# Reproducibility of Cephalometric Measures Obtained by Dental Radiologists

Reprodutibilidade de Medidas Cefalométricas por Especialistas em Radiologia

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## Resumo

**Objetivo:** A análise cefalométrica é utilizada por dentistas no auxílio ao diagnóstico, planejamento e acompanhamento dos tratamentos ortodôntico, ortopédico e cirúrgico. Entretanto, a cefalometria não é uma ferramenta precisa e há erros significativos nas medidas obtidas por examinadores diferentes ou pelo mesmo avaliador em momentos distintos. O objetivo deste estudo foi avaliar a reprodutibilidade das medidas cefalométricas de três especialistas em radiologia odontológica e compará-las com os resultados obtidos por três clínicas de radiologia.

**Materiais e métodos:** Os examinadores traçaram os cefalogramas de 39 telerradiografias convencionais da amostra utilizada por Silveira e Silveira (2006).

**Resultados:** O teste de ANOVA revelou uma boa reprodutibilidade para 17 dos 32 fatores nas análises realizadas pelos dentistas especialistas. Houve concordância entre os especialistas para 53,1% dos fatores, enquanto que para as clínicas de radiologia a concordância foi de somente 12,5%.

**Conclusão:** Os resultados mostraram que os três especialistas em radiologia obtiveram maior concordância nas aanálises cefalométricas realizadas do que aquelas recebidas pelas clínicas de radiologia estudadas previamente.

**Palavras-chave:** Circunferência Craniana; Pontos de Referência Anatômicos; Diagnóstico por imagem

## Abstract

**Objectives**:Cephalometric analysis is used by dentists to assist in the diagnosis, planning and follow-up of orthodontic, orthopedic and surgical treatments. However, cephalometry is not a precise tool, and there are significant errors in the measures obtained by the same or different examiners. The purpose of this study was to evaluate the reproducibility of cephalometric measures obtained by three specialists in oral radiology, and to compare them with the results obtained by three radiology clinics.

**Materials and Methods**: Examiners traced cephalograms from 39 conventional cephalograms from the sample used by Silveira and Silveira (2006). ANOVA revealed good reproducibility of 17 of the 32 factors in the analyses conducted by dental specialists.

**Results**: Agreement between dental specialists was found for 53.1% of the factors, whereas agreement for the results obtained by radiology clinics was only 12.5%.

**Conclusion**: Results showed that tracings by the 3 radiology specialists had greater agreement than those by the radiology clinics under study.

**Key words:** Cephalometry; Anatomic Landmarks; Diagnostic Imaging

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## Introduction

Cephalometry summarizes the complexity of the human head in a geometric outline by obtaining measures of distances and angles to be compared with the population standards, models, or their own baseline values. Therefore, it is essential for the diagnosis, planning and follow-up treatment of orthodontic, orthopedics and surgical-orthognathic patients (MOYERS; BOOKSTEIN ; HUNTER, 1991). However, these tracings may be inaccuracy because they are subject to errors. The use of a cephalostat for acquisition the images and of computers for calculations reduced errors, but those from landmark identification remained (STEINER, 1953; YEN, 1960; BAUMRIND; FRANTZ, 1971; RUDOLPH; SINCLAIR; COGGINS, 1998; ONGKOSUWITO et al., 2002) .

Difficulties in determining the exact location of important anatomic structures is associated with no coincident images of paired structures found on the left and right sides of the face and projected on the same film (STEINER, 1953; YEN, 1960). According to Stabrun and Danielsen (1982), Lau, Coocke and Hagg (1997) and Silveira, Silveira and Dalla-Bona (2000), errors both in the identification of landmarks and in the measurement of angles and lines occur due to differences in individual conceptions about the definition of landmarks and in the individual perception of anatomic landmarks. An examiner's perception of anatomic landmarks identification is, therefore, the main source of error in cephalometric analysis.

