THE CUTTING EDGE

(Editor's Note: This quarterly column is compiled by JCO Technology Editor Ronald Redmond. To help keep our readers on The Cutting Edge, Dr. Redmond will spotlight a particular area of orthodontic technology every three months. Your suggestions for future subjects or authors are welcome.)

This month's Cutting Edge column caused me to reflect on my personal experience with "smart" diagnostic software. Over the years, as my practice became busier, I found myself occasionally delegating a computerized cephalometric tracing to a talented employee. While this delegation saved time, it created its own problems, such as improper location of some cephalometric landmarks. These problems could be easily corrected, which took less of my time than doing the entire analysis. But any doctor who delegates a cephalometric analysis to a "smart" computer program and doesn't expect to have to check the results for accuracy is overlooking the inherent idiosyncrasies of the software.

Drs. Dana, Goldstein, Burch, and Hardigan have done a good job of analyzing Dolphin Imaging 8.0 and VistaDent 9.0 AT for such peculiarities. I have not tried the VistaDent program, but I have used Dolphin Imaging 8.0 for 18 months, and recently began using version 9.0. I quickly realized (as did others) that Dolphin Imaging 8.0 placed gnathion in a location contrary to my understanding of that point. The latest version has resolved this disagreement.

The Wits analysis is a problem of a different degree. As the authors point out, Wits depends on the location of the occlusal plane, which has more operator variability than most cephalometric planes. We will need to reach agreement on the construction of this plane before a Wits analysis can be accurately performed by any "smart" program. It underscores the importance of doctor supervision of the entire diagnostic process.

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Comparative Study of Manual and Computerized Cephalometric Analyses

Since Broadbent introduced cephalometrics in 1931,[1] manual tracing has been regarded as the standard for measuring cephalometric relationships. Today, however, many clinicians are using digital radiography and tracings, which have the advantages of instantaneous image formation, simplified image storage, reduced tracing time, and elimination of radiation exposure and chemical development processes.[2]

Previous authors have established that the greatest errors in cephalometric analysis occur during landmark identification.[3-7] Although studies have been published assessing the validity and reproducibility of linear and angular measurements made by digitized vs. manually traced cephalometric radiographs,[8-10] no studies to our knowledge have compared the accuracy of different digitizing software programs. Therefore, the present investigation was undertaken to determine the validity and reliability of two commonly used digital tracing programs, Dolphin

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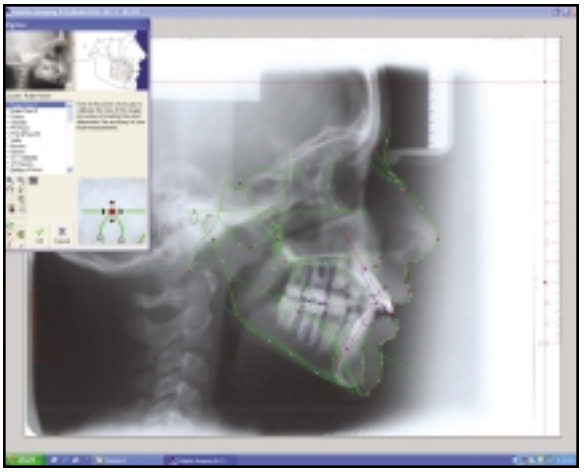

Fig. 1 Dolphin Imaging 8.0 analysis.

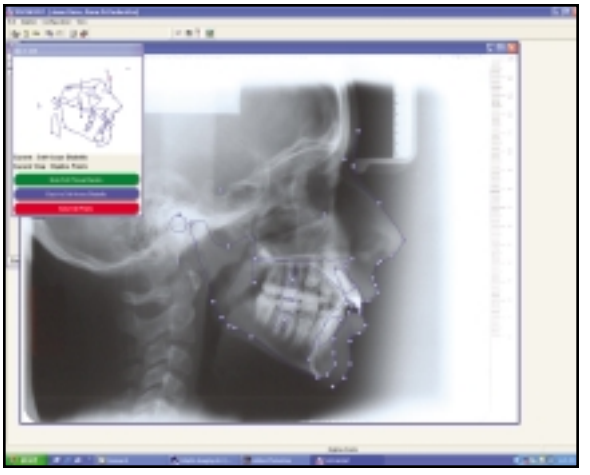

Fig. 2 VistaDent AT 9.0 analysis.

Imaging 8.0* (Fig. 1) and VistaDent AT 9.0** (Fig. 2), as compared with manual tracings.

Materials and Methods

Thirty lateral cephalometric radiographs with high-quality resolution and definition were selected for use in this study. All were traced on acetate paper and manually measured by two investigators. Standard digital calipers, accurate to within .05mm, were used for the linear measurements, and a common orthodontic protractor for angular measurements. To evaluate inter- and intra-examiner reliability, 10 radiographs not used in this study were traced twice, one week apart, by each of the two examiners. There were no statistically significant differences in any of the 33 measurements.

All radiographs and acetate tracings were scanned with an Epson Expression 1600 scanner,† using Gateway Solo 9550 laptop computers‡ with the Dolphin Imaging 8.0 and VistaDent AT 9.0 programs (the most recent versions at the time this study was conducted). Radiographs were scanned at 150dpi resolution. Cephalometric analyses were carried out for each radiograph with both digitizing programs. The manual acetate tracings were also digitized with both programs.

Statistical analysis was performed using the generalized linear model procedure, using least-squares estimation, with statistical significance determined at a level of $p < .05$ (Tables 1,2).

