

Comparison Of The Reliability Of Computerized And Manual Cephalometric Measurements Of Soft Tissue

*Tamar Kublashvili, Katerin Kula, Alan Glaros,
Zurab Vadachkoria*

UMKC School of Dentistry Department of Orthodontics, USA;
Department of Pediatric and Prevention of Dental Diseases, Tbilisi State Medical University,
Georgia

Abstract

The purpose of this study was to compare the reliability of eleven linear and four angular cephalometric measurements of soft tissue among two software programs (Dolphin 7.0 [D] and Vistadent 8.0 [V]) using both digitized (scanned) conventional films and digital radiography when compared to manual tracings. The cephalometric images were captured simultaneously for each research subject by placing a conventional film in front of the storage phosphor screen in the same cassette. The conventional film was then scanned and saved on disk. The storage phosphor screen was read via a laser scanner and also saved on disk. One investigator made all the measurements. Ten different cephalograms were traced manually, both the scanned image and digital image were loaded into D and V on separate days and analyzed. Holdaway's and Steiner's soft tissue cephalometric analysis were performed. Student-Newman-Keuls statistical procedures were used to determine which computer program (D or V) was closest to hand tracing (Reliability using different subjects). Statistically significant differences were seen in all techniques (Vistadent Scanned [VS], Vistadent Digital [VD], Dolphin Digital [DD]) except Dolphin Scanned, which was closest to HT. From all the statistically significant values only one measurement, facial angle has clinical significance.

Keywords: *orthodontics, cephalometrics, soft tissue, storage phosphor screen, digital radiography*

Introduction

Cephalometric radiographs are an integral part of an orthodontist's records, being used primarily in diagnosis, treatment planning, and in the evaluation of case progression. Currently, most clinicians obtain essential data from these radiographs through the use of manual tracing (Gottlieb, Nelson, and Vogels 1996). However, the relatively recent development of computerized cephalometric software has allowed an increasing number of orthodontists to utilize this technology by digitally recording craniofacial landmarks and permitting the computer programs to calculate the desired measurements.

Digital radiography in the orthodontic practice now makes the paperless, filmless office conceivable. Commercially available cephalometric software has proven to be clinically acceptable for landmark identification and measurements for scanned conventional film. In order to convert to a totally filmless practice, computerized analysis of storage phosphor images must be as accurate and reliable as conventional radiographic measurements.

In current digital imaging, two types of technology are used. One method utilizes charged couple device (CCD) sensor, and the other utilizes a photo-stimulable phosphor plate. The CCD sensor was invented by Bell

Laboratories in 1970 (Sun, 1995) and was mainly used in video records and cameras. The first dental application of the CCD sensors was attributed to Trophy in mid 80's (Preston, 1998; Menig, 1999).

Implementation of image techniques used in the medical community (Lackey, 1998) allowed the development of storage phosphor plates that were similar to conventional intraoral film. These plates were as thin as conventional film and could be used multiple times. They could store images and, therefore, did not need the cables necessary for CCDs, nor was there a need for a dark room because these screens are not as light sensitive as traditional film.

Soft tissue profile analysis began in 1950s (Burstone 1958; Ricketts 1957; Broadbent, Matthew 1957) and it is very important for orthodontic diagnosis and treatment planning.

Seki and Okano (1993) investigated the effects of exposure reduction on the determination of cephalometric landmarks with computed radiography using photostimulable storage phosphor. Lateral cephalograms were taken on forty patients. Patients were exposed with different amount of radiation. Authors were able to produce diagnostically acceptable images even with 10% (3mAs) of radiation. Ten dentists determined 13 landmarks; three of these were soft tissue landmarks. Statistical analysis showed no significant differences for landmark locations.

The purpose of this study is to compare the reliability of measurement of cephalometric parameters on storage phosphor digital cephalograms and conventional cephalograms using traditional hand tracing and two commercially available cephalometric analysis software (Dolphin 7.0, Vistadent 8.0). The null hypothesis is that there is no significant difference in the reliability of measurements derived from the various soft tissue landmarks between conventional and digital cephalometric images using the different modes of analysis.

Material and Methods

Subjects

Materials were obtained from the orthodontic department, UMKC dental school and included ten conventional and ten digital lateral cephalometric images of Caucasian patients between 13 and 18 years of age. Patients were selected from the clinic patients scheduled for orthodontic records. Routine orthodontic records include a lateral cephalogram as an important part of diagnosis. Obese subjects were excluded because soft tissue could interfere with locating

anatomic points. Subjects with craniofacial defects were excluded as well.

