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Comparison of cephalometric measurements from three radiological clinics

Comparação de grandezas cefalométricas obtidas em três clínicas radiológicas

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ABSTRACT: The orthodontic documentation carried out in radiological clinics is essential for diagnosis, planning and control of the orthodontic treatment. Amongst the diagnosis elements used are the cephalometric measurements, and errors can be incorporated as they are obtained. The objective of this work was to evaluate the values of some cephalometric measurements obtained in three radiological clinics using 30 lateral cephalometric radiographs of the head randomly chosen from the archives of the Department of Child Dentistry (Discipline of Orthodontics), School of Dentistry of Piracicaba, UNICAMP. These values were compared with the measurements obtained manually (control group) using variance analysis and Tukey's and Friedman's tests. Of the fourteen cephalometric measurements evaluated, the results demonstrated that only four of them presented statistically significant differences: IMPA, 1-NA, FMA, and H-nose. We concluded that although the majority of the mean cephalometric values did not present statistically significant differences, a great variability in the results was found when all the radiographic values were compared. This variability may influence the interpretation of the cephalometric measurements. Hence, we suggest that when the practitioner receives orthodontic documentation, he/she should redo the cephalometric analysis and compare the measurement values found with those presented to him. In addition, the practitioner should be prepared to use other elements for diagnosis, planning and control of the orthodontic treatment.

DESCRIPTORS: Cephalometry; Observation variations; Diagnostic errors.

RESUMO: A documentação ortodôntica realizada em clínicas radiológicas é essencial para diagnóstico, planejamento e controle do tratamento ortodôntico. Dentre os elementos de diagnóstico utilizados estão as grandezas cefalométricas, e erros podem ser incorporados durante a obtenção das mesmas. O objetivo deste trabalho foi avaliar os valores de algumas grandezas cefalométricas obtidas em três clínicas radiológicas, utilizando-se 30 telerradiografias da cabeça em norma lateral, escolhidas ao acaso, do arquivo do Departamento de Clínica Infantil (Disciplina de Ortodontia) da Faculdade de Odontologia de Piracicaba - UNICAMP. Esses valores foram comparados com os das grandezas obtidas manualmente (grupo controle), utilizando-se a análise de variância e os testes de Tukey e Friedman. Os resultados demonstraram que das 14 medidas cefalométricas avaliadas, apenas 4 apresentaram diferenças estatisticamente significantes: IMPA, 1-NA, FMA, e H-nariz. Concluímos que apesar de a maioria dos valores médios das grandezas cefalométricas não apresentarem diferenças estatisticamente significantes, ao compararmos todos os valores obtidos em cada uma das radiografias, encontramos grande variabilidade nos resultados, o que pode interferir na interpretação das grandezas cefalométricas. Assim, os autores sugerem ao ortodontista, quando receber a documentação ortodôntica, realizar novamente as análises cefalométricas para comparar os valores das grandezas, e utilizar outros elementos para diagnóstico, planejamento e controle do tratamento ortodôntico.

DESCRITORES: Cefalometria; Variações de observação; Erros de diagnóstico.

INTRODUCTION

The orthodontic documentation carried out in radiological clinics is essential for diagnosis, planning and control of the orthodontic treatment. Amongst the diagnosis elements used are the cephalometric measurements obtained from tracings performed on acetate paper placed upon the lateral cephalometric radiographs of the head. Radiological clinics use specific computer software in order

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to obtain cephalometric values, but errors may occur as the points are previously marked by the operator, which can influence measurements.

Cephalometric analysis has long been used for orthodontic diagnosis, and today it can be performed by using a computer setting according to two different ways of digitizing, namely:

a) the cephalometric landmarks are marked by means of a digitizing table, then they are transferred to the computer which measures the angular and linear measurements based on Cartesian coordinates;
b) the cephalometric landmarks are marked on the digital image of a radiographic film so that the computer software can perform the cephalometric measurements.

The cephalometric measurements can be marked either on a radiographic film, with anatomical tracings made on ultraphan paper, or on a digital image. Many types of malocclusion treatments are frequently studied and compared in order to seek indicators of high quality. As a result, error control is absolutely necessary for cephalometric measurements.

For controlling the errors involving cephalometric measurements, Houston[10] (1983) stated in his article that the control of radiographic procedures such as X-ray intensity, head position, duplicated X-rays, duplicated measurements, calibration, and experience of the operators had all been crucial.

In order to determine the error of both conventional and digitized cephalometric methods, a study by Martins *et al.*[14] (1995) demonstrated that regardless of the method used, the incorporation of errors may occur, particularly for those measurements involving incisors, which present a greater number of errors. For this reason, they recommend repetition of the measurements.

The error reproducibility of cephalometric values was evaluated both in digitized and conventional methods by Albuquerque Júnior and Almeida[1] (1998). The conventional method showed more errors because of the significant interference by the operator. The landmarks concerning the inferior incisors generated more errors and, as a result, the repetition of measurements is recommended for minimizing them.

