Comparative study between conventional and digital radiography in cephalometric analysis

Estudo comparativo entre radiografia convencional e digital na análise cefalométrica

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Abstract

Objective – Technological improvement is usually followed by comparisons between conventional and new. Those who work with radiographic assessment, such as cephalometric analysis for orthodontic diagnosis, have been living a new challenging and learning phase since the introduction of digital images. It is possible to obtain reproducible and clear images with digital radiography, but radiography printing is still a necessity for teaching purposes. The aim of this study was to compare cephalometric analysis performed on conventional radiography and on digitized and printed radiography. **Methods** – Eleven lateral cephalometric radiographies were taken from different patients, digitized by scanner and printed on transparent proper paper. Ricketts cephalometric analysis was performed on conventional radiographies and on digitized-and-printed radiographies. **Results** – After statistical analysis, it was found that there were no significant differences between printed and conventional radiography. High correlation between the techniques was found for LAFH, EF, PF and PM; while moderate correlation was found for MA. **Conclusion** – Digital radiography acquired with indirect method, when properly printed, presents satisfactory results for cephalometric analysis.

Descriptors: Cephalometry; Radiography image enhancement; Radiography, dental/methods

Resumo

Objetivo – Com o desenvolvimento tecnológico, são inevitáveis as comparações entre o novo e o convencional. Aqueles que trabalham com estudos radiográficos, incluindo análises cefalométricas para o diagnóstico em ortodontia, têm vivido uma fase de adaptação e aprendizado com a introdução das imagens digitais. Tornou-se, com elas, possível a obtenção de imagens mais nítidas e reprodutíveis, embora sua impressão ainda seja necessária para propósitos de ensino. Este trabalho tem por objetivo comparar radiografias convencionais e digitais impressas com finalidade de se realizar análises cefalométricas. **Métodos** – Onze teleradiografias laterais foram realizadas em diferentes pacientes. As imagens foram digitalizadas e impressas em papel apropriado transparente. A análise cefalométrica de Ricketts foi realizada nas radiografias convencionais e digitalizadas. **Resultados** – De acordo com a análise estatística, não houve diferenças entre as radiografias convencionais e digitalizadas. Grande correlação foi encontrada para ângulo da altura facial anterior, eixo facial, profundidade facial e plano mandibular; enquanto correlação moderada foi encontrada para arco mandibular. **Conclusão** – A radiografia digital adquirida pelo método indireto quando adequadamente impressa, serve satisfatoriamente aos anseios da análise cefalométrica.

Descritores: Circunferência craniana; Intensificação de imagem radiográfica; Radiografia dentária/métodos

Introduction

Innovation is usually welcome in science. But for this to be considered a technological improvement, several studies must be done contesting and comparing it with what is conventional.

The coming of digital radiography, professionals that work in radiology area, including cephalometric analysis for diagnosis in orthodontics, faced a challenge: to verify if this image was reproducible, reliable, sensitive and valid.

Concerning the legality of documentation, "Provisional measure 2200-2 of August 24, 2001" instituted means for legal validation of images obtained or transmitted in digital form, ensuring its authenticity, integrity and legal validity[1].

Digital radiographic image became a reality when conventional radiographies, printed on radiographic film, were scanned and digitally stored on computer. Many researchers have been working in order to produce radiographic systems that dispense the use of conventional film, in which sensors capture images of excellent diagnostic capacity with reduced time of exposure to ionizing radiation, which means minimal exposure of the patient.

The concept of digital radiographic image refers to the image obtained from X-rays incidence and displayed on computer. It can be achieved by two different ways: through systems with or without the use of radiographic films. These methods can also be called indirect or direct method. In the direct method, the image is captured directly through a Charged Coupled Device (CCD) eliminating the use of radiographic film and darkroom. In the indirect method, also called hybrid system, a conventional radiography is recorded by a video camera or scanner and converted into digital format in a computer through a software program[2-4].

The indirect method is an important source of digital imaging in dentistry. This method offers capture at different resolutions and formats, as well as varied ranges of shades. Another advantage is its low cost, since it is cheaper to purchase a good-quality scanner, than a full digital system[3].

