Research article

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The cornea as a reference point in orthodontic diagnosing, a retrospective study

A. Impellizzeri[1], M. Horodynski[2], A. De Stefano[3], E. Serritella[4], A. Polimeni[5], G. Galluccio[6]

[1]Ph.D. Student, Department of Oral and Maxillofacial Sciences, "Sapienza" University of Rome, Italy; [2]School of Orthodontics Student, Department of Oral and Maxillofacial Sciences, "Sapienza" University of Rome, Italy; [3]Ph.D. Student, Department of Oral and Maxillofacial Sciences, "Sapienza" University of Rome, Italy; [4]Ph.D. Student. Department of Oral and Maxillofacial Sciences, "Sapienza" University of Rome, Italy; [5]Full Professor, Department of Oral and Maxillofacial Sciences, "Sapienza" University of Rome, Italy; [6]Associate Professor, Department of Oral and Maxillofacial Sciences, "Sapienza" University of Rome, Italy

Abstract

Background. The aim of the study is to provide scientific evidence on the possibility of using the Corneal point a skin point for measurements that can be made on both standard and three-dimensional photographs. Also, we want to demonstrate the stability of corneal point during the growth, to use it as a reference point.

Methods. A sample of 105 radiographs was reached. A descriptive and longitudinal statistical analysis was performed.

Results. By data analysis we obtained more variability inter-subject of the millimetrically value of the SC plan. For this reason, we considered the relationship between the SN and SC values and not a single value. In the cross-sectional study the T- test analysis did not show a different significant result of variations between SC and SN in both sexes; therefore, we considered these as unique sample.

Conclusion. Longitudinal study has a major importance for to establishing the age-related changes. By cross-selection and longitudinal analysis we obtained an overlapping trend of the SN and SC plan. As the SN plan has always been used as a reference plan for cephalometric measurements, although its variations in growth, it can be concluded that the SC plan can be considered equally a reference plan. ***Clin Ter 2022; 173 (2):141-148 doi: 10.7417/CT.2022.2408***

Key words: *Cornea, corneal point, orthodontic diagnosing, three-dimensional photo, reference point, cephalometry, tele-radiograph*

Introduction

Orthodontic diagnosis is classically based on the analysis of data from the patient's visit with physical examination, like intra and extra oral photographs, plaster models of the dental arches in habitual occlusion, orthopanoramic x-ray and the cephalometric study (1-3). To it can be added additional records that become necessary based on the patient's clinical picture (4).

With the progress of technology (5) , it has been possible to introduce new instrument that can be useful in diagnosis (6), as an additional or replacement for classic records. For example, with the advent of the intra-oral scanner (7) it is now possible to replace the classic alginate impressions for the study of the case, for the construction of intra-oral appliances and in the evaluation of the effects of therapy on the arches.

Three-dimensional photography is an instrument still little used in orthodontics, but widely used in other disciplines such as forensic medicine and plastic surgery (8,9) . Like all innovative methods, it needs to be standardized in order to be used scientifically. It also requires a period of learning and acceptance by clinicians.

The purpose of this work is to provide scientific evidence on the possibility of using the Corneal point (10-12) a skin point not used in classical orthodontic diagnosis, for measurements that can be made on both standard and three-dimensional photographs. The necessary prerequisite to be able to use it as a reference point is that it is stable during and after growth (13,14), or that its changes in space are negligible.

Furthermore, the actual need for cephalometry is investigated in the diagnosis and overall treatment plan of some types of patients, in order to reduce the radiation dose to which the patient is subjected and try to make measurements and choices more dictated by facial aesthetics (15).

Materials and Methods

The study was realized in our hospital, in Orthodontic department. We have selected patients cared among our structure. Patients with syndrome, outcomes of trauma at ocular level and endocrinology pathologies are excluded by the work. Myopia patients were not excluded because myopia alone does not cause an alteration of the eye protrusion (16).