Manual cephalometric tracings using digitized images of 50 teleradiographs were compared by Brangeli *et al.*[2] (2000). The incorporation of errors occurred in both methods and the landmarks involving dental structures were the main source of errors. They also concluded that the digitized method is reliable and has good reproducibility.

The estimated error for some cephalometric measurements using tracings made in 20 teleradiographs by twelve professionals was assessed by Médici Filho *et al.*[15] (2002). Errors were observed in all measurements involving dental structures, which was demonstrated by the high indices.

The effects of landmark differences in the values of cephalometric measurements made on digitized cephalograms in comparison with those obtained from original radiographs were explored by Chen *et al.*[4] (2004). The results supported the benefits of digital cephalometry regarding the reliability of cephalometric analysis.

The accuracy and precision of the values obtained from cephalometric measurements is of crucial importance, since the orthodontist also relies on these values to perform the correct diagnosis and, consequently, to elaborate a treatment plan.

The objective of this work was to analyze some cephalometric measurements performed in three radiological clinics by comparing them to measurements obtained manually (control group). In addition, both the result equivalence and the reliability determination were also evaluated.

MATERIAL AND METHODS

Thirty lateral cephalometric radiographs of the head, which had been taken using the same equipment, were all randomly chosen from the archives of the Department of Child Dentistry, Piracicaba Dental School, UNICAMP.

Three radiological clinics which had been commonly recommended by orthodontists were chosen from three different cities. Magnification information of the X-ray equipment (1.09 to 1.14) used for taking the lateral cephalometric radiographs was recorded.

The cephalometric measurements had been requested according to the cephalometric analyses adopted by USP and UNICAMP, and the following landmarks were used in this study: FMA; FMIA; IMPA; 1-NA; 1.NA; 1-NB; 1.NB; 1.1; SNA; SNB; ANB; H-nose; SN.Gn; and SN.GoGn.

The tracing and measurement procedures involving each radiograph were manually performed by one of the authors, who performed them twice in order to minimize errors. Dahlberg's formula was used to verify possible errors between the measurements, and no statistically significant difference was found. Then, the mean cephalometric measures (control

group) were compared to those obtained in the three radiological clinics using variance analysis as well as Tukey's and Friedman's tests. As some values were negative, Friedman's non-parametric test was used for ANB, 1-NA, and H-nose measures.

The tracings performed manually by the author were all made in a dark room using 0.3 mm propelling pencil, ultraphan paper placed upon the radiographs and a transparency viewer. Each radiograph was traced twice at an interval of one month in order to avoid memorization of the anatomical structures, and the mean cephalometric measurements were used for the present study. As the points directly marked on the radiographs are, theoretically, less susceptible to errors, the manual cephalometric values were used for the control group. These same values were compared with those measurements obtained in the radiological clinics using the same method, i.e., the radiographs were scanned and the cephalometric points and respective measurements were obtained by means of specific computer software.

Since our study had the objective of comparing cephalometric measurements obtained from thirty radiographs in order to assess the differences in the results, we did not concern ourselves with the fact that the same software had been used by the radiological clinics. In addition, most orthodontists make their diagnosis and treatment plan based on such values.

RESULTS

The results found in the present study (Tables 1 to 5) show that ten out of the 14 cephalometric measurements presented no statistically significant difference. Concerning the other four cephalometric measurements, at least one result obtained by the radiological clinic was equivalent to that obtained for the control group. Although

TABLE 1 - Mean values for SNA, SNB, and IMPA measurements (degrees).

Clinic	SNA		SNB		IMPA	
	mean	SD	mean	SD	mean	SD
1	82.67 A	3.53	78.42 A	3.72	91.90 B	7.35
2	82.80 A	2.80	78.12 A	3.49	97.70 A	7.59
3	84.23 A	4.67	79.82 A	4.58	95.09 AB	7.72
Control	82.59 A	4.24	78.97 A	3.58	93.15 AB	7.30

Mean values followed by different letters differ from each other according to Tukey's test ($p < 0.05$).

TABLE 2 - Mean values for 1.NA, 1-NB, and 1.NB measurements.

Clinic	1.NA (°)		1-NB (mm)		1.NB (°)	
	mean	SD	mean	SD	mean	SD
1	20.84 A	6.14	6.92 A	2.72	26.15 A	6.70
2	23.20 A	6.45	6.90 A	3.29	28.72 A	6.78
3	24.85 A	7.56	6.91 A	2.55	28.40 A	7.63
Control	25.03 A	7.39	6.91 A	2.55	27.80 A	6.57

Mean values followed by different letters differ from each other according to Tukey's test ($p < 0.05$).

TABLE 3 - Mean values for 1.1, FMA and FMIA measurements (degrees).