Results

The Dolphin Imaging measurements of SN-GoGn and FH-GoGn from the acetate tracings differed significantly from the manual and VistaDent measurements. The Dolphin Imaging digital measurement of SN-GoGn was also significantly different. Both computer programs exhibited statistically significant differences in both the digital and acetate measurements of the Wits appraisal.

Discussion

Held and colleagues found no statistically significant differences among scans made at resolutions of 75dpi, 200dpi, 400dpi, and 600dpi.[11] In fact, they concluded that 75dpi in black and

*Dolphin Imaging & Management Solutions, 9200 Eton Ave., Chatsworth, CA 91311.

**Trademark of GAC International, Inc., 355 Knickerbocker Ave., Bohemia, NY 11716.

†Seiko Epson Corporation, Nagano, Japan.

‡Gateway, Inc., Poway, CA.

TABLE 1
ANGULAR MEASUREMENTS (°)

	Dolphin Cephalogram		VistaDent Cephalogram		Dolphin Acetate		VistaDent Acetate	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
SSN-FH	10.65	2.87	10.65	2.94	11.06	2.51	11.05	2.53
SNA	79.98	5.14	79.93	5.02	80.27	4.94	80.28	4.96
SNB	76.63	5.59	76.44	5.37	76.57	5.39	76.62	5.37
ANB	3.35	2.47	3.63	2.33	3.70	2.62	3.70	2.52
FH-NB	87.29	4.65	87.09	4.59	87.64	4.41	87.68	4.44
SN-GoGn	33.05*	4.37	35.05	4.56	32.90*	4.52	34.74	4.33
SN-PP	9.97	3.92	10.39	3.82	9.87	3.54	9.89	3.52
FH-GoGn	22.48	4.28	24.36	4.58	22.09*	4.29	23.75	4.32
FH-SGn	58.16	3.22	58.35	3.33	57.68	3.15	57.42	3.11
U1-SN	100.71	9.71	100.97	9.35	100.29	9.91	100.36	9.92
U1-FH	111.59	9.18	111.62	9.13	111.59	9.34	111.41	9.44
U1-NA	12.19	10.23	12.27	10.33	11.68	10.07	11.77	10.06
L1-GoGn	98.78	9.56	96.91	9.87	98.68	8.52	97.02	8.76
L1-NB	16.88	13.52	16.79	13.41	16.81	13.12	16.84	13.14
L1-APo	14.48	12.97	15.23	17.52	14.20	12.80	15.45	18.36
U1-L1	127.37	14.23	127.15	13.89	127.84	13.12	127.84	13.34
FMIA	58.17	9.49	58.73	9.64	59.19	8.72	59.24	8.90
NLA	112.06	9.07	111.40	10.31	112.89	9.72	111.99	11.27

*Significantly different from manual measurements, $p < .05$.

TABLE 2
LINEAR MEASUREMENTS (MM)

	Dolphin Cephalogram		VistaDent Cephalogram		Dolphin Acetate		VistaDent Acetate	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
U1-NA	12.19	10.23	12.27	10.33	11.68	10.07	11.77	10.06
Po-NB	1.64	2.86	1.66	2.76	1.85	2.77	1.88	2.72
NPo-A	2.60	3.49	2.66	3.62	2.86	3.64	3.14	3.38
L1-NB	16.88	13.52	16.79	13.41	16.81	13.12	16.84	13.14
L1-AP	14.48	12.97	15.23	17.52	14.20	12.80	15.45	18.36
E plane-UL	–4.44	3.79	–4.66	3.96	–4.52	3.87	–4.77	4.15
E plane-LL	–2.34	3.79	–2.45	3.87	–2.29	3.89	–2.25	3.98
U1-UL	127.37	14.23	127.15	13.89	127.84	13.12	127.85	13.34
Interlip	2.07	2.86	2.00	2.66	2.03	2.81	1.81	2.75
Wits	0.15*	3.28	–0.09*	3.54	0.46*	3.26	0.24*	3.46
NFH-A	0.49	4.34	0.51	4.40	1.20	4.19	1.15	4.22
NFH-Po	–3.51	8.65	–3.91	8.62	–2.69	8.46	–2.53	8.47
Co-A	91.61	4.85	91.13	5.01	91.75	5.66	90.00	11.68
Co-Gn	117.08	8.77	116.38	8.87	117.59	9.36	117.05	8.72
ANS-Me	66.24	6.03	66.31	5.97	67.16	6.45	66.88	6.13

*Significantly different from manual measurements, $p < .05$.

white may be the best combination. Chen and colleagues established that digital cephalometric programs produced the best results from a resolution of 150dpi.[10] That value was selected for the present study.

The Dolphin Imaging 8.0 program was significantly different from the VistaDent AT 9.0 program and manual tracings in measuring the mandibular plane (GoGn). It should be noted that the Dolphin system automatically constructs gnathion, at a point more superior on the curvature of the symphysis than where the examiners for this study would have placed it.

Both programs showed statistically significant differences from manual tracings in the Wits appraisal, as was also observed by Ongkosuwito and colleagues.[12] Because the Wits value depends on construction of the occlusal plane, clinicians can expect unreliable appraisals from these digitizing programs.

No other cephalometric measurements made by these programs differed significantly from manual measurements. Therefore, except as noted, the orthodontist can rely on either digital program to be as accurate and applicable as manual methods.

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