Correspondence: Impellizzeri Alessandra, Via Caserta 6, 00161- Roma. Tel. +390649976641 - +393473300169; Fax Number 0961738012
email: Alessandra.impellizzeri@uniroma1.it Ale.impellizzeri@gmail.com

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Only patients who have presented two consecutive skull radiographs spaced at least a year apart were considered for the initial measurements. 172 X-rays were selected. A further selection on radiographs was performed on these patients, in fact only skull tele-radiographs that had a measuring ruler were taken into consideration in order to standardize all the measurements. A sample of 105 radiographs was reached.

The points were traced on each radiograph:

- C Corneal: point of maximum protrusion of the eyeball;
- S sellar: central midpoint of the Turkish saddle. It is a construction point, built as a meeting point on the sagittal plan of the maximum horizontal diameter with the maximum vertical diameter of the Turkish saddle (Cozza, 2013);
- N nasion: midpoint anterior to the frontal nasal suture.

The following have been reported:

- patient registry;
- date of birth;
- date on which the X-ray was taken in order to notice the patient age during the examination;
- the measurement corresponding to 1 mm on the ruler to calculate its proportion and standardize the calculations.

The measurement of the SC segment, the SN segment with a millimeter ruler was calculated. Measurements were performed with the same ruler in order to uniform the sample. The data obtained were then entered into an Excel database specifically created and used for the subsequent statistical processing of the data.

Since not all radiographs were performed by the same machine, an attempt was made to standardize the values by measuring the millimeter value of the scale positioned on the radiography. The values found are between a minimum of 0.8mm and a maximum of 1.4mm. At this point, a simple proportion was carried out:)

This transformation was performed for all millimeter values measured.

Statistical Analysis

As mentioned earlier in the literature studies (17), there are mostly cross-sectional studies. To compare our results with those in the literature, the data obtained were sampled in two different ways.

At first the 105 radiographs were analyzed individually, without considering that they belonged to the same patients in different stages of growth. The data obtained and recorded were analyzed with statistical software to develop a purely statistical descriptive part of the analyzed data and a second part in which the variables considered were put into a statistical relationship.

In the descriptive analysis, a uni-varied statistical processing was carried out, consisting of a descriptive analysis of the variables taken into consideration, including the calculation of the mean and standard deviation. The mean and the total standard deviations and that obtained by dividing the patients by sex were calculated.

The sample was divided into 5 age groups, so it the sample was equally distributed. The mean and standard deviation of each group was calculated.

Finally, the 5 groups, divided according to age, were further divided according to gender and the average and standard deviation were calculated. A comparison was made between the data in all the groups examined in order to identify differences related to sex or age.

In the inferential phase, once the data was normal, it was decided to carry out a parametric statistical investigation.

Group means of two were then compared using the T-Test. The α significance level was set at 0.05 normally used in medical statistics.

In a second phase we proceeded to study the changes of the individual patient over time. For this analysis, 35 patients were selected from the previous sample and had at least two radiographs spaced at least one year apart as a requirement. The SN values of SC and their relationship were compared and the change in values in the same patient over the years was compared. The x-rays were arranged in chronological order and numbered with consecutive numbers (1°,2°,3°). The Value of:

- SN1-SN2
- SC1-SC2
- (SC1/SN1)-(SC2/SN2)

These values were compared with each other and the mean and standard deviation were calculated. An interferential statistical analysis was not carried out because the differences found between an X-ray and the following were too small to be able to constitute the data for a statistical analysis.

The correlation index r was calculated between the values of SC and SN in each radiograph, to assess whether there is a correlation between the two values in the individual radiographs.

In addition, the correlation index between the SC values and the age of radiography was calculated.

Results

Statistical Descriptive Analysis of The Cross-Sectional Study

105 radiographs of 53 patients were analyzed, of which 23 are males and 30 females. Considering the x-rays, 47 are male (44%) and 58 (56%) are female.