Equipments

The cephalometric equipment included a Quint Sectograph Cephalometric-Tomographic X-ray Unit (322 West Twelfth, Los Angeles, California 90015) and tube (Duocon-M) with cephalostat. Radiographs were taken with the patient in the fixed head position in the cephalostat with constant source to object and object to cassette distance. The source to object distance was 150 cm and object to cassette distance was 15 cm.

For clear soft tissue contour, an aluminum wedge was placed between the soft tissue parts of the profile and the film. All cephalograms were taken with relaxed lips and with the teeth in maximum intercuspation. A conventional film and a digital image were obtained simultaneously with a single exposure. A storage phosphor plate (Densply International, Gendex dental X-ray Division, 901 W. Oakton Street, DesPlaines, IL 60018-1884) was sandwiched with the conventional film into a standard cassette (Kodak X-Omatic Cassette) with Lanex Regular Screens. The film was facing the tube head followed by the phosphor screen. The exposure parameters were 82Kvp 1/5 sec 50 ma.

All films were processed immediately after exposure. The image plate was processed by a laser scanner (Densply International, Gendex Dental X-ray Division, 901 W. Oakton Street, DesPlaines, IL 60018-1884). The storage phosphor images were stored as JPEG and the compression format used was TIFF JPEG LOSSLESS, the default format for radiographic images. The conventional cephalogram was scanned by an Epson Expression 1600 Scanner professional using standardized image settings (Image type: 24-bit color (std); Document source: TPU for positive film; Destination: screen/web; and Resolution: 200). Scanned and storage phosphor images were saved to a Zip disc as .JPG files. All films were scanned at one setting to insure consistency.

Experimental

There were total of twenty images (10 conventional, 10 digital) two from each of ten subjects. The conventional cephalogram was hand traced and then digitized (scanned) and saved to disk (*Fig.1*). The scanned image of the conventional cephalogram as well as the digital cephalogram was imported into each of the two cephalometric software: Dolphin 7.0(D) and Vistadent 8.0(V). (D-Dolphin Imaging, Canoga Park, CA; V-Dentsply International Inc., York, Pennsylvania).

Reliability Using Different Subjects

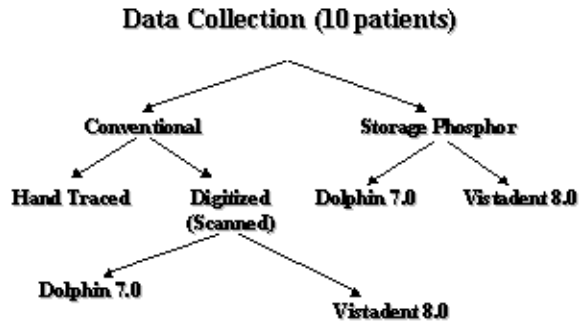


Fig.1 Reliability Using Different Subjects.

All measurements were made by a single investigator to prevent variability in interpretation. The hand tracing was considered the "gold standard". The digital tracing landmarks were identified on a monitor (Dell, OptiPlex, GX110). Landmark sampling in Dolphin 7.0 was performed with a mouse controlled crosshair cursor. In Vistadent 8.0 conventional arrow pointer was used for the same purpose. Landmarks were automatically recorded as X-Y coordinates and the angular and linear parameters calculated and displayed by the different programs. The landmarks in each software program were registered using the same computer (Dell OptiPlex BX 110, Dell Computer Corporation, Round Rock, Texas) with the monitor setting at True color (24 bit).

A view box (Slimlight, Image Marketing Corporation) was used for hand tracing. Landmarks were recorded on standard 8X10 inch sheet of 0.003-inch matte, acetate tracing paper with 0.5mm mechanical lead pencil. 3M Unitek cephalometric protractor with millimetric ruler nearest 0.5 mm was used for linear and angular measurements. Landmarks were identified on both the conventional and the monitor-displayed images in a dimmed room.

Reliability Using Different Subjects

The reliability using different subjects was determined by hand tracing of cephalograms of 10 patients and by analyzing the scanned and digital images on 10 separate days (Fig.1).

Cephalometric Analysis

On hand tracing a total of 12 soft tissue landmarks and two hard tissue landmarks were used. Eleven linear and 4 angular (total of 15) parameters were measured. The same procedure was repeated with Dolphin (ceph Version 7.0) and Vistadent Image Management System

(ceph Version 8.0). Holdaway's and Steiner's soft tissue analysis were performed.

