The accuracy of video imaging for mixed dentition and adolescent treatment

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Currently, two of the most controversial areas in orthodontics revolve around the accuracy of growth prediction and the potential applications of video imaging. Our ability to predict and modify growth has long been a source of frustration to clinicians and the focus of research by academics. At times, it has also been the topic of heated discussion by many respected and prominent members of our profession.[1-3] Similarly, the introduction of video imaging in orthodontics has faced its own share of comments, ranging from those critical of its marketing aspects to those enthusiastically supportive of its communication and educational potential.[4-7]

Irrespective of the various techniques and appliances used in the treatment of skeletal Class II malocclusions, it is clear that growth modification, when practical, remains the ideal solution for producing the best skeletal, dental and facial outcomes.[8] However, there are two prevailing schools of thought as to the optimum time for treatment of Class II malocclusions.[9,10] The first calls for intervention during the mixed dentition (8 to 11 years) when patients may be more cooperative in wearing orthopedic appliances, followed by a second, primarily dental phase of treatment. The second approach suggests accomplishing the entire correction during the adolescent years (12 to 15 years) to take advantage of the pubertal growth spurt and to complete the treatment in one phase. While a considerable amount of current research effort is being extended to answer this question, the jury is still out as to both the best time and the best treatment approach for these skeletal problems.[11]

Presently, three types of growth forecasting

Abstract
The purpose of this study was to evaluate the accuracy of computerized video imaging in predicting the soft tissue outcome of growth modification treatment for skeletal Class II malocclusions. Pretreatment and posttreatment cephalometric and facial photographic records of 22 mixed dentition (8 to 10 years old) and 20 adolescent (12 to 14 years old) patients were digitized, and the known outcomes were compared with computer-generated VTOs and video images. The predicted video images were found to be reasonably accurate for the mixed dentition group, but unacceptable for the adolescent group. When graded by a panel of judges, orthodontists were far more critical of the findings than their lay counterparts. These results emphasize the potential of video imaging as a communication medium, rather than as a diagnostic tool for growing patients.

Key Words
Video imaging • Growing patients • Diagnosis • Communication medium

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Table 1
Sample characteristics

	Mixed dentition	Adolescent
Number of patients	22	20
Initial age (yrs/mo)	9.1	12.9
Final age (yrs/mo)	11.2	14.3
Treatment time (mo)	25.0	18.0
Treatment time range (mo)	17-29	13-28

have been widely used for Class II problems, although with limited success. The first method requires observation of an individual's growth over a period of time prior to treatment and is based on the assumption that individual growth patterns, once established at an early age, do not change throughout the growth period.[12-15] The second method suggests that specific anatomical factors such as mandibular plane angle, condylar angulation, or concavity of the antegonial notch should be analyzed to allow for a more precise individualized growth prediction.[16-20] Hixon approached the problem of forecasting in yet a third way, suggesting that by adding average growth increments derived from a normative sample to the current facial dimensions of each patient, the eventual size and shape could be predicted.[21] Similarly, Ricketts introduced the arcial method of growth prediction, using geometric procedures in which accumulated past growth was projected to forecast further developments for individual patients.[22] In general, the success of these methods has been limited.

Computerized cephalometric analysis has been commercially available for over a decade, and many programs have incorporated growth forecasting into their systems.[23,24] Computerized growth forecasting in one format or another has been the topic of considerable research, but to date, no system has offered an acceptable solution to the forecasting dilemma.[25] In addition to growth forecasting, some computer programs also include video imaging as part of their diagnostic armamentaria. The introduction of video imaging has opened a new era in patient communication and education as well as in diagnosis and treatment planning. Early uses of this technology have centered primarily around the communication of specific treatment goals in orthognathic surgery,[26,27] and most of the studies conducted to date have assessed the accuracy of video imaging for surgical prediction.[28,29]

It is important to recognize that in the adult surgical patient, there is a certain amount of stasis; therefore, the bony movements and the subsequent soft tissue responses are likely to be fairly predictable.[30] On the other hand, the use of video imaging in the prediction of nonsurgical growth modification treatment becomes more complicated because we must accommodate factors such as hard and soft tissue growth prediction, cooperation, and the variability in treatment responses that have bedeviled growth prediction in the past. Perhaps it is because of all these complicating factors that nobody has yet melded the growth prediction and video imaging technologies to assess the potential benefits in forecasting the facial growth changes associated with growth modification treatment. However, the application of video imaging in this area could offer an excellent opportunity to increase our treatment prediction capabilities, improve patient communication and education, as well as increase patient motivation.