The mean value of SC is 61.47 ± 3.73, while that of SN is 66.47 ± 3.85, and the mean value of their ratio is 0.93±0.03.

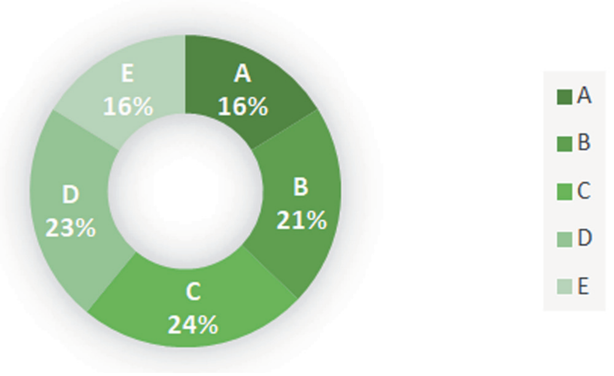
Both the SN plan and the SC plan in the male sex have a higher value than the mean value of the female sample. In particular, the SC plan differs by less than 1 mm on average (0.92mm) while the difference of the SN plan is greater (1.56mm).

This is also reflected in a different average SC / SN ratio: 0.92 in the male sex, 0.93 in the female sex. It should be emphasized that the female sample has a greater number.

The T-test was performed to evaluate whether there is a correlation between the millimeter value of the SC plan, the SN plan and the SC / SN ratio with the sex of the subject examined. The result is not significant, therefore the variations existing between the female and male sample can be considered randomly. The sample can be considered as a single sample.

The x-rays were divided into 5 groups based on the age of the patient during the execution of the x-ray.

16% of subjects are <9 years old, 21% are between 10-11 years old, 24% are between 12-13 years old, 23% are between 14-16 years old, 16% are over 17 years old (Graphic 1).



Graphic 1. Distribution based on sample age in all groups.

Table 1. μ and σ respectively of SC, SN and SC/SN values in two sexes in order of age.

Group A	Sample Number	μ SC	σ SC	μ SN	σ SN	μ R	σ R
M	13	59,42	5,41	66,09	4,46	0, 90	0,03
F	4	59,09	2,68	62,16	2,66	0,95	0,02
Group B							
M	8	62,49	3,79	67,37	3,23	0,93	0,02
F	14	60,44	3,05	64,58	3,96	0,94	0,02
Group C							
M	10	61,43	5,24	66,91	6,06	0,91	0,02
F	15	61,40	2,56	66,47	3,79	0,93	0,03
Group D							
M	8	62,95	2,82	68,21	2,84	0,91	0,03
F	16	61,27	3,20	65,20	3,10	0,94	0,02
Group E							
M	8	65,07	2,40	68,85	2,66	0,94	0,02
F	9	62,32	2,37	66,35	3,28	0,93	0,01

The mean and standard deviation of the SN and SC value and their ratio for each group were calculated. A progressive increase in both SN and SC values was obtained, while the ratio remains constant.

For the SC value, the greatest differences occurred during the transition between group A (<9 years) to group B (10-11), the difference on average is + 1.85mm. The SC value remains constant in groups B, C and D and then increases again between group D and E (+ 1.78mm).

The SN plan has a similar trend with an average increase of +0.43 mm between group A and group B, in addition there is a further +1.05 mm increase between group B and group C. The value remains stable between group C and group D and then increases again in group E (+ 0.99mm).

T-test was performed among the SC averages, to assess when age affects the SC value. The result is not significant, therefore there is no association between age and SC value. This data is in favor of the stability of point C during growth. The same was done with the SN values, achieving the same result.

The SC/SN ratio is constant between the B-C-D-E groups. The ratio between the groups increases between the transition from group A to group B, but remains constant in the other groups.

This suggests that the two points C and N are equally stable after 9 years.