Clinic	1.1		FMA		FMIA	
	mean	SD	mean	SD	mean	SD
1	128.74 A	10.65	27.07 AB	6.10	61.04 A	8.06
2	123.05 A	11.10	23.34 B	5.58	58.84 A	7.74
3	122.22 A	11.97	25.61 B	5.58	59.17 A	8.89
Control	123.63 A	11.09	29.69 A	5.89	57.17 A	7.87

Mean values followed by different letters differ from each other according to Tukey's test ($p < 0.05$).

TABLE 4 - Mean values for 1-NA, ANB and H-nose measurements.

Clinic	1-NA (mm)		ANB (°)		H-Nose (mm)	
	mean	SD	mean	SD	mean	SD
1	5.99 A	2.25	4.27 A	3.01	6.07 A	5.36
2	4.16 B	2.28	4.62 A	2.82	5.18 AB	5.23
3	6.05 A	2.24	4.35 A	3.01	4.61 B	5.70
Control	6.80 A	3.34	3.63 A	2.95	4.73 B	5.68

Mean values followed by different letters differ from each other according to Friedman's test ($p < 0.05$).

TABLE 5 - Mean values for SN.Gn and SN.GoGn measurements.

Clinic	SN.Gn (°)		SN.GoGn (°)	
	mean	SD	mean	SD
1	68.90 A	3.89	35.86 A	6.59
2	68.80 A	3.81	34.68 A	6.54
3	67.14 A	4.69	33.40 A	7.01
Control	67.95 A	3.98	35.30 A	6.80

Mean values followed by different letters differ from each other according to Tukey's test ($p < 0.05$).

our study involved three radiological clinics only, a great variation between the cephalometric measurements obtained separately was also observed, which was enough to justify the objective of the present study. Another result to be taken into account was the high standard deviation obtained in most measures analysed, thus corroborating the great variation amongst the results.

DISCUSSION

Errors can be incorporated into cephalometric tracings by either the conventional method or by the digitized one. According to several studies[1,5,6,9,10,11,12,16], such errors occur due to failures involving projection, poor image quality, differences between operators (e.g. during radiograph taking, which can lead to incorrect positioning of the patient, or during the cephalometric tracing itself), tracing method (manual or digitized), equipment used, cephalogram quality, and even difficulties in marking the landmarks.

Some landmarks are commonly subjected to error because they are difficult to locate, thus making them less reliable[2,3,7,15,16,18,19].

In this work, four cephalometric measurements presented statistically significant differences: IMPA and 1-NA (Tables 1 and 4), both having landmarks related to dental structures, which is corroborated by other studies[1,2,14,15]; FMA (Table 3), the angular measurement where the porion point is difficult to locate[3,7,18]; H-nose (Table 4), linear measurement related to soft tissue[6].

Of the fourteen measurements evaluated by radiological clinics and for the control group, ten showed no statistically significant differences; the other four showed statistically significant differences, but at least one value obtained by the radiological clinics was always equivalent to the value obtained for the control group (Tables 1 through 5). Therefore, one can consider that no difference was found to be significant for the results between the manual method and the digitized one, which is corroborated by other studies[4,13]. On the other hand, such results are not corroborated elsewhere[1,7,8,17].

As we have mentioned before, cephalometry is helpful for diagnosis, planning, and control of the treatment. In this work, when comparing the mean values of the evaluated measurements, the differences were not so high; however, when comparing all the values obtained for each measurement of the thirty teleradiographs, we observed a great variability in the results (e.g. higher values for 1.1 and 1.NA), mainly in the angular measurements related to incisors, in accord with the results of several studies[1,2,14,15]. Although some differences reached 19°, many varied from 5° to 10° or from 5 mm to 10 mm, as suggested by some works[9,10], despite the fact that they had been obtained by three acknowledged radiological clinics having experienced professionals as well as for the control group.

Some authors have suggested that repetition of the measurements can minimize errors[1,10], thus we believe that orthodontist should redo their cephalometric analyses upon receiving orthodontic documentation in order to check the results.

CONCLUSIONS

Based on the analysis of the results obtained in this study we concluded that:

- The cephalometric tracings performed by radiological clinics were not entirely reliable since the measurements for IMPA, FMA, 1-NA, and H-nose showed statistically significant differences.
- Although there was no statistically significant difference in the mean values involving other measurements used in this study, we found many discrepant values among them.

Because of the variation involving the results found in this study, we suggest that no diagnosis, planning or orthodontic treatment should be done based only on the cephalometric values obtained by radiological clinics.

Orthodontists should discuss and compare the services provided by the radiological clinics by demanding that they designate more experienced operators to establish the cephalometric points so as to provide better services to patients.

In addition, the orthodontist should check the measurements provided and consider other elements for diagnosis such as clinical and radiographic exams, anamnesis, models, photographs, and the like.

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