DOI: https://doi.org/10.2298/SARH190213100V
UDC: 616.314-073

ORIGINAL ARTICLE / ОРИГИНАЛНИ РАД

Comparison between Steiner cephalometric and modified Andrews photometric method for assessing antero-posterior position of the maxillary central incisors

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SUMMARY
Introduction/Objective Maxillary incisors, when exposed during smile, are one of the most important facial features. In an attempt to overcome limitations of standard cephalometric methods, Andrews described an approach to determine ideal anteroposterior (AP) position of maxillary central incisors in smiling profile in relation to the forehead. We compared traditional Steiner cephalometric method, using surrounding skeletal landmarks, to the method proposed by Andrews, with the aim of determining whether distant but very noticeable craniofacial structures can affect our impression of tooth position.
Methods The study comprised 90 randomly selected lateral cephalograms, divided into three groups according to maxillary central incisors AP position according to Steiner cephalometric norms. The AP relationship of the maxillary central incisors was measured as a perpendicular distance from facial axis point to the nasion A line and to the vertical line through forehead facial axis point respectively. Student's t-test and Pearson's correlation were used to compare tested variables.
Results There was statistically significant difference between two methods ($p = 0.01108$). According to the Steiner method 46.67% subjects had retrusive incisors and 53.33% subjects had protrusion. Andrews's method showed different results; 35.56% subjects had retrusion, while 64.4% had protrusion.
Conclusion The method proposed by Andrews showed consistently more protrusion than the traditional cephalometric method according to Steiner. Slightly retruded position of maxillary central incisors according to Steiner analysis does not always imply poor facial esthetics, if they have favorable position to the forehead. Low levels of correlation indicate that we should never rely on just one set of parameters.
Keywords: incisors; forehead; facial esthetics

INTRODUCTION

The smile and facial esthetics are the most important motivating factors for many patients to seek orthodontic care. For that reason, most of them are moved solely by a desire to improve appearance, without considering other morphological or functional disorders.

On the other hand, most orthodontic professionals choose their decisions and plan treatment by obtaining optimal occlusal relationship. The literature we found contains numerous studies that have shown significant improvements of post treatment dentofacial features and a high ability of different orthodontic treatments in manipulation of facial attractiveness [1–8]. However, there is also clear evidence that an ideal occlusion often results in a not-so-desirable appearance and facial esthetics [9]. An orthodontic treatment that adheres strictly to cephalometric standards, based on traditional osseous landmarks to define jaw and teeth positions can often be deceiving, since a good facial harmony has been shown to exist within a wide range of cephalometric values. Recently, there has been a paradigm shift that emphasizes the importance of considering the dentition, especially incisors, as a part of the face and not just some cephalometric value among other bony structures [10, 11].

When exposed during smile, maxillary incisors are one of the most important facial features. Most traditional cephalometric values estimate incisors anteroposterior (AP) position relative to surrounding bone structures, like jaw axis, or anterior point of cranial base. Others use soft tissue analysis, like nasolabial angle and E–line that indirectly convey the position of incisors. However, other nearby structures (nose, chin, and forehead) can sometimes distort our perception, visually improving or deteriorating their appearance, thus making traditional hard tissue cephalometric values unreliable. Recently, smile esthetics, especially from the frontal perspective, has frequently been studied [12–15]. In profile, conversely, the maxillary incisors are not typically assessed in relation to other external facial landmarks. In an attempt to overcome aforementioned limitations of standard cephalometric methods, Andrews and Andrews [16] in Six Elements of Orofacial Harmony™, described an approach for determining the ideal AP position of maxillary central incisors in smiling profile, which optimizes

Received • Примљено: February 13, 2019
Revised • Ревизија: August 20, 2019
Accepted • Прихваћено: August 22, 2019
Online first: September 19, 2019

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esthetics of the soft tissue profile. Andrews favors the forehead as a stable landmark because, unlike internal osseous radiographic landmarks, it is a part of the face, with predictable and repeatable relationship to the incisors. Moreover, both lay people and professionals are sensitive to the incorrect AP relationship of the maxillary incisors to the forehead, thus this is a method unconsciously used in determining profile acceptance [17, 18, 19].