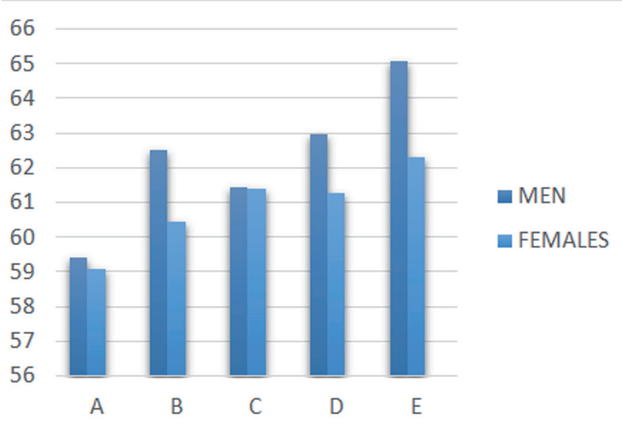
We calculated the mean value of SN plan, SC plan and SC/SN considering the following variables: age and sex.

Data obtained are shown in Table 1.

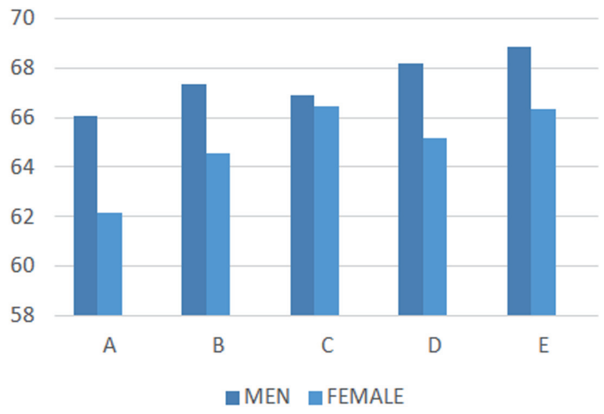
The mean difference between SC values in two sexes is 1.37 mm. Graphic 2 shows a different trend of SC value in male sex and female sex groups, with higher values in male sex group than female sex.

The higher difference between mean values were obtained in group B (+2.05mm), D (+1.68mm) and E (2.75mm).

Results of T-test is not significant, so the data variations are independent of sex of patients. Also, the SN value in all groups is higher in male sex, with a mean value more of 2.73 mm than female sex as shown in Graphic 3.



Graphic 2. Trend of SC mean values in two sexes



Graphic 3. Trend of SN mean values in two sexes

This graphic shows a progressive increase of mean values in the female sex groups from group A to group C, a drop-in in group D (-1.32mm), and no variation in group C compared to mean values in male sex groups. The male sex groups show a gradual increase from group A to group E, except between Group B to group C, where there is a drop-in of SN value (<1mm). T-Test analysis not given a significantly results, so the data variations are independent by sex of patient.

The SC/SN values in two sexes show a fluctuating trend; in fact, in male sex there is an increase from group A to group B, a drop-in from group B to group C, it is constant from group C to group D, and there is another increase from group D and group E. In female sex, instead, there is a progressive drop-in from group A to group C, an increase from group C to group D, a constant value from group D to group E (Graphic 4).

Longitudinal Statistical analysis

In the longitudinal study a total number of 35 patients was evaluated, with 57.14% female sex (20 patients) and 42.8% male sex (15 patients).

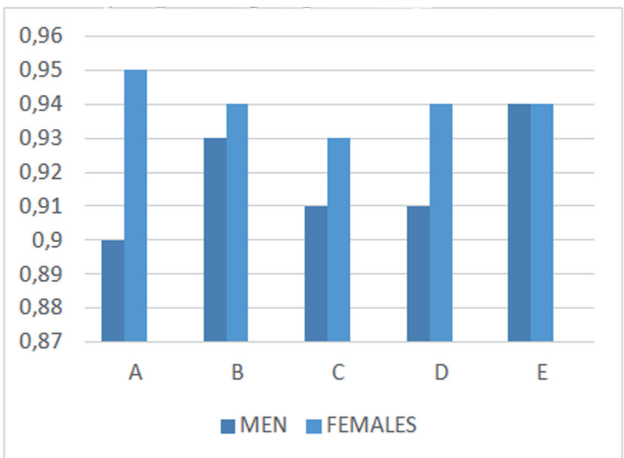
On average, a 2 years difference holds between a radiograph and the follow-up. The mean difference of the same value taken by two radiographs is shown in Table 2.

