantly higher. Average value in the group with Class III (26.07±4.08˚) that's significantly lower related to the control group.

Nasal tip angle: The average value for subjects with Class I was 91±5.39˚. Significant differences were established by comparing Class I and Class II/2, so as Class I and III subjects.

Nasolabial angle: The average value of this angle in subjects with Class I was 111.67±10.76˚. There were no significant differences between the subjects with Class I and other patterns.

DISCUSSION

Protrusion or retrusion of midfacial (nasal) segment influences the facial aesthetics and can be objectively determined by measuring the facial angles of this segment. Protrusion of this segment is racially characterististic for Africans, retrusion for Asians [6,11,17]. In Caucasians, retrusion of nasal third is rarely connected to normal racial antropological variations. It is the consequence of dentofacial deformity or existence of adenoid face. In case of adenoid face, middle third of the face is short and depressed with nose that undeveloped in all three dimensions. External physiognomy of the nose is divided into its component, aesthetic parts.

The nasofrontal angle is more open in females than in males, revealing a less convex nasal radix [16]. It demonstrates a higher nasal tip rotation in females, that is considered aesthetically favorable [4,7,8,20]. According to various authors, in Caucasian eugnathic subjects, it has a value of 132.39 ± 8.015˚ [1], 133.16 ± 8.88˚ [32], 137.13 ± 7.98˚ [5], to 139.1 ± 6.35˚ [3], that's similar to mean values in the current study (Tab. II).

The nasofrontal angle is independent of the sagittal dentoskeletal pattern as indicated by these results. Based on reported results, among members of different races, there are higher differences in values of nasofrontal angle than among subjects with different pattern. Results indicate large standard deviations and a large degree of individual variability. Accordingly, comparisons should be performed with the range of normal values not mean values.

The nasofacial angle indicates its prominence in relation to the entire facial massif [6]. The average values for eugnathic subjects range, according to various authors, from 30˚ to 40.5˚ [3,8,20]. In the current study, for subjects with Class I it is 29.63±3.61˚, being lower than values published by other authors. This value is significantly lower than average in the group with Class II/1 and higher than average in the group with Class III (Tab.II, III). The result was the effect of the Pogonion point position. The Pogonion has an anterior position in subjects with Class III, thus reducing the nose projection in relation to the N-Pg line. On the other hand, in subjects with Class II/1, the distal Pogonion projection, due to posterior mandible position, leads to a larger projection of the nose tip in relation to the N-Pg line. Because of this finding, it would be better if this anglewas reduced at Class II division 1, so distal position of mandible can be camuflaged. On the other hand, it would be better if that angle was increased at Class III, so domination of mandible is camuflaged. Insignificant differences were found in values of this angle between the group with Class I and Class II/2, since the Pogonion position of both groups, due to the specific skeletal pattern of this Class, is similar to the one with Class I. Fortes et al.by comparing this angle to Caucasian subjects with pleasant and unpleasant facial profiles, found the values of 32.73±2.77˚ for pleasant facial profiles and the values of 33.43±3.01˚ for unpleasant facial profiles. The difference is statistically insignificant. Accordingly, the aesthetic impression is not affected by the value of the nasal projection angle [10].

The average value of *the nasal tip angle* in the Caucasian eugnathic subjects is 70.1˚ to 84.3˚ [1,3,5,20,31,32], in the current study 91±5.39˚, indicating higher values compared to subjects from other reference studies. Significant differences were established by comparing Class I and Class II/2, so as Class I and III (Tab. III). Mentioned differences in the nose tip angle between Class I and Class II/2 may be explained by a specific nose tip

in subjects with this dentoskeletal pattern. A smaller nose tip angle characterizes these subjects, therefore the tip of the nose has a tendency of convergence with the chin, being a frequent characteristic Class II/2 [23]. Subjects with Class III are found to have a significantly smaller nose tip angle thus indicating a compensatory tendency of the nose tip to mask the skeletal discrepancy. Consequently the nasomaxillary complex is positioned more posterior in relation to the lower jaw. The sharper nasal tip (reduced nose tip angle) is responsible for the reduced nasolabial angle [4,5,21].