In Brazil, cephalograms are usually traced by radiology clinics, as they are part of the dental documentation required by dentists before, during and after their patients' treatment. Therefore, tracings are under the responsibility of dentist, which may or may not

be specialists in dental radiology. However, Silveira and Silveira (2006) studied the measures obtained by 3 radiology clinics and demonstrated the low reproducibility of cephalometric values. Therefore, the purpose of this cross-sectional study was to evaluate the reproducibility of cephalometric values obtained by 3 specialists in dental radiology and to compare them with the results obtained by Silveira and Silveira (2006).

## Materials and Methods

Thirty-nine lateral conventional cephalograms from files were used. They were all obtained with the same radiography unit (Siemens Orthophos D 3200, Germany) from adult patients of both sexes who underwent orthodontic treatment. The only selection criterion was the technical quality of the radiographs, which had to present correct patient positioning and good contrast of the image. The radiographs were the same used in the study conducted by Silveira and Silveira (2006). However, the number was reduced from 40 to 39 because one of the patients moved to another city and requested his records and dental examinations.

The selection of 3 radiology specialists was intentional. The 3 specialists completed their graduate courses at the same time and had been routinely doing cephalometric tracings in their practices at the time of the study. Therefore, the homogeneity of the group under evaluation attempted to avoid biases, such as different experience times and greater or lower familiarity with the process.

Each specialist received a CD with the 39 radiographs digitalized (UMAX 2400S scanner, Miami, EUA). Tracings were made according to the instructions that the specialists had received in their specialization courses and with the same software (Radioceph System, Radio Memory Ltda,, Belo Horizonte, Brazil) used in the study by Silveira e Silveira (2006). 32 cephalometric measurement were selected (Table1), totalizing 3840 measures that were analyzed and compared with the results reported by Silveira and Silveira (2006). Analysis of Variance (ANOVA) for 3 or more paired samples was used to separately compare each factor. Significance level was established at 5%.

## Results

The results of ANOVA comparing the cephalometric values obtained by the radiology specialists are shown in Table 2. The most relevant results are described below:

- There was no significant difference among the radiology specialists in the analysis of 17 factors.
- There was a significant difference among the 3 specialists in only one factor: (N-Pog).(Po-Orb).
- There was a significant difference between specialists 1 and 2 and between 1 and 3 in the analysis of the following 4 factors: /1-NB, /1.Npog, FMIA and F.(V-T).
- There was a significant difference between specialists 2 and 1 and between 2 and 3 in the analysis of the following 2 factors: 1/.NS, /1-Orbit.
- There was a significant difference between specialists 3 and 1 and between 3 and 2 in the analysis of the following 7 factors: S-N.A, S-N.B, S-N.D, S-N.Gn, S-N.Ocl, (S-N).(Go-Me) and FMA.
-There was a significant difference only between specialists 1 and 3 in the analysis of genial tubercle.

Table 1: Description of 32 Cephalometric Factors Analyzed on Cephalograms[a]