Digital radiography offers several advantages since it allows improved assessment of the image by using graphic and image processing software, which can reverse color scale, enhance specific areas, provide texture manipulation and others. According to manufacturers, it also presents approximately 80% radiation dose reduction compared to conventional radiographies[3].

In addition to the easy and quick image manipulation, digital images can be stored as computer files, reducing volume of files and allowing rapid access to archives of image[5].

Cephalometric analysis on digital radiography also dispenses ultraphan paper and light box: landmarks and structures are directly traced on the printed radiography, with the advantages of being reproducible for as many copies as needed and also not missing visual acuity that happens when ultraphan paper is superimposed on conventional radiography[6].

There still exists some controversy among clinicians about distortion in digital radiography, though. Due to the manner in which the optical reader scans during the obtaining of the radiographies

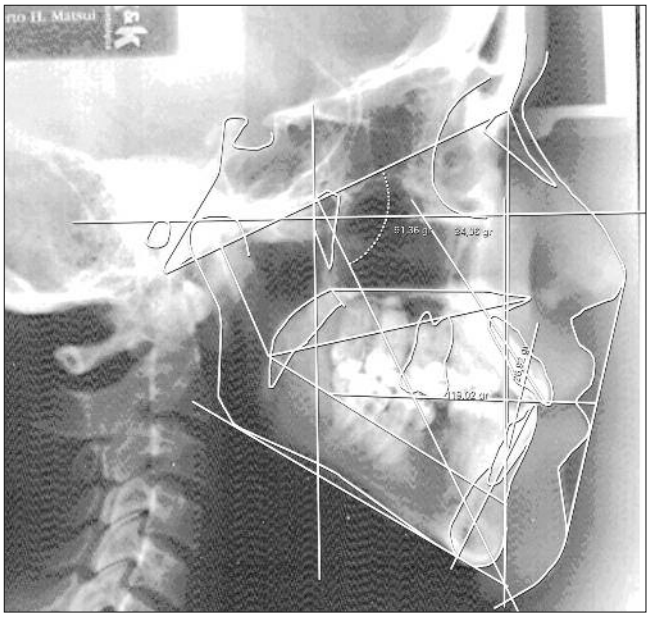


Figure 1. Ricketts´cephalometric analysis using a conventionally obtained radiography

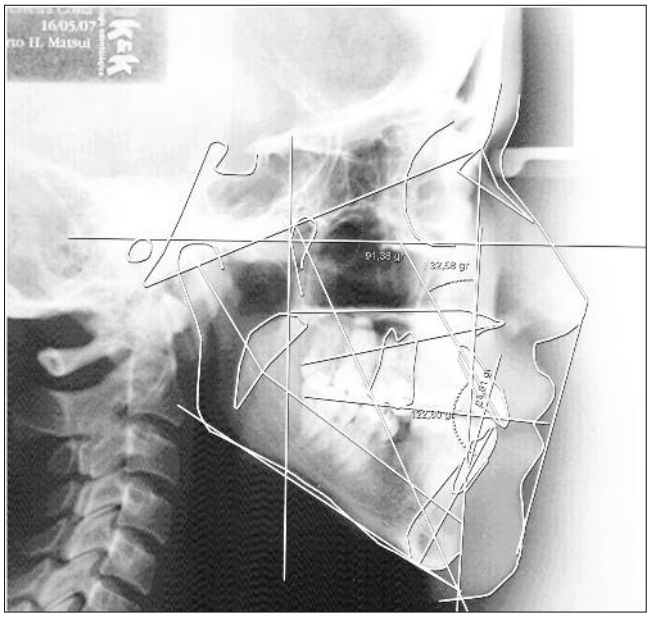


Figure 2. Ricketts´cephalometric analysis in a digital radiography obtained by indirect method

or due to the disposal of fluorescent particles of the optical board, some distortion can exist. According to the tooth which is evaluated, distortion varies presenting higher distortion in the mesio-buccal roots and disto-buccal upper molar, but lower distortion in the areas of palatal roots of maxillary molars and mesial and distal roots of mandibular molars. This issue is very important for Endodontics, since errors in determining working length of the root canal may lead to iatrogenic complications during manipulation of the root canal system[7].