Results

The aggregate of difference scores for Vistadent scanned, Vistadent digital, and Dolphin digital were significantly different from zero, $F(14,135) = 5.46, 8.27,$ and $2.19,$ respectively, $p < .05.$ These findings indicate that the scores for these three techniques differed significantly from hand tracing values. Dolphin scanned difference scores did not differ significantly from zero (Tab.1).

Post-hoc tests using Student-Newman-Keuls procedures to compare parameter differences within a mode of measure showed that the difference scores for facial angle for Vistadent scanned were significantly greater than for all other parameters within Vistadent scanned. For Vistadent digital, the difference scores for both facial angle and nasolabial angle were significantly different from one another and from all other parameters within Vistadent scanned as well. Dolphin digital difference scores showed no significant differences on post-hoc testing.

Discussion

With the current advances in digital technology, the dental profession has witnessed a revolution in diagnostic imaging, patient interaction and, especially, practice management. Intraoral cameras provide instant images that allowed easier diagnosis and better patient education. Digital cameras make film development obsolete and give the orthodontist immediate imaging for treatment plan presentations. Internet access allows the transmission of these images to colleagues for consultation and/or referral needs. Digital radiography reduces the radiation exposure (Lackey, 1998) while eliminating the need for film or the associated chemicals necessary for development. All of these advances will make the future of orthodontic care more simplistic and friendly towards the patient's needs.

Baskin, Cisneros (1997) studied reliability and reproducibility of measurements obtained from two popular programs, Dentofacial Planner (Trademark of Dentofacial Software, Inc.) and Quick Ceph (Trademark of Orthodontic Processing). They compared data achieved from two computer cephalometric programs to the results of hand tracing. A Steiner's analysis was used for each computerized or manual tracing. Study showed that Dentofacial Planner and Quick Ceph could produce reliable Steiner's analysis.

In our study, statistically significant differences existed among techniques $HT=DS<DD<VS=VD$ (Vistadent

Scanned (VS), Vistadent Digital (VD), Dolphin Digital (DD)) except for Dolphin scanned, that was the closest to the reference (HT). It appears that Vistadent although reliably produces measurements of some parameters that can differ significantly from HT.

According to Wisth and Boe (1975) soft tissue measurements are more dependent on the quality of the cephalogram than hard tissue measurements are. Mostafa, El-Mangoury, Salah, Rasmy (1990) performed automated cephalographic soft-tissue analysis. Thirty lateral cephalographs were hand traced and computer traced using image-processing algorithm. Differences between manual and computed soft-tissue measurements showed that angular measurements have more error than linear measurements (total of 10 linear and 7 angular measurements). This is in agreement with our findings in which two angular

measurements, facial angle and nasolabial angle showed greater error.

Our study shows that Vistadent has greatest differences in landmark identification from hand tracing compared to Dolphin. Although there were statistically significant differences between modes of analysis and radiographic format, only one measurement, facial angle, appears to be clinically significant. Factors affecting this could be obscurity of landmarks, facial angle requires Porion and Orbitale, and identification of these landmarks is difficult.

Conclusions

Reliability studies using different subjects revealed that Dolphin scanned values were the closest to reference Hand tracing.

	Descriptive statistics, Mean Value "±" Std Deviation			
	DS	DD	VS	VD
	X±SD	X±SD	X±SD	X±SD
G-Sn/Sn-Me	0.0±0.0	-0.1±0.0	-0.1±0.0	-0.1±0.0
Nasolabial angle (°)	1.6±7.5	1.9±5.4	3.1±5.1	4.5±4.2
Interlabial gap (mm)	-0.2±0.4	-0.2±0.4	0.0±0.4	0.1±0.4
Angle of facial conv (°)	1.3±1.3	1.7±1.6	1.9±1.6	1.4±1.7
Upper lip to E-line (mm)	-0.3±0.4	-0.4±0.5	0.5±0.8	0.5±0.5
Lower lip to E-line (mm)	-0.2±0.7	-0.4±0.6	0.5±0.8	0.3±0.6
Facial angle (°)	-0.5±1.0	1.9±4.1	-5.7±7.7	-6.2±7.4
H-line angle (°)	-0.5±0.7	-0.6±1.1	0.0±0.7	-0.2±0.7
Nose prominence (mm)	0.3±0.8	-1.0±1.7	0.1±1.2	0.1±1.3
Upper sulcus depth (mm)	0.4±1.3	0.6±1.5	0.2±1.2	0.3±1.2
Lower sulcus depth (mm)	-0.1±1.3	0.2±1.0	-0.5±0.7	-0.3±0.8
Upper lip thickness (mm)	0.3±0.8	0.2±1.1	-1.8±1.9	-1.8±1.9
Upper lip strain (mm)	0.4±0.5	0.3±0.5	1.1±1.0	1.1±1.0
Lower lip to H-line (mm)	0.5±0.8	0.3±0.7	0.6±0.7	0.5±0.5
Soft-tissue chin thickness (mm)	-0.6±0.8	-0.8±1.1	-0.3±0.9	-0.2±0.6