The aim of this study was to evaluate and compare traditional Steiner cephalometric method for assessing maxillary central incisors AP position, using surrounding skeletal (osseous) landmarks to the method proposed by Andrews [20], which we modified to use patient radiographs instead of photographs to determine the position of the incisors relative to the forehead.

METHODS

Ninety randomly selected patients (41 males, 49 females, mean age 14.1 years) comprised the study sample. All patients were treated at the Clinic of Dentistry, Faculty of Medicine, University of Novi Sad. Patients with severe congenital skeletal malformations were excluded from the research (clefts, syndromes, etc.). Initial digital cephalometric radiographs were taken, following a standardized procedure, and the hairline was marked with radiocontrast material (barium paste), in order to make point Trichion clearly visible. Radiographs were digitally traced, using Onyx-Ceph 3D (ONYXCEPH^{3}™, Chemnitz, Germany) cephalometric software, and six skeletal and soft tissue landmarks identified. Skeletal landmarks were detected according to Steiner [nasion, A (NA) point, u1FA maxillary central incisor facial axis (FA) point], while landmark points for the forehead were identified as described by Andrews [Trichion, Superion, Glabella, and the forehead facial axis (FFA) point] (Figure 1) [16]. Originally, Andrews's method of evaluation of orofacial harmony is done on lateral photographs, instead, we proposed a radiological evaluation method, on lateral cephalograms, in order to simplify the procedure and avoid any possible problems and inaccuracy due to different head positions and size ratios of photographs and cephalograms.

The entire sample was divided into three groups according to the accepted Steiner analysis cephalometric norms for maxillary central incisors anteroposterior position: group I (norm position u1-NA 2–4 mm), group II (retruded u1-NA < 2 mm) and group III (protruded u1-NA > 4 mm).

In addition to conventional cephalometric nasion-point A line, two vertical reference lines were also constructed: line 1 through the FFA point, line 2 through the maxillary central incisors FA point. The AP relationship of the maxillary central incisors was measured as a perpendicular distance from FA point to the NA line and to the vertical line through forehead's FFA point respectively (Figure 2). Accepted cephalometric norm for the distance of u1FA point to the NA line was 4 mm, as suggested by Steiner, and was assumed to be "u1-NA Δ 4 mm = 0" or base value. A positive value was assigned when u1FA to NA line distance was more than 4mm and negative when less. Base value (0) for the incisors position in relation to the forehead was with u1FA point touching the FFA vertical. A positive value was assigned when maxillary central incisors were anterior to the forehead's FFA point (line1) and negative when posterior.

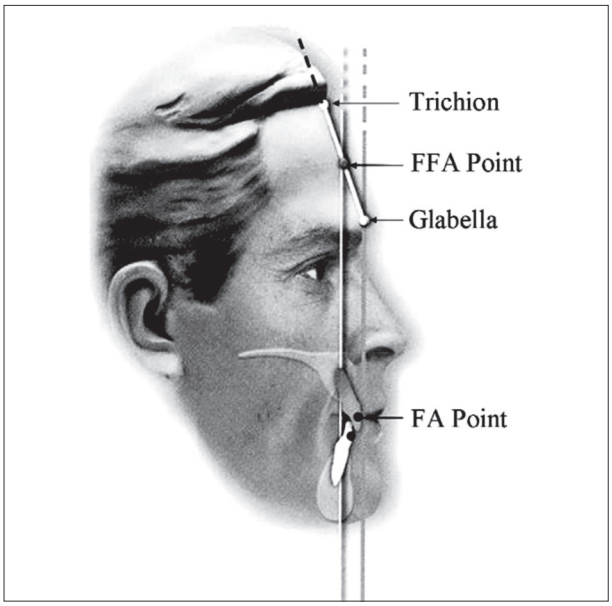

Figure 1. Landmarks used by Andrews to assess the anteroposterior position of the maxillary central incisors relative to forehead [20]