Table 2. µΔSC, µΔSN, µΔSC/SN.

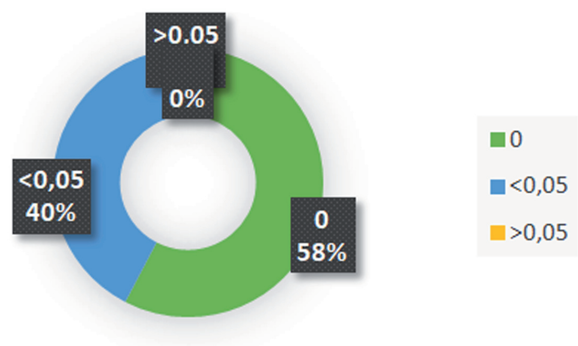
SN1-SN2	**-0.62±2.28**
SC1-SC2	-0.62±2.59
R1/R2	0.00±0.02

The mean difference between the SN and SC values show an increase of 0.62 mm in both values of SC and SN, probably due by a blow-up between a radiograph and the follow-up. In fact, the patients have not implemented the radiograph with the same machine and protocol. This hypothesis is supported by 0 mean difference between the mean values of SC/SN. Analysing the single comparisons, for 52 totals, in 57.7% of cases (30 comparisons) the SC/SN ratio is constant and the value is 0, in 40.4% of cases (21 comparisons) the ratio is less than 0.05, in one case (1.9%) the value is 0.9, as shown in a Graphic 5.

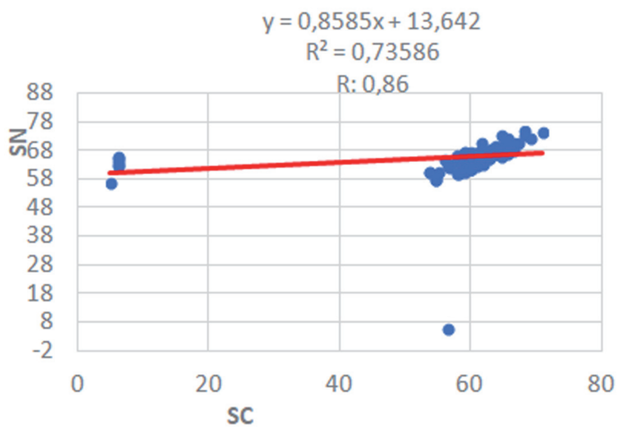
Since the differences obtained are low among the radiographs, it is not necessary a more advanced statistical research. Also, by this descriptive statistical analysis and the correlation index equal to 0.87, the SC plan has the same development of SN, as it is shown in graphic 6.



Graphic 4. Trend of SC/SN mean values in two sexes



Graphic 5. Analysis of the Single Comparisons.



Graphic 6. Values of Correlation index between SC and SN plan.

Discussion

In literature, there are cross-sectional studies on this topic, and we did not find observational longitudinal studies. In this study, we obtained with the same values, cross-data for comparing this with a literature data and longitudinal-data to establish the effectiveness stability in the same patient.