| Cephalometric Factor | Description |
|---|---|
| /1-NPog | Position of lower incisor relative to nasion-pogonion line |
| A-(V-T) | Position of maxilla relative to V-T line |
| CD (Vigorito) | Vigorito's cephalometric discrepancy |
| /1-Orb | Distance from long axis of upper incisor to orbitale |
| H-Nose | Nose projection relative to Holdaway line |
| 1/-NA | Position of upper incisor relative to maxilla |
| /1-NB | Position of lower incisor relative to mandible |
| Pog-NB | Distance from pogonion to NB line |
| /1-(V-T) | Distance of lower incisor incisal to V-T line |
| S-N.A | Position of maxilla relative to anterior cranial base |
| S-N.B | Position of mandible relative to anterior cranial base |
| S-N.D | Position of mandible relative to anterior cranial base |
| 1/.NA | Inclination of upper incisor relative to maxilla |
| /1.NB | Inclination of lower incisor relative to mandible |
| 1/.NS | Inclination of upper incisor relative to anterior cranial base |
| S-N.Ocl | Inclination of occlusal plane relative to anterior cranial base |
| H.(N-B) | Soft-tissue profile of face |
| (S-N).(Go-Me) | Inclination of mandibular plane relative to anterior cranial base |
| FMIA | Frankfort mandibular incisor angle |
| FMA | Frankfort mandibular angle |
| 1/./1 | Interincisor angle |
| IMPA | Incisor mandibular plane angle |
| (N-Pog).(Po-Orb) | Facial angle |
| N-A.Pog | Angle of convexity |
| A-N.B | Relative position of maxilla to mandible |
| S-N.Gn | Growth axis |
| (Go-Me).(V-T) | Inclination of mandibular plane relative to V-T line |
| F.(V-T) | Inclination of Frankfort plane relative to V-T line |
| (Go-Gn).Ocl | Inclination of oclusal plane relative to mandibular plane |
| Genial tubercle | Projection of genial tubercle. |
| H.(V-T) | Angle formed by Holdaway line and V-T line |

[a] V-T line indicates Long axis of mandibular symphysis Line 1, Interlandi's line.

The comparison of mean, standard deviation and minimum and maximum differences among specialists regarding cephalometric values are shown in Table 3. It revealed, for angle measures, differences of up to 66.71° in 1/.NA, and differences of up to 14.76 mm in A-(V-T) for linear measures.

The comparison of the results obtained by Silveira and Silveira (2006) for the 3 clinics with the results found for the 3 radiology specialists in this study revealed that:

- Dental radiology specialists did not show significant differences in 53.1% of the cephalometric factors, whereas dental radiology clinics did not show significant differences in only 12.5% of the cases.

- There were no significant differences among the 3 radiologists in 17 factors, whereas no significant differences were found in only 4 factors in the comparison of radiology clinics. None of the factors was common to both studies.

- There was a significant difference among the 3 radiology specialists (1, 2 and 3 differed from each other) in only 1 factor; whereas significant differences were found in 8 factors in the comparison of radiology clinics. None of the factors was common to both studies.

- The greatest difference for angle factors among the 3 radiology specialists was in 1/.NA, which reached 66.71°; among the 3 clinics, it was in FMIA, with a difference of up to 20.13°.

- The greatest difference for linear factors among the 3 radiologists was in A-(V-T), which reached 14.76 mm; among the 3 radiology clinics, it was in 1/-NA, with a difference of up to 11.33 mm.

## Discussion

Cephalometric analysis is an important aid for diagnosis, planning and follow-up in orthodontic, orthopedic and surgical-orthognathic treatments. Therefore, reproducibility of cephalometric measurements is fundamental, once it indicates a satisfactory performance of the examiner. Silveira and Silveira (2006) found a poor reproducibility of cephalometric values obtained by 3 different radiology clinics responsible for performing and sending cephalometric analyses to orthodontists and oral and maxillofacial surgeons. After evaluation of the study mentioned above, we felt the need to understand such discordant results that may change treatment plans for patients depending on which clinic performed the analysis. Therefore, this study was conducted with the collaboration of 3 dental radiology specialists that traced the cephalograms from the same radiographs used by Silveira and Silveira (2006) to compare the results of the two studies.

The radiology specialists had just finished the specialization course and, therefore, had a similar level of knowledge about cephalometry. This avoided that one of the examiners had a different performance due to longer experience in the area, as observed by Martins et al. (1995), or that there were differences in the familiarity with the process employed.

The 3 radiologists showed a significant improvement of reproducibility in the cephalometric measures when compared with the results reported by Silveira and Silveira (2006). The present study found reproducibility of measurements in 17 cephalometric factors, whereas agreement was found in only 4 of the linear and angles measures obtained by the radiology clinics. Although agreement among radiologists was better, a clinically acceptable level of reproducibility, that would ensure result dependability, was not reached. The metric evaluation of the cranium depends on a set of cephalometric factors, and not on isolated measures, which requires that the evaluation should be accurate for the whole exam and not only for some factors.