The purpose of this study was to evaluate the technical accuracy and the clinical acceptability of video imaging in predicting the soft tissue outcomes of growth modification treatment for skeletal Class II malocclusions in the early mixed dentition and in adolescence.

The specific questions addressed were:

1. Can video imaging be used in growing patients to accurately predict the soft tissue outcomes of Class II growth modification treatment?
2. Does the age of the patient under treatment influence the accuracy of the video imaging prediction?
3. Do orthodontists and lay people feel that the predicted video images adequately resemble the actual posttreatment outcomes?

Materials and methods

The database for this study— the records of 42 Caucasian patients who were divided into two age groups—was obtained retrospectively from the office of a single orthodontist using the following criteria.

1. The first group comprised 22 growing patients ranging from 8 to 10 years old (mixed dentition). The second group comprised 20 patients from 12 to 14 years old (adolescent) (Table 1). Each patient underwent significant mandibular growth during the treatment period (3 mm or more of horizontal growth occuring at pogonion).
2. The patients were all healthy, with no se-

vere systemic diseases or craniofacial deformities except for a Class II skeletal and dental relationship. Skeletal Class II was defined as a difference of 5 mm or more horizontally between A-point and pogonion. A minimum of 3 mm of reduction in Class II (as defined above) during treatment was a requirement for inclusion.

3. The patients underwent nonextraction, growth modification treatment using a conventional orthopedic device (headgear) with less than 1 mm of concurrent anteroposterior anterior dental movement. Appliance selection was not an issue, because only the treatment results dictated the inclusion or exclusion of cases.

4. All records were taken in similar head positions, with teeth in centric relation.

Each pretreatment (initial) and posttreatment (final) cephalometric headfilm was positioned on a Kaiser (Kaiser, Inc, Buchen, Germany) copy/viewstand using a reference plane that was constructed 7° off SN. They were then digitized and recorded into the Quick Ceph (Orthodontic Processing, Chula Vista, Calif) program using a CCD (Pentax, Inc, Japan) video camera that was positioned at a standardized distance from the viewbox and was attached to a 7100/66AV Power Macintosh (Apple, Inc, Cupertino, Calif). The initial and final lateral photographs were also captured into the program using a color Sony (Sony, Inc, Japan) super eight camcorder and were carefully aligned over their respective headfilms (to minimize possible distortion) to be used later in morphing procedures.

For every patient, an untreated growth prediction was first performed based on the initial headfilm, using a period corresponding to the known length of the previously completed treatment. For growth prediction, Quick Ceph uses a modified Ricketts incremental growth method radiating out from Pt-point (the junction of foramen rotundum and the pterygomaxillary fissure).[31] It then performs a second radial growth prediction for the soft tissue nose and the soft and hard tissue chins, as described by Ricketts.[22]

In order to take into account individual variations, the computer-generated growth prediction tracing was then superimposed on the actual final headfilm and was modified (the length of treatment was increased or decreased) so that the two tracings were of identical size when calibrated at SN. This procedure helped produce a more accurate and proportional prediction, rather than just using the chronological growth period.

Table 2
Actual growth between pretreatment and posttreatment

Measurement	Pretreatment (mm) X ± SD	Posttreatment (mm) X ± SD	Tx change (mm) X ± SD
Mixed dentition sample			
A-point (h)	50.5 ± 3.5	50.9 ± 3.2	+0.4 ± 3.6
B-point (h)	39.0 ± 4.1	42.4 ± 5.2	+3.4 ± 4.0***
Pogonion (h)	38.5 ± 4.9	42.9 ± 6.3	+4.4 ± 4.2***
A-point (v)	30.5 ± 4.4	33.5 ± 3.5	+3.0 ± 3.3***
B-point (v)	63.7 ± 5.9	70.1 ± 6.0	+6.4 ± 2.9***
Pogonion (v)	75.5 ± 6.1	83.0 ± 6.6	+7.5 ± 3.4***
Adolescent sample			
A-point (h)	50.6 ± 4.0	50.7 ± 3.4	+0.1 ± 1.9
B-point (h)	41.9 ± 5.4	44.2 ± 4.5	+2.3 ± 2.1***
Pogonion (h)	42.4 ± 6.2	46.4 ± 5.1	+4.0 ± 2.7***
A-point (v)	29.9 ± 2.2	33.4 ± 2.4	+3.5 ± 2.0***
B-point (v)	60.4 ± 4.6	67.2 ± 3.8	+6.8 ± 3.0***
Pogonion (v)	72.6 ± 5.1	80.5 ± 4.1	+7.9 ± 3.2***