According to Mol[8] (2004), and contrary to what sometimes manufacturers announce, digital images do not improve the diagnostic efficiency compared to conventional intraoral radiographies. Recent evidence suggests that there is no improvement or reduction in the efficiency of diagnosis, and radiographic films remain technically equivalent, if not superior to digital receivers.

Concerning this controversy, accuracy, reliability and specificity of conventional and digital radiography have been compared for several diagnostic purposes. Both methods – direct and indirect – have been tested:

In comparisons between direct digital and conventional radiography for vertical root fracture diagnosis[9], recurrent caries diagnosis10 and third molar surgery[11], no significant differences in specificity or sensitivity were found between these methods.

For indirectly obtained digital images, similar results were found:

Wolf *et al.*[12] (2001) evaluated the reproducibility and validity of linear measurements of interproximal bone loss in intrabony defects by means of digitized bitewing radiographies, with the use of various magnifications and manipulation tools. No statistically significant differences were found.

For orthodontic diagnosis purposes, reproducibility and reliability of digital cephalometry was compared to manual cephalometry. The first was obtained with the use of an analog X-ray, digital camera and software program for tracing, while the second was done according to conventional method. A high mutual correlation was found for 40 repeated measurements in 100 cephalograms. According to the authors, the dispersion of values in repeated measurements was higher in manual method and therefore, the digital method could be considered more accurate[13].

In Grybauskas's *et al.*[14] (2007) study, analogue cephalometric radiographies were performed on 15 human dry skulls. Acetate tracings and digital photographs were digitized and analyzed by software for cephalometric analysis. Validity was acceptable for all measurements, and although statistically significant differences between the methods existed, they appeared to be clinically insignificant.

Whatever the method of image digitalization, for cephalometric analysis, printing radiographies are still important for teaching purposes, so identical copies, which is possible to obtain by digital radiographic methods[6], can be handed to students to practice their tracing.

The aim of this study was to compare cephalometric analysis performed on conventional radiography and on digitized and printed radiography, by undergraduate and postgraduate students.

Methods

Eleven lateral cephalometric radiographies were taken (Gendex Dental System Corporation, IL, United States) from the laboratory of Radiology, Department of Diagnosis and Surgery, School of Dentistry of São José dos Campos, UNESP – Universidade Estadual Paulista.

Ricketts cephalometric analysis was manually performed by undergraduate and postgraduate students (Figure 1).

All radiographies were scanned by Scanner HP Scanjet 6100C with transparency adapter HPC 6261 – 6100 C (Hewlet Packard Co., Colorado, EUA).

All the radiographies were printed (Hewlet Packard Co., Colorado, EUA) in Drystar DT2B 25x30 transparent paper (Agfa HealthCare Corporation, Greenville, SC, United States), in which Ricketts cephalometric analysis was also performed (Figure 2).

According to the facial classification of Ricketts (VERT), it was calculated the sum of the angles, which are related to patients' growth trend: mandibular plane (MP), facial axis (FA), facial depth (FD), mandibular arc (MA), lower anterior facial height (LAFH) and standard deviation, finally divided by five.

The data were submitted to the statistic analysis, using Bland Altman analysis to compare the measurements obtained from cephalometric analysis[15], with computer software GraphPad Prism 5 (GraphPad Software, Inc., CA, USA).