The improvement of reproducibility of the results obtained by the 3 dental radiology specialists in the comparison with the 3 clinics evaluated by Silveira and Silveira (2006) might have been affected by the previous information that it was part of a scientific study. Other studies (CHEN, S. et al., 2004; CHEN, Y. et al., 2004) also found a better interexaminer reproducibility, and demonstrated that, if the specialists are qualified and focused on their work, error in the identification of anatomic landmarks may be reduced. Besides, the specialists invited for this study have just finished their course, showing the importance of continuous educating, as demonstrated by Delamare et al. (2010). In this scene, Silveira et al. (2009) have developed and tested a learning virtual object for cephalometric training.

In spite of oral and maxillofacial area is moving towards 3D-images, bidimensional cephalograms are still in use, because it is an established method, have reproducibility with the three-dimensional analysis, and, especially, by the lower radiation dose received by patients (OZ; ORHAN; ABE, 2011; LIEDKE et al., 2012). Therefore, are recommended if the patient has no need for a tomographic examination.

Table 3: Results of ANOVA to compare specialists 1, 2 and 3 in the analysis of cephalometric factors.

| FACTORS | p VALUE | DIFFERENCES |
|---|---|---|
| **N-A.Pog** | 0,073 | 1, 2, 3 did not differ |
| **A-N.B** | 0,134 | 1, 2, 3 did not differ |
| **(Go-Gn).Ocl** | 0,902 | 1, 2, 3 did not differ |
| **1/./1** | 0,051 | 1, 2, 3 did not differ |
| **1/.NA** | 0,650 | 1, 2, 3 did not differ |
| **1/-NA** | 0,139 | 1, 2, 3 did not differ |
| **/1.NB** | 0,077 | 1, 2, 3 did not differ |
| **H.(N-B)** | 0,135 | 1, 2, 3 did not differ |
| **H-Nose** | 0,364 | 1, 2, 3 did not differ |
| **Pog-NB** | 0,060 | 1, 2, 3 did not differ |
| **IMPA** | 0,290 | 1, 2, 3 did not differ |
| **/1-Line I** | 0,162 | 1, 2, 3 did not differ |
| **(G0-Me).(V-T)** | 0,306 | 1, 2, 3 did not differ |
| **A-(V-T)** | 0,117 | 1, 2, 3 did not differ |
| **Iii-(V-T)** | 0,081 | 1, 2, 3 did not differ |
| **H.(V-T)** | 0,788 | 1, 2, 3 did not differ |
| **DC (Vigorito)** | 0,860 | 1, 2, 3 did not differ |
| **Genial tubercle** | 0,027 | **2 differed from 3** |
| **/1-NB** | 0,000 | **1 differed from 2 and 3** |
| **/1.NPog** | 0,001 | **1 differed from 2 and 3** |
| **FMIA** | 0,000 | **1 differed from 2 and 3** |
| **F.(V-T)** | 0,000 | **1 differed from 2 and 3** |
| **1/.NS** | 0,000 | **2 differed from 1 and 3** |
| **/1-Orbit** | 0,000 | **2 differed from 1 and 3** |
| **S-N.A** | 0,000 | **3 differed from 1 and 2** |
| **S-N.B** | 0,000 | **3 differed from 1 and 2** |
| **S-N.D** | 0,000 | **3 differed from 1 and 2** |
| **S-N.Gn** | 0,000 | **3 differed from 1 and 2** |
| **S-N.Ocl** | 0,000 | **3 differed from 1 and 2** |
| **(S-N).(Go-Me)** | 0,000 | **3 differed from 1 and 2** |
| **FMA** | 0,000 | **3 differed from 1 and 2** |
| **(N-Pog).(Po-Orb)** | 0,000 | **1, 2 and 3 differed from each other** |