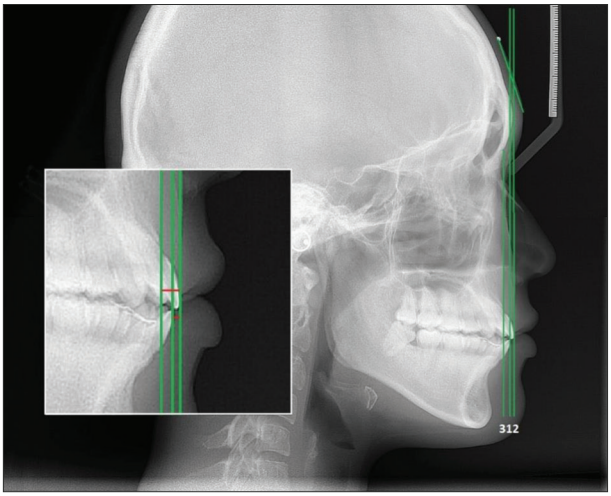

Figure 2. Referent lines on lateral cephalogram used to assess anteroposterior position of maxillary central incisors according to Steiner method and Andrews method;

Line 1 – vertical through the forehead facial axis point; line 2 – vertical through maxillary central incisors facial axis point; line 3 – nasion-point A; (the anteroposterior relationship of the maxillary central incisors was measured as a perpendicular distance from facial axis point to the nasion point A line and to the vertical line through forehead facial axis point, respectively)

Reliability

The reliability of the visual assessment of the morphological characteristics of the forehead was determined by interobserver evaluations between the authors, showed very good agreement (κ = 0.82) as assessed by the kappa coefficient [21].

Duplicate determinations were also carried out for all variables. The measurements were undertaken two weeks apart by the same examiner on a random sample of 20 cephalograms. The systemic error between two measurements was calculated using a paired t-test, for $p < 0.05$, and no significant differences were found for any of the hard or soft tissue variables in the two data sets. The error variance was calculated according to Dahlberg formula.

Data analysis

Descriptive and comparative statistical analyses were performed using IBM SPSS Statistics for Windows, Version 25.0 (IBM Corp., Armonk, NY, USA) computer software. The means for both tested values were compared using Student's t-test. P-value of 0.05 or less indicated significant differences. Correlation between variables was tested using Pearson's correlation.

Ethics

The study was conducted according to the Declaration of Helsinki. The study has been approved by the Ethics Committee of the Dentistry Clinic of Vojvodina (Nr: 01-33/2-2019, 29.01.2019).

RESULTS

There were no significant differences between male and female subjects, therefore all data was unified. Descriptive statistics and Student's t-test results of the maxillary central incisors position for the entire sample are shown in Table 1. Relative to the NA point line, maxillary central incisor position ranged from -12.5 mm to +5.8 mm, with an average value of 0 mm and standard deviation of 3.7 mm. Relative to FFA line maxillary central incisors position ranged -16–16 mm, with an average value of 1.45 mm and standard deviation of 6.09 mm. There was statistically significant difference between two cephalometric measurements for evaluation of maxillary central incisors position ($p = 0.01108$). Distribution of established incisors positions according to two different methods are shown in Figure 3 and Figure 4. According to the Steiner method, 42 (46.67%) subjects had retrusive maxillary central incisors, positioned behind threshold value line, and 48 (53.33%) subjects had protrusion. Method proposed by Andrews showed different results; 32 (35.56%) subjects had maxillary central incisors FFA point positioned posterior to the forehead's FFA point indicating retrusive position. Fifty-eight (64.4%) subject had maxillary incisors FFA point somewhere at or in front of the FFA line.

Descriptive statistics and difference testing results for three groups of subjects, according to accepted Steiner analysis cephalometric norms are shown in Table 2. Arithmetic mean values for maxillary central incisors position relative to the NA point line for different groups are 0 mm, -4.10 mm and +3.10 mm and relative to FFA line +3.45 mm, -0.30 mm and +1.45 mm, respectively.