We had highlighted that it is important to consider that all patients do not have implemented the radiograph in the same structure (they have not used the same instrument and protocol), this could influence the data standardization. Through data analysis we have obtained more variability inter-subject of the millimetric value of the SC plan. For this reason, we considered the relationship between the SN and SC values and not a single value. In the cross-sectional study the T- test analysis does not show a different significant result of variations between SC and SN in both sexes, therefore we considered these as a unique sample, like in other studies (18-21). Also, T-test analysis does not show a relation between SC value and patient's age; in particular the groups trend of SC and SN plan is the same from 9 years old (transition between groups A and B), in fact the values of SC/SN are constants after 9 years (mean value 0.93). Caprioglio et al. (19) noted that the ocular protrusion is stable from 7 to 10 years, but there is an increment of 1 mm from 10 years and adulthood.

Moreover, the SC value is not dependent by age and sex and since the relationship SC/SN is constant, SN plan can be considered stable as well as SC plan. As S is a fix point, we can conclude by cross data analysis that the C corneal point does not change position after 9 years age.

Longitudinal study has a major importance to establish age-related changes. In fact, it is possible to value the effective growth of single patient.

In our study, we obtained that the μDSC e μDSN value are overlay, then between a radiograph and the next, the mean increment of the values is less than 1 mm and their increment is the same. This data is concordant with the study of Masoud et al. (9) that had calculated the SN and SC pre-pubertal and post-pubertal peak values; the mean value of SN pre-pubertal is 64.36±3.21mm, post-pubertal peak value is 69.98±2.79; SC value increments also after post-pubertal peak, with a transition between 60.36±3.64 to 65.89±2.55. The value of DSN is 5.62±2,10mm and of DSC is 5.51±2.55mm.

If we calculated the SC/SN value of pre-pubertal and post-pubertal we obtained a 0.838 value pre-pubertal and 0.941 post-pubertal, the ΔSC/SN= -0.003 values are concordant with our results, this shows as the two planes have overlay growth. In our study (ΔSC/SN=0) or the different are not relevant

(ΔSC/SN<0.05), only in one case there is a 0.09 value of difference.

It follows that the SC and SN planes, although their millimeter value is not the same between one radiograph and the next, maintain the same ratio.

This data can be interpreted in two ways:

- the growth of point C is comparable to that of point N. Both planes SC and SN have a certain degree of millimeter growth, which however is of the same entity.
- The points C and N are stable but there is a distortion of the image which causes an enlargement / decrease of both structures. This would explain why the growth of both is of the same magnitude between one radiograph and the next. In conclusion, point C can be used as a reference point in measurements, just as point N is used.

Correlations index graphic shows as the values of SC and SN are assembled in a small distant area, with only 2 outliers. This result means that the correlation is very strong; when one variable value increases proportionally, also increase the value of another variable. This means that by the independent variable value it is possible to know approximately the dependent variable value. Coefficient of determination r2 is 0.735. The equation of the line which describes the linear correlation between the two variables is y = 0.8585x + 13.642.

In both longitudinal and cross-sectional studies, the results show a growth similar of the SN and SC values. Indeed, cross-sectional study carry out that ratio became stable after 9 years; longitudinal study carries out there is also a ratio stable down the 9 years. The SN plan is formed by two points considered stable and also SN/SC ratio is constant in the growth, with a variations less than 0.62 mm of mean value, it's possible to declare that these points can be used in the same way in cephalometric analysis.

Enlow (22) shows that the N point has an important variation during the growth, in relation to age, sex, ethnic and individual differences. Also, Bjork (16) shows that N point has a growth forward and down. Despite the growth that characterizes N point, this point with S point forms an important reference plan in cephalometric analysis. At the same way, C point has a variation during the growth, that is not statistically significant; for this reason, SC plane can be considered a stable reference plane equal to the SN plane. Masoud (9) has studied a correlation of other cephalometric measurements (millimetrically and corner) referred to corneal point and N point, they found a correlation coefficient in the range 0.74 – 0.99.

Thus, considering 2d optical, both radiograph and photograph, C point can be used as an alternative of N skeletal or cutaneous point. The use of C point as a growth point

0 in order to do other measurements in alternative to N point, gives mainly advantages when it's impossible to find skeletal point.