Table 3: Mean, standard deviation and minimum and maximum differences between radiology specialists 1, 2 and 3 in cephalometric values, in millimeters or degrees.

| FACTORS | DIFFERENCES BETWEEN RADIOLOGY SPECIALISTS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 and 2 | | | | 1 and 3 | | | | 2 and 3 | | | |
| | Mean | SD | MIN | MAX | Mean | SD | MIN | MAX | Mean | SD | MIN | MAX |
| (N-Pog).(Po-Orb) | 2.56 | 1.75 | 0.01 | 6.30 | 2.97 | 2.51 | 0.08 | 8.31 | 2.14 | 1.42 | 0.03 | 5.26 |
| N-A.Pog | 3.04 | 2.86 | 0.16 | 11.40 | 2.99 | 2.61 | 0.07 | 12.81 | 2.57 | 2.02 | 0.03 | 8.97 |
| S-N.A | 2.22 | 1.85 | 0.00 | 8.18 | 2.68 | 1.77 | 0.28 | 7.00 | 2.94 | 2.12 | 0.11 | 8.45 |
| S-N.B | 1.56 | 1.34 | 0.01 | 5.81 | 2.14 | 1.27 | 0.22 | 5.05 | 2.69 | 1.50 | 0.07 | 6.69 |
| A-N.B | 1.50 | 1.32 | 0.01 | 5.64 | 1.22 | 1.10 | 0.01 | 5.27 | 1.28 | 0.94 | 0.17 | 3.39 |
| S-N.D | 1.32 | 1.14 | 0.00 | 5.16 | 2.22 | 1.20 | 0.05 | 5.38 | 2.57 | 1.42 | 0.24 | 6.23 |
| S-N.Gn | 1.03 | 0.77 | 0.04 | 3.32 | 2.18 | 1.21 | 0.15 | 4.84 | 1.83 | 1.18 | 0.16 | 4.63 |
| S-N.Ocl | 2.06 | 1.87 | 0.01 | 6.84 | 3.13 | 2.29 | 0.09 | 9.71 | 2.39 | 2.26 | 0.02 | 11.05 |
| (S-N).(Go-Me) | 1.55 | 1.43 | 0.01 | 5.63 | 2.13 | 1.31 | 0.23 | 6.62 | 2.52 | 1.74 | 0.15 | 7.71 |
| (Go-Gn).Ocl | 2.67 | 2.38 | 0.01 | 11.35 | 2.90 | 2.06 | 0.26 | 7.80 | 2.20 | 2.06 | 0.19 | 10.56 |
| 1/./1 | 5.20 | 5.09 | 0.02 | 27.85 | 4.48 | 5.71 | 0.06 | 34.70 | 3.19 | 2.24 | 0.13 | 8.50 |
| 1/.NS | 3.93 | 3.44 | 0.16 | 18.54 | 3.03 | 2.79 | 0.08 | 15.20 | 3.48 | 2.29 | 0.24 | 10.08 |
| /1-Orbit | 4.47 | 2.97 | 0.23 | 11.59 | 2.98 | 1.95 | 0.54 | 7.34 | 3.79 | 3.05 | 0.14 | 12.95 |
| 1/.NA | 4.98 | 10.05 | 0.01 | 63.83 | 4.86 | 10.41 | 0.02 | 66.71 | 2.66 | 1.81 | 0.26 | 7.00 |
| 1/-NA | 1.84 | 1.76 | 0.02 | 8.09 | 1.99 | 1.65 | 0.03 | 8.31 | 1.81 | 1.28 | 0.02 | 4.19 |
| /1.NB | 2.81 | 2.10 | 0.06 | 9.14 | 2.65 | 1.92 | 0.09 | 6.57 | 2.77 | 2.06 | 0.05 | 7.97 |
| /1-NB | 1.13 | 0.93 | 0.03 | 3.96 | 0.97 | 0.92 | 0.02 | 4.58 | 0.74 | 0.75 | 0.02 | 3.15 |
| /1-NPog | 0.94 | 0.85 | 0.11 | 3.36 | 0.94 | 0.88 | 0.02 | 4.10 | 0.62 | 0.51 | 0.03 | 1.81 |
| H.(N-B) | 1.56 | 1.18 | 0.11 | 5.94 | 1.57 | 1.27 | 0.03 | 4.78 | 1.55 | 1.51 | 0.15 | 5.95 |