Table 1. Anteroposterior position (mm) of the maxillary central incisors relative to nasion-point A line and to the forehead facial axis line for the entire sample

ALL	Mean	SD	Min.	Max.	t-test (p-value)
u1-NA Δ 4 mm	0	3.7	-12.5	5.8	0.01108*
u1-FFA	1.45	6.09	-16	16	

NA – nasion A; FFA – forehead facial axis; u1-NA Δ 4 mm – accepted cephalometric norm for the distance of u1FA point to the NA line was 4 mm, as suggested by Steiner, and was assumed to be "u1-NA Δ 4mm = 0" or base value; u1-FFA – perpendicular distance from facial axis point to the vertical line through forehead's forehead facial axis point; base value (0) for the incisors position in relation to the forehead was with u1FA point touching the forehead facial axis vertical;
*$p < 0.05$;

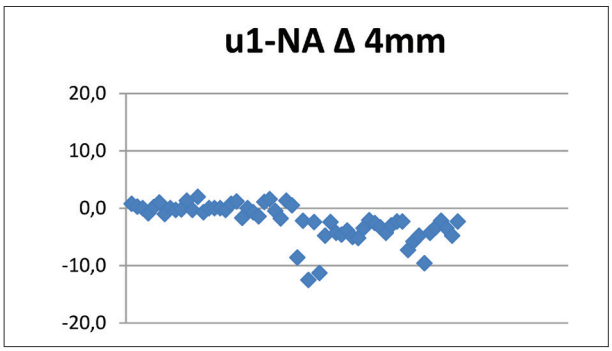

Figure 3. Distribution of established incisors positions relative to nasion-point A line;

u1-NA Δ 4 mm – accepted cephalometric norm for the distance of u1FA point to the nasion-point line was 4 mm, as suggested by Steiner, and was assumed to be "u1-NA Δ 4 mm = 0" or base value

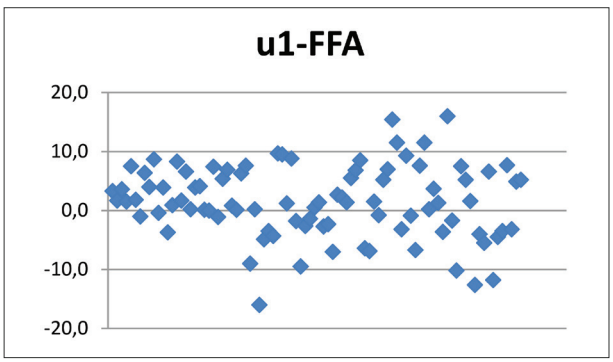

Figure 4. Distribution of established incisors positions relative to the forehead facial axis;

u1-FFA – perpendicular distance from facial axis point to the vertical line through forehead facial axis point; base value (0) for the incisors position in relation to the forehead was with u1FA point touching the forehead facial axis vertical

Significant difference was established for subjects with normo position ($p = 0.00000$) or retruded ($p = 0.00132$) maxillary central incisors.

There was no significant correlation between tested variables overall ($r = 0.24844$), nor in all three groups (Table 4).

DISCUSSION

Of all the factors related to a balanced facial expression and smile esthetics, AP position of the maxillary incisors is one

Table 2. Anteroposterior position (mm) of the maxillary central incisors relative to nasion-point A line and to the forehead facial axis line for three groups (normal, retruded and protruded incisors) according to Steiner cephalometric analyses

Normal (2–4 mm)	Mean	SD	Min.	Max.	t-test (p-value)
u1-NA Δ 4 mm	0	0.96	-1.8	2	0.00000***
u1-FFA	3.45	3.32	-3.7	8.7	
Retruded (< 2 mm)	Mean	SD	Min.	Max.	t-test (p-value)
u1-NA Δ 4 mm	-4.1	2.72	-12.5	-2.1	0.00132**
u1-FFA	-0.3	6.15	-16	9.7	
Protruded (> 4 mm)	Mean	SD	Min.	Max.	t-test (p-value)
u1-NA Δ 4 mm	3.1	1.09	2.1	5.8	0.49020
u1-FFA	1.45	7.62	-12.6	16	