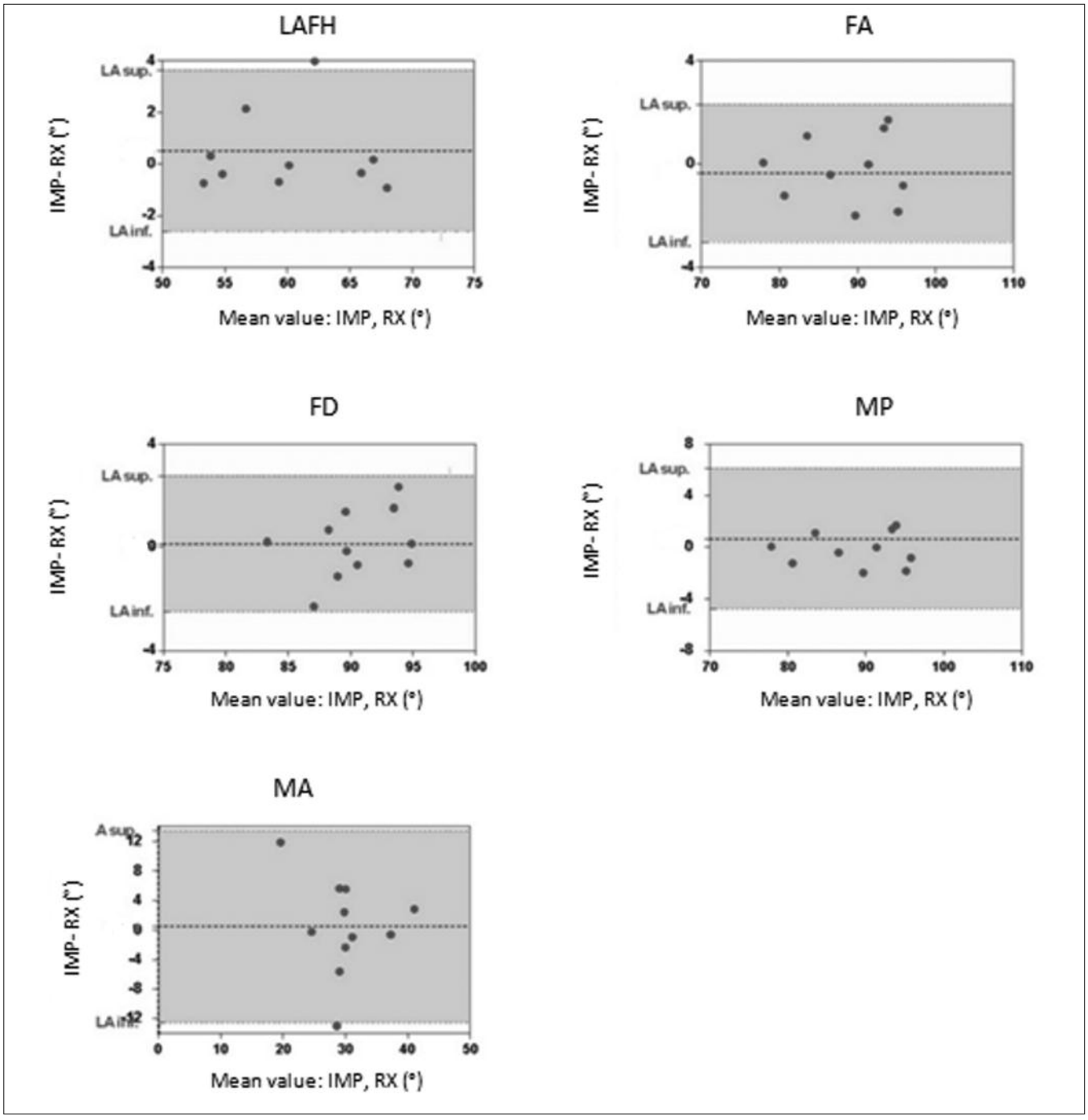
The differences between imaging modalities were evaluated by Two-Way Analysis of Variance for each reference point.

Results

For a cephalometric analysis with a total of 21 reference points, there was no significant difference between printed and conventional radiography, as follows:

Graph 1 represents the dispersion plot relating the means of both methods in x-axis and the bias (difference between them) in y-axis.

It was settled in this study that standard error of the estimate (SEE),



Graph 1. Bland Altman´s graphic of concordance analysis – * LA sup: superior limit of agreement; LA inf: inferior limit of agreement

which is a measure of the accuracy of predictions, should be < 3% (which is considered very good according to Lohman´s[5] (1992) classification).

The center dotted line indicates the average difference between the tests. Greater proximity to this line of equality (bias near zero) means better agreement between the tests.

The superior lines indicate the superior limits of agreement (LA sup), while the inferior lines, the inferior limits of agreement (LA inf). If the average differences follow a normal distribution, 95% of the differences should fall within these limits.