In bi or three-dimensional photograph analysis, it defaults used N cutaneous point as reference.

Moreover, it used these following different points (Fig. 1) (15)

- Nasion cutaneous (n);
- Pronasal (prn);
- Labial superior (ls);
- Pogonion cutaneous (pg);
- Tragion (t)

The CT plan can be used as a reference plan in linear and square measurement on profile picture, just like it's done with SN plan in cephalometric measurements. So, C point is an equal point in reverse on N cutaneous point.

Masoud (9) proposed the use of Farkas' landmark (23) and find three planes passing by M point between two pupils (0,0,0). The three planes are: (Fig.2)

Coronal plan for sagittal measurement (MC) that is tangent to pupils (right and left corneal point) and perpendicular to horizon line;

Axial plan (MA) for vertical measurement parallel to real horizontal line passing by M point;

Sagittal plan (MS) for transverse measurement perpendicular to other planes passing by M point and Two C points.

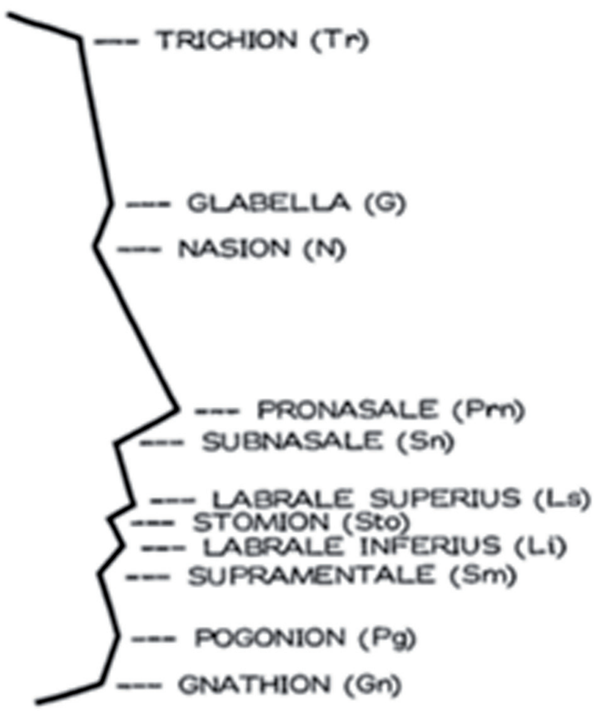


Fig. 1. Reference points on profil analysis (Peck&Peck,1970).