NA – nasion A; FFA – forehead facial axis; u1-NA Δ 4 mm – accepted cephalometric norm for the distance of u1FA point to the NA line was 4 mm, as suggested by Steiner, and was assumed to be "u1-NA Δ 4 mm = 0" or base value; u1-FFA – perpendicular distance from facial axis point to the vertical line through forehead's forehead facial axis point; base value (0) for the incisors position in relation to the forehead was with u1FA point touching the forehead facial axis vertical;
**p < 0.01;
***p < 0.001

Table 3. Percentage of patents with protrusive or retrusive maxillary central incisors relative to nasion-point A line and to the forehead facial axis line

Protrusion		Retrusion
ALL		
46.67%	< u1-NA Δ 4 mm >	53.33%
35.56%	< FFA >	64.4%
Group 1		
33.33%	< u1-NA Δ 4 mm >	66,66%
13.33%	< FFA >	86,67%
Group 2		
0%	< u1-NA Δ 4 mm >	100%
50%	< FFA >	50%
Group 3		
100%	< u1-NA Δ 4 mm >	0%
43.33%	< FFA >	56.67%

FFA – forehead facial axis

Table 4. Correlation between Incisors position relative to nasion-point A line (u1-NA) and to the forehead facial axis (u1-FFA) line

	u1-NA Δ 4 mm	u1-FFA
u1-NA Δ 4 mm	1	
u1-FFA	0.248447	1

Pearson's correlation coefficient (r) was calculated, and significant relationships were marked (*)

that can easily be controlled and influenced by orthodontic treatment. If we consider maxillary incisors as a part of the face, then evaluating its position should unavoidably include other facial landmarks. Some facial features such as the nose and chin are very variable and can change considerably over time. Moreover, in many cases, several still widely used cephalometric indices, like nasolabial angle, lip prominence and esthetic lines, does not reflect true position of the maxillary incisors and often depend more on the soft tissue thickness and muscle tonus rather than incisors AP position [22–25].

This research showed a significant difference between maxillary central incisors AP position established by the widely used method according to Steiner, and method by Andrews [16] and Andrews [20] suggesting that the maxillary central incisors should be positioned somewhere at or between the forehead's FFA point and glabella. Average value of u1-NA Δ 4 mm for the entire sample was 0 mm, indicating optimal AP position of maxillary incisors to the NA line, while u1-FFA mean was showing more protruded appearance, but still quite harmonious. Andrews's method showed more subjects with some degree of protrusion, than method according to Steiner. The differences were statistically significant. According to these cephalometric variables, we can conclude that the average patient from tested population is in general with neutral AP position towards a slight protrusion of maxillary central incisors.

If we consider only subjects with harmonious position of maxillary central incisors according to Steiner (group 1) (Table 2), the difference between average values of two indices is much larger.

That inconsistency is even more pronounced in group 2, where all subjects had retruded maxillary central incisors according to the Steiner method, while Andrews's approach showed only one-half of subjects with that characteristic. The average position of maxillary central incisors was far behind NA line, whereas the mean value of u1-FFA variable indicates very harmonious and esthetically pleasing position of incisors in relation to the forehead, as suggested by Andrews that the maxillary central incisors be positioned somewhere at or between the forehead's FFA point and glabella [20]. The established difference was highly significant. Because of these findings, it is evident that the Steiner method is significantly biased towards diagnosing more retrusive maxillary central incisors than photometric method for assessing facial and smile harmony proposed by Andrews.

Even though many studies of facial attractiveness indicate very low acceptance for retrusion of upper incisors, slightly retruded maxillary incisors according to the Steiner analysis, at the beginning or at the end of the treatment, does not always imply poor facial esthetics, if they have a favorable position to the forehead [3, 11, 26, 27]. This finding is emphasizing the importance of using extraoral reference points in evaluating and setting positional treatment goals for upper incisors, since this is the method that the society unconsciously uses to determine facial attractiveness and profile acceptance, rather than, for them obscured, skeletal structures [20, 28].