The nasolabial angle is important in the assessment of the relationship between the nasal base and the upper lip. It is a strategic part of the facial profile. Burstone defines the nasolabial angle as a representation of the maxilla inclination - when increased, this angle represents the maxillary retroclination, and when decreased, it represents the maxillary proclination [9]. Some authors consider this angle to be of great clinical importance with its size depending on the anteroposterior position and the inclination of the upper incisors respectively [21]. Other authors believe that analyses of this angle can`t provide the answer which segment of the nasomaxillary complex causes the problem. Therefore identification of the exact cause of decreasing the nasolabial angle is difficult to achieve. This angle is formed of two lines, one from the base of the nose, and the other from the upper lip. They are independent as the measurement of this angle does not reveal the component responsible for its variability. It could be either a nose or a lip, or both [9,10]. It is believed that the larger angle is aesthetically more favorable for women, whereas the sharper one for men [13,19,25,27]. The average value of this angle in subjects of current study with Class I is 111.67±10.76˚. In other studies performed on the Caucasian eugnathic subjects, slightly lower values were obtained: Ballin et al. in Brazilian Caucasian 105.41±10.66˚[5], Anić-Milošević et al. for males 105.49˚ and for females 109.78˚[3], Lapter-Varga et al.106.39˚[14], Uysal et al.for males 102.9 ±10.5˚, for females 107.7±8.6˚in Turkey and for Caucasian North American 112.6±10.6˚ for males and 111.1±9.7˚ for females, being close to the average values of nasolabial angle in our sample [30]. Fortes et al. when comparing this angle with Caucasian subjects, found the following average values: 104.37±7.25˚ for pleasant facial profiles and 104.53±12.91˚ for unpleasant facial profiles. The difference is statistically insignificant [10].

In the current study the values of the nasolabial angle in subjects with different patterns are approximate, with insignificant differences (Tab.III). The result is unexpected since different dentoskeletal patterns indicate different projections of the nasomaxillary complex. Consequently, thickness of the upper lip compensates the development of the nasomaxillary complex, which most likely masks skeletal discrepancy and maintains an angle relationship with columella [25,27], making insignificant the established differences on our sample.

During forensical facial reconstruction based on the skull, as the most defined angles were determined nasofrontal and nasolabial angle. These angles, with knowing awerage thickness of the soft tissues on specific places, are possible to determine with a lot of accuracy. However, when it comes to the nose tip angle and the nasofacial angle we need to take into consideration dentoskeletal pattern because the values of these angles are conditioned with the dentoskeletal class, which is established in the current study.

CONCLUSION

By comparing the average values of the profile angles of the midfacial segment, it was established that the nasal tip angle is significantly lower in subjects with Class II Division 2 as well as Class III. The nasofacial angle was significantly higher in subjects with Class II Division 1 and significantly lower with Class III. The frontonasal and nasolabial angle were independent of the sagital dentoskeletal pattern.

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Table I. Facial landmarks (with abbreviations) used for the determination of angular parameters

Glabella (G)	the most anterior point of the middle line of the forehead
Nasion (N)	the point in the middle line located at the nasal root
Nasal dorsum (Nd)	the middle point the external ridge of the nose
Pronasale (Prn)	the most prominent point of the tip of the nose
Columella (Cm)	the most inferior and anterior point of the nose
Subnasale (Sn)	the point where the upper lip joins the columella
Labiale superior (Ls)	the point that indicates the mucocutaneous border of the upper lip
Pogonion (Pg)	the most anterior point of the chin

Table II. Descriptive statistics for Class I, Class II division 1, Class II division 2 and Class III (mean value, standard deviation and min-max value)

Classes	**I**	**II/1**	**II/2**	**III**
G-N-Nd	138.80±9.39	138.50±9.91	138.70±6,63	134.23±12,58
Min-max	117.0-153.0	111.0-152.0	121.0-148.0	110.0-160.0
Prn-N-Pg	29.63±3.61	33.13±4.61	31.00±4,16	26.07±4,08
Min-max	25.0-39.0	26.0-47.0	23.0-38.0	20.0-35.0

N-Prn-Cm	91.00±5.39	88.87±6.28	86.57±11,15	86.20± 8,21
Min-max	79.0-98.0	75.0-102.0	60.0-108.0	72.0-114.0
Cm-Sn-Ls	111.67±10.76	114.30±8.56	111.37±14,3	106.47±10,94
Min-max	90.0-130.0	92.0-133.0	80.0-135.0	86.0-132.0