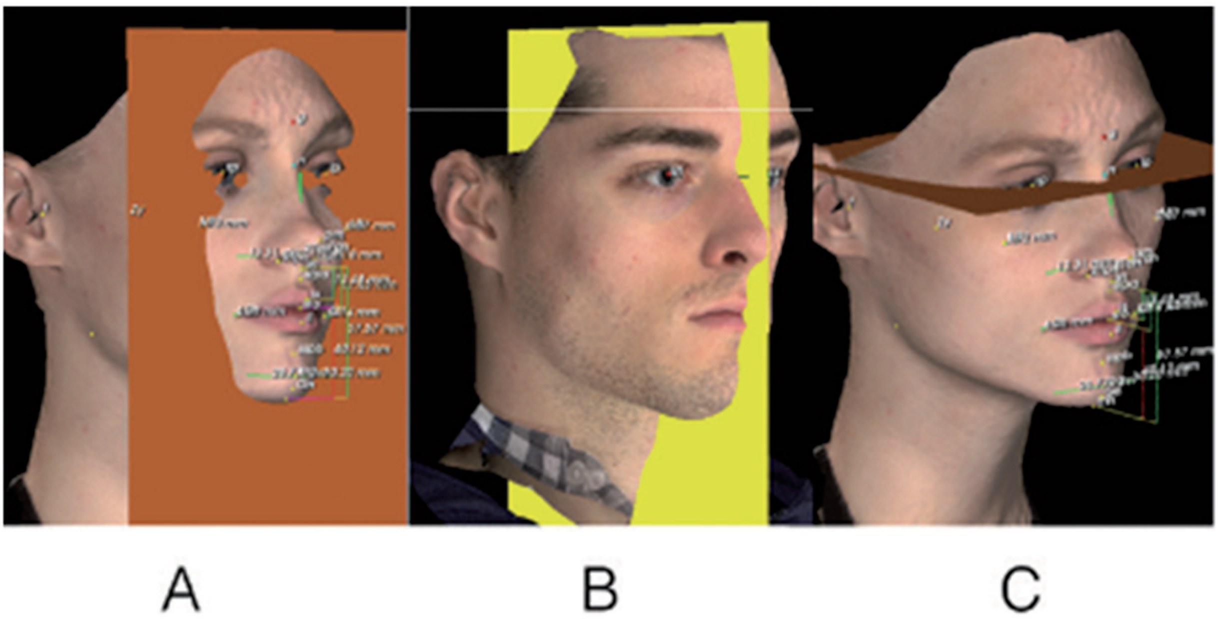


Fig. 2. Graphic planes representation on three-dimensional photographs. A: Coronal plan (MC); B: Axial plan (MA); C: Sagittal plan (MS). Masaud, 2017

Conclusions

The aim of this work was to demonstrate the stability of corneal point during the growth, so that it can begin a reference point for orthodontic diagnosing. By cross-selection and longitudinal analysis we have obtained a completely overlapping trend of the SN and SC plan.

As the SN plan has always been used in orthodontics as a reference plan for cephalometric measurements and although there are variations in length in growth, it is considered stable, it can be concluded that the SC plan is equally stable. Furthermore, a correlation was found between the value of the SN and SC plan. It follows that if SN is considered stable, SC can be considered it as well.

The advantages, negligible in the cephalometric field, are important in the photographic field where there is no possibility to use the skeletal point N. In photographic profile analysis what is used as a cranial reference point is the T point (tragus). Therefore the straight line TC can be used as a reference plan in photographic analysis.

Looking towards a more technological perspective, the stability of the corneal position can be used to trace the reference planes on three-dimensional photographs.

This reference point cannot be used in patients suffering from pathologies that alter the eye protrusion (24-26). Moreover, they were also excluded from the study. In adult patients, the main cause of exophthalmos is Basseldow-Graves disease (27). This type of patient cannot use the C points as reference points in the analysis because it is located in an altered and unstable position. In growing patients the main cause of exophthalmos is an ocular tumor, very infrequent (28,29). On the contrary, the main causes of enophthalmos are syndromic patients and patients who have suffered an ocular fracture with dislocation. In these patients, the use of this landmark is not recommended because it is altered even if its position remains theoretically stable.

The next working hypothesis is to be able to standardize measurements on three-dimensional photographs using point C as a reference point, in order to support cephalometry, or replace it in cases where it is not necessary, in the diagnosis and treatment plan.

We want to emphasize the importance of photographic analysis, both as an alternative and an aid in the diagnosis and in the orthodontic treatment plan. Certainly, as previously highlighted, the transition to a non-radiographic method has an advantage from a biological point of view for the patient, but the importance for the orthodontist himself must also be stressed. Cephalometric values do not always reflect the ideal of beauty in the population. Therefore entrusting the treatment objectives to the achievement of a cephalometric standard in all patients is therefore counterproductive. It should be emphasized that cephalometric values are obtained from average values studied in a Caucasian population. This does not always adapt to the facial features of other populations.

Even, if cephalometry becomes necessary to reach a correct diagnosis, three-dimensional photographs can complement and add useful information to the orthodontist especially in the aesthetic field.

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Conflicts of Interest: The authors declare no conflict of interest.

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