In group 3 (subjects with protruded incisors according to Steiner method) average value of u1-FFA was showing less protrusive characteristics of central maxillary incisors, than Steiner's method, but the difference was not statistically significant.

A very low level of correlation between compared variables point out that we must never only rely on one set of parameters, and should always incorporate into the assessment more cephalometric, photometric and clinical indices for evaluating the smile, prior to final decisions.

The finding of this study implies that morphology of the face and smile esthetics can sometimes be very deceptive and elusive, and it confirms other authors results that it is possible to obtain harmonious and attractive facial appearance even if some skeletal and dentoalveolar features are deviating from the established norms [27, 29]. Chasing cephalometric norms, without considering the broader view, can sometimes have detrimental effect on facial esthetics. Holdaway [30] in his article concluded that patients for whom orthodontic treatment adhered only to cephalometric standards often did not meet the esthetic principles. Each individual is a unique entity, therefore cephalometric norms for maxillary central incisors AP position should be used only as a general guide and a compliment to visual evaluation of facial attractiveness. As facial esthetics becomes more and more important objective in orthodontics, some of traditional cephalometric dentofacial norms should be evaluated cautiously, or possibly revised, in order to obtain optimal and balanced smile for patients.

CONCLUSION

In general, the method proposed by Andrews and Andrews, for assessing AP position of the maxillary central incisors in relation to the forehead, showed consistently more protrusion than traditional cephalometric method according to Steiner.

Slightly retruded position of maxillary central incisors according to Steiner analysis does not always imply poor facial esthetics, if they have favorable position to the forehead.

Conflict of interest: None declared.

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Поређење Стајнерове кефалометријске и модификоване Ендрузове фотометријске методе за процену антеропостериорног положаја максиларних централних секутића

Предраг Вучинић, Ђорђе Петровић, Стојан Ивић, Сања Вујков

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САЖЕТАК

Увод/Циљ Максиларни секутићи који се виде током осмеха представљају једну од најважнијих карактеристика лица. У покушају да превазиђе ограничења стандардних рендгенкефалометријских метода, Ендруз предлаже методу за одређивање идеалног антеропостериорног (АП) положаја горњих централних секутића у односу на чело. Стога смо упоредили традиционалну Стајнерову рендгенкефалометријску методу за процену положаја горњих централних секутића, која користи околне скелетне структуре и методу коју је предложио Ендруз, са циљем да се утврди да ли удаљене али веома уочљиве краниофацијалне структуре могу утицати на наш утисак о положају зуба.

Методе Материјал за ову студију састојао се од 90 насумично одабраних латералних рендгенкефалограма, подељених у три групе, у односу на АП позицију максиларних централних инцизива према Стајнеровим рендгенкефалометријским нормама. АП однос максиларних централних секутића је мерен као перпендикуларно растојање од најантериорније тачке крунице горњег централног секутића до линије која спаја тачке *назион* и *субспинале*, као и до вертикалне линије кроз средишњу тачку чела. Студентов *t*-тест и Пирсонова корелација коришћени су за поређење тестираних варијабли.

Резултати Утврђена је статистички значајна разлика између испитиваних метода ($p = 0,01108$). Према Стајнеровој методи, 46,67% испитаника је имало ретрузију секутића, а 53,33% испитаника имало је протрузију. Ендрузова метода је показала другачије резултате: 35,56% испитаника је имало ретрузију, док је 64,40% имало протрузију.

Закључак Метода коју предлаже Ендруз показала је знатно више особа са протрузијом горњих централних секутића него традиционална рендгенкефалометријска метода према Стајнеру. Благо ретрудирани положај горњих централних секутића према Стајнеровој анализи не значи увек и лошу естетику лица, ако секутићи имају повољан положај према челу. Низак ниво корелације указује на то да се никада не треба ослањати на само једну групу показатеља.

Кључне речи: секутићи; чело; естетика лица