Table III. Statistical differences between Class I and other groups. (Z value; P- probability value)

		I-II/1	**I-II/2**	**I-III**
G-N-Nd	(Z)	-.044	-.333	-1.480
	P	0.965	0.739	0.139
Prn-N-Pg	(Z)	-3.162	-1.577	-3.401
	P	0.002 **	0.115	0.001***
N-Prn-Cm	(Z)	-1.704	-2.201	-3.132
	P	0.088	0.028**	0.002**
Cm-Sn-Ls(Z)		-1.030	-.163	-1.701
	P	0.303	0.871	0.089

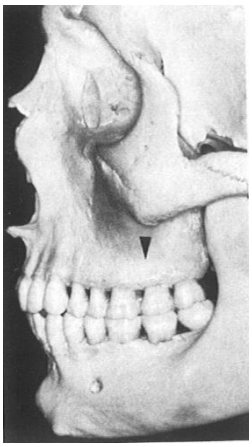

Figure 1. Skull with Class I dentoskeletal pattern [Source 26].

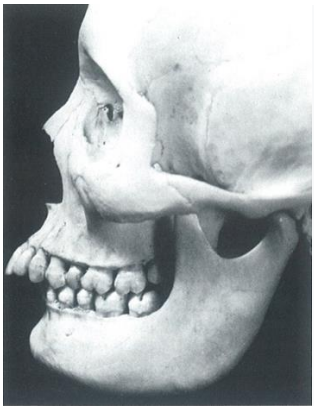

Figure 2. Skull with Class II division 1. dentoskeletal pattern [Source 26].

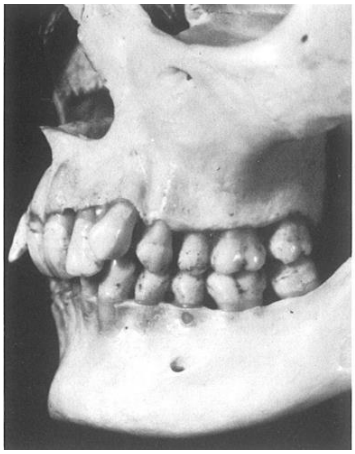

Figure 3. Skull with Class II division 2. dentoskeletal pattern [Source 26]

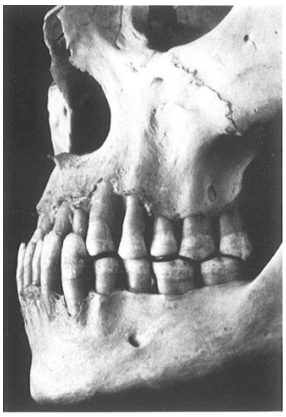

Figure 4. Skull with Class III dentoskeletal pattern [Source 26].

Figure 5. The cephalometric ANB angle and the angle of inclination of upper incisors.

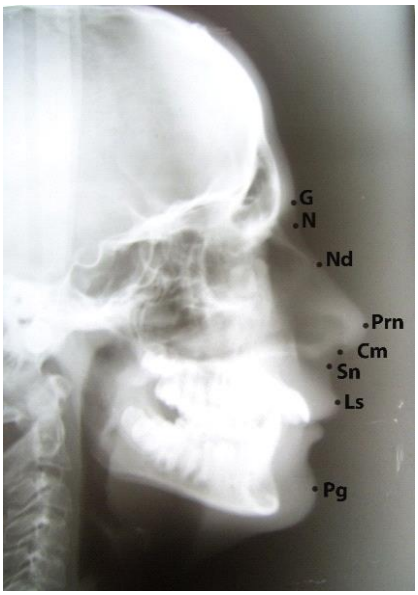

Figure 6. The landmarks used in this investigation: glabella (G), nasion (N), nasal dorsum (Nd), pronasale (Prn), columella (Cm), subnasale (Sn), labiale superior (Ls), pogonion (Pg).

Figure 7. Angular parameters: 1. Nasofrontal angle (G-N-Nd); 2. Nasofacial angle (Prn-N-Pg); 3. Nasal tip angle (N-Prn-Cm); 4. Nasolabial angle (Cm-Sn-Ls).