For LAFH, the mean value obtained by conventional and digital method respectively (59.54° and 60.05°) did not differ statistically. The difference between the methods was 3.628%. Thus, as it slightly exceeds SEE of 3%, it can be established a reasonable agreement between the two methods. Besides, LAFH presented values near the equality line, which means similar values of dispersion, approximately 5 units, and correspond to a high correlation (correlation coefficient (r) = 0.958).

For MA values, the mean values (29.78° and 30.27°) also did not differ statistically. However, the difference between the two methods was 13.47%. So, as this difference far exceeds SEE of 3%, it can be concluded that there is disagreement between the two methods, though they present similar values of dispersion, near to 6 units, which correspond to a moderate correlation (r = 0.511).

For FA, the mean values (89.53° and 89.17°) did not differ statistically. The difference between the two methods found was 3.02%. Since it is close to SEE of 3%, it can be established an agreement between the two methods, which also present similar values of dispersion, near to 6 units and correspond to a high correlation (r = 0.978).

For FD, the mean values (90.32° and 90.44°) did not differ statistically. The difference between the two methods found was 2.75%. Since it is close to the SEE of 3%, it can be established a reasonable agreement between the two methods, which present similar values of dispersion, approximately 3 units and correspond to a high correlation (r = 0.942).

For MP, the mean values (23.26° and 23.90°) did not differ statistically. The difference between the two methods found was 6.07°. Thus, as it slightly exceeds the SEE of 3°, it can be established a disagreement between the two methods, though it presented similar values of dispersion, near to 6 units and presents high correlation (r = 0.927).

Discussion

Conventional radiography is the most economical and accessible method. Besides, its quality seems to be comparable with digital methods for diagnosis.

Printing previously scanned radiography on transparent paper presents advantages of reducing chance of errors during tracing of landmarks and structures, since they are marked directly on the copy. Another advantage is that it allows reproduction of unlimited number of copies, without losing the visual acuity of the printed radiographs.

Direct digital imaging system eliminates the use of radiographic film and hence the darkroom[4,17] discussed about direct digital radiography presenting advantages such as significant reduction in radiation exposure, possibility of image enhancement using image processing software. However, they also remind studies that have shown that direct digital radiography, even with image processing and enhancement, is no better than conventional radiography in the diagnostic accuracy.

In this study, it was found a high correlation between measurements obtained from cephalometric analysis on conventional radiography and that obtained from indirect method. High correlation between the techniques was found for LAFH, EF, PF and PM; while moderate correlation was found for MA. Differences between measurements from cephalometric analysis were not statistically significant. This agrees to previous studies in which digital tracing, instead of manual tracing on a printed digitized radiography, was performed[13,18-20]. Cephalometric measurements of most parameters were reproducible for both methods and any differences were minimal and clinically acceptable.

According to Uysal's *et al.*[21] (2009) findings, computer-assisted cephalometric analysis does not increase intra- and inter-examiner reliability but can result in time saving.

Celik's *et al.*[22] (2009) findings indicated that most of the cephalometric measurements were highly reproducible with direct digital radiographs as well as with printouts using both software and hand tracing. According to the authors[22], the user-friendly and time-saving nature of the computerized method using digital radiographs makes it the preferred option.

Ricketts´ cephalometric analysis was done in this study in conventional lateral cephalometric radiography and in digitized and printed radiography. Several studies compared other types of cephalometric analysis by conventional techniques, direct method, indirect method, using software for tracing or performing it manually, finding similar results: digital radiographies obtained by direct and indirect methods were comparable with conventional radiographies for cephalometric purposes.

The choice of one or other method, then, will be based on the purposes and advantages for a specific moment.

Conclusion

Digital lateral cephalometric radiographies, obtained by indirect method were comparable to conventional radiographies when performing Ricketts' cephalometric analysis. It is possible to conclude that radiographies printed in special papers by a high-quality printer satisfactory serve for its purposes of cefalometric measurements.

References

1. Provisional Measure 2200-2 of August 24, 2001. [cited 2010 Nov 23]. Available from: https://www.planalto.gov.br/ccivil_03/MPV/ntigas_2001/2200-2.htm.

2. Watanabe PCA, Tanaka EE, Fenyo Pereira M, Panella J. Estado atual da arte da imagem digital em Odontologia. Rev Assoc Paul Cir Dent. 1999;53(4):320-5.