| H-Nose | 1.22 | 0.94 | 0.07 | 4.67 | 1.34 | 1.07 | 0.12 | 4.47 | 1.08 | 0.92 | 0.01 | 3.70 |
| Pog-NB | 0.99 | 1.03 | 0.03 | 5.18 | 0.65 | 0.46 | 0.07 | 2.03 | 0.95 | 0.97 | 0.01 | 5.32 |
| Genial tubercle | 1.11 | 1.10 | 0.04 | 5.48 | 1.04 | 1.20 | 0.02 | 6.30 | 1.03 | 0.96 | 0.01 | 5.09 |
| FMIA | 3.98 | 2.85 | 0.07 | 9.36 | 4.08 | 2.59 | 0.07 | 10.42 | 2.67 | 2.34 | 0.02 | 8.71 |
| FMA | 2.82 | 1.98 | 0.03 | 7.05 | 3.27 | 2.53 | 0.15 | 9.39 | 2.24 | 2.00 | 0.06 | 9.90 |
| IMPA | 3.38 | 2.75 | 0.10 | 9.88 | 3.42 | 2.13 | 0.12 | 8.92 | 2.98 | 2.17 | 0.04 | 8.00 |
| /1-Line I | 1.06 | 0.94 | 0.02 | 4.64 | 1.16 | 0.86 | 0.01 | 3.97 | 0.80 | 0.62 | 0.02 | 2.34 |
| (Go-Me).(V-T) | 3.25 | 2.82 | 0.09 | 14.68 | 2.62 | 2.17 | 0.06 | 9.36 | 2.64 | 2.98 | 0.02 | 12.00 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| F.(V-T) | 3.84 | 3.23 | 0.07 | 17.81 | 4.07 | 2.98 | 0.11 | 10.54 | 3.17 | 2.74 | 0.07 | 10.18 |
| A-(V-T) | 2.89 | 2.85 | 0.04 | 14.76 | 2.69 | 2.52 | 0.11 | 13.45 | 2.57 | 2.44 | 0.00 | 11.13 |
| Iii-(V-T) | 1.85 | 1.56 | 0.06 | 7.35 | 1.73 | 1.61 | 0.03 | 8.68 | 1.39 | 1.47 | 0.04 | 6.13 |
| H.(V-T) | 3.01 | 2.76 | 0.12 | 13.28 | 3.20 | 2.47 | 0.26 | 10.81 | 2.49 | 2.46 | 0.01 | 9.71 |
| DC (Vigorito) | 1.30 | 1.14 | 0.02 | 5.49 | 1.23 | 0.94 | 0.09 | 3.94 | 1.01 | 0.64 | 0.06 | 2.56 |

SD, standard deviation ; MIN, minimum; MAX, maximum

## Conclusion

In conclusion, this study showed that the three radiology specialists had better reproducibility in cephalometric tracings than the radiology clinics. The reproducibility found for the three radiology specialists was four times greater than that found for the radiology clinics. Of the measures studied, the one with the lowest reproducibility among the 3 dental radiology specialists was (N-Pog).(Po-Orb), and among the 3 clinics, S-N.D, \(S-N).(Go.Me), 1/.NS, 1/.NA, FMIA, FMA, A-(V-T) and DC (Vigorito). Besides, periodical calibration of specialists that perform cephalometric analyses for the clinical practice should be routinely conducted, although this recommendation has usually been found only in scientific studies.

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