Tab.1 Reliability of cephalometric parameters using different subjects, Differences from hand tracing.

Reference

1. Baskin HN, Cisneros GJ. A comparison of two computer programs. J Clin Orthod, 1997; 231-233.
2. Gottlieb EL, Nelson AH, Vogels DS III. Study of orthodontic diagnosis and treatment procedures. Clin Orthod, 1996; 30:615-629.
3. Holdaway RA. A soft-tissue cephalometric analysis and its use in orthodontic treatment planning. Part I. Amer J Orthod, 1983; 84:1-28.

4. Jacobson AL. Radiographic cephalometrics. Quintessence books, Chicago. 1995; 239-271.
5. Lackey, AD. The integration of filmless radiology in a restorative general practice. CDA Journal. 1998 Dec;26(12):906-13.
6. Mostafa YA, Mangoury NH, Salah A, Rasmy EM. Automated cephalometric soft-tissue analysis. J Clin Orthod, 1990; 9:539-543.
7. Proffit W, Fields H. Contemporary orthodontics. Mosby, St.Louis. 2000; 174-175.
8. Preston JD. Digital tools for clinical dentistry. An internet tutorial. CDA Journal. 1998 Dec;26(12):915-22.
9. Seki K, Okano T. Exposure reduction in cephalography with a digital photostimulable phosphor imaging system. Dentomaxillofac Radiol, 1993; 22:127-130.
10. Steiner C, Hills B. Cephalometrics in clinical practice. Angle Orthod. 1959;29:8-29.
11. Suni et al, 1995 Keynote paper, Seventh Annual IEEE International Conference on Wafer-Scale Integration
12. Wisth PJ, Boe OE. The reliability of cephalometric soft tissue measurements. Archives Oral Biol, 1975;20:595-599.

Определение точности цефалометрических параметров мягких тканей лица с применением общепринятых и компьютерных методов

Тамара Кублашвили, Катерин Кула, Алан Гларос, Зураб Вадачкория

Департамент ортодонтии школы Канзас Сити Миссурского университета, США;
Кафедра стоматологии детского возраста и профилактики стоматологических заболеваний
Тбилисского гос. медицинского университета, Грузия

Р Е З Ю М Е

Целью работы являлось сравнение точности цефалометрических параметров мягких тканей лица (11 линейных и 4 угловых параметров) с применением двух компьютерных программ (Dolphin 7.0 [D] и Vistadent 8.0 [V]). Использованы цефалограммы, выполненные общепринятым и цифровым рентгеновскими аппаратами. Компьютерные программы сравнены с ручными чертежами с целью определения, которая из них является более близким к ручным чертежам. Общепринятый рентген был сканирован и сохранен на диске, а фосфорный экран обработан лазерным сканером (Densply International, Grendex dental x-ray Division, 901 W. Oakton Street, DesPlaines, IL 60018-1884) и сохранен на диске. Все измерения были сделаны одним лицом. Десять различных рентгенограмм были начерчены рукой, сканированные и цифровые рентгенограммы - двумя компьютерными программами (D и V). Все чертежи сделаны в разные дни. Анализ параметров мягких тканей лица проведен с использованием двух различных методов (Голдвей, 1983; Стайнер, 1959). Статистическая обработка по Student-Newman-Keuls показала достоверную разницу при использовании методик (Vistadent Scanned [VS]; Vistadent Digital [VD]; Dolphin Digital [DD]). Лишь методика Dolphin Scanned [DS] была ближе к ручным чертежам, так как при её использовании не отмечено статистически достоверной разницы.

Ключевые слова: ортодонтия, цефалография, мягкие ткани, профилт, цифровая рентгенография