3. Attaelmanan A, Borg E, Grondahl H-G. Digitization and display of intra-oral films. Dentomaxillofac Radiol. 2000;29(2):97-102.

4. Sewell CMD, Pereira MF, Varoli OJ. Princípios de produção da imagem digitalizada. RPG Rev Pós-Grad. 1997;4(1):55-8.

5. Borg E, Attaelmanan, Gröndahl H-G. Subjective image quality of solid-state and photostimulable phosphor systems for digital intra-oral radiography. Dentomaxillofac Radiol. 2000;29(2):70-5.

6. Geelen W, Wenzel A, Gotfredsen E, Kruger M, Hansson lG. Reproducibility of cephalometric landmarks on conventional film, hardcopy, and monitor-displayed images obtained by the storage phosphor technique. Eur J Orthod. 1988; 20(3):331-40.

7. Sales MAOL, Costa J, Nascimento Neto JBS. Controvérsias em radiologia digital. Rev Bras Patol Oral. 2002;1(1):13-8.

8. Mol A. Imaging methods in periodontology. Periodontology. 2004;34(1):34-48.

9. Tofangchiha M, Bakhshi M, Fakhar HB, Panjnoush M. Conventional and digital radiography in vertical root fracture diagnosis: a comparison study. Dent Traumatol. 2011 Feb 1. doi: 10.1111/j.1600-9657.2010.00973.x. [Epub ahead of print].

10. Anbiaee N, Mohassel AR, Imanimoghaddam M, Moazzami SM. A comparison of the accuracy of digital and conventional radiography in the diagnosis of recurrent caries. J Contemp Dent Pract. 2010;11(6):25-32.

11. Parissis N, Angelopoulos C, Mantegari S, Karamanis S, Masood F, Tsirlis A. A comparison of panoramic image quality between a digital radiography storage phosphor system and a film-based system. J Contemp Dent Pract. 2010;11(1):9-16.

12. Wolf B, von Bethlenfalvy E, Hassfeld S, Staehle HJ, Eickholz P. Reliability of assessing interproximal bone loss by digital radiography: intrabony defects. J Clin Periodontol. 2001;28(9):869-78.

13. Thurzo A, Javorka V, Stanko P, Lysy J, Suchancova B, Lehotska V *et al*. Digital and manual cephalometric analysis. Bratisl Lek Listy. 2010;111(2):97-100.

14. Grybauskas S, Balciuniene I, Vetra J. Validity and reproducibility of cephalometric measurements obtained from digital photographs of analogue headfilms. Stomatologija. 2007;9(4):114-20.

15. Bland JM, Altman DG. Statistical method for assessing agreement between two methods of clinical measurement. Lancet. 1986;327(8476):307-10.

16. Lohman TG. Advances in body composition assessment. Champaing, Illinois: Human Kinetics Publishers; 1992.

17. Raghav N, Reddy SS, Giridhar AG, Murthy S, Yashodha Devi BK *et al.* Comparison of the efficacy of conventional radiography, digital radiography, and ultrasound in diagnosing periapical lesions. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2010;110(3):379-85.

18. Power G, Breckon J, Sherriff M, McDonald F. Dolphin Imaging Software: an analysis of the accuracy of cephalometric digitization and orthognathic prediction. Int J Oral Maxillofac Surg. 2005;34(6):619-26.

19. Naoumova J, Lindman R. A comparison of manual traced images and corresponding scanned radiographs digitally traced. Eur J Orthod. 2009;31(3):247-53.

20. Polat-Ozsoy O, Gokcelik A, Toygar Memikoglu TU. Differences in cephalometric measurements: a comparison of digital versus hand-tracing methods. Eur J Orthod. 2009;31(3):254-9.

21. Uysal T, Baysal A, Yagci A. Evaluation of speed, repeatability, and reproducibility of digital radiography with manual versus computer-assisted cephalometric analyses. Eur J Orthod. 2009;31(5):523-8.

22. Celik E, Polat-Ozsoy O, Toygar Memikoglu TU. Comparison of cephalometric measurements with digital versus conventional cephalometric analysis. Eur J Orthod. 2009;31(3):241-6.

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