(h) = horizontal (v) = vertical
* $p<0.05$; ** $p<0.01$; *** $p<0.001$

To further increase accuracy, the resulting growth forecast and the final tracing were superimposed on a second reference line constructed 7° off SN and registered at Pt-point, and the hard tissue structures were manipulated in the growth tracing until the two tracings were accurately superimposed at A-point, B-point, pogonion, menton, upper incisor, and lower incisor. Finally, the initial lateral photograph was morphed to this new, modified VTO, thus producing a video image that was fully representative of the underlying superimposed hard tissues and dental landmarks.

To assess the accuracy of the soft tissue predictions, the following points on the predicted cephalometric line drawings (VTOs) were measured and compared with similar measurements on the actual final tracings: nose, subnasale, superior sulcus, upper lip, upper stomion, lower stomion, lower lip, inferior sulcus, chin, and soft tissue menton. These comparisons were statistically evaluated using unpaired *t*-tests. Method error for this part was assessed with double determinations of Cartesian landmark locations in both areas; all replications were well within acceptable ranges for this type of data.

To assess the acceptability of the video image predictions, the three video images of each patient (initial, actual final, predicted final) were displayed simultaneously on the monitor and were evaluated and graded by a panel of four

Table 3
Accuracy of hard tissue superimpositions in mm, mixed dentition sample

Measurement	Actual X± SD	Predicted X ± SD	Difference X ± SD
A-point (h)	50.9 ± 3.2	50.3 ± 3.4	-0.6 ± 0.8**
B-point (h)	42.4 ± 5.2	42.6 ± 5.0	0.2 ± 1.4
Pogonion (h)	42.9 ± 6.3	42.6 ± 6.2	-0.3 ± 0.7
Menton (h)	28.4 ± 6.5	27.8 ± 5.9	-0.6 ± 1.3*
A-point (v)	33.5 ± 3.5	34.0 ± 3.8	0.5 ± 1.4
B-point (v)	70.1 ± 6.0	70.0 ± 6.3	-0.1 ± 1.8
Pogonion (v)	83.0 ± 6.6	83.1 ± 6.5	0.1 ± 1.2
Menton (v)	85.0 ± 6.5	84.8 ± 6.5	-0.2 ± 1.1
Upper incisor (h)	52.8 ±4.0	52.9 ± 4.2	0.1 ± 0.2*
Upper incisor (v)	55.4 ± 4.8	55.4 ± 4.9	0.0 ± 0.2
Upper I-FH	106.6 ± 5.8	107.0 ± 5.7	0.4 ± 1.1
Lower incisor (h)	49.3 ± 3.9	49.3 ± 3.8	0.0 ± 0.2
Lower incisor (v)	51.3 ± 5.1	51.2 ± 5.0	-0.1 ± 0.3
Lower I-FH	57.1 ± 6.1	57.4 ± 6.3	0.3 ± 1.2

(h) = horizontal (v) = vertical
* p<0.05; ** p<0.01; *** p<0.001

Table 4
Accuracy of hard tissue superimpositions in mm, adolescent sample

Measurement	Actual X ± SD	Predicted X ± SD	Difference X ± SD
A-point (h)	50.7 ± 4.0	50.6 ± 4.1	-0.1 ± 0.9
B-point (h)	44.2 ± 5.4	44.5 ± 5.4	0.3 ± 0.8
Pogonion (h)	46.4 ± 6.2	46.5 ± 5.9	0.1 ± 0.7
Menton (h)	33.7 ± 5.8	32.7 ± 5.3	-1.0 ± 1.4**
A-point (v)	33.4 ± 2.2	33.6 ± 3.0	0.2 ± 1.4
B-point (v)	67.2 ± 4.6	67.1 ± 4.8	-0.1 ± 1.7
Pogonion (v)	80.5 ± 5.1	80.0 ± 5.2	-0.5 ± 1.4
Menton (v)	83.3 ± 4.8	83.0 ± 5.1	-0.3 ± 1.1
Upper incisor (h)	52.7 ± 4.5	52.8 ± 4.4	0.1 ± 0.4
Upper incisor (v)	52.9 ± 2.9	52.8 ± 2.8	-0.1 ± 0.2*
Upper I-FH	110.8 ± 5.6	111.1 ± 5.6	0.3 ± 1.4
Lower incisor (h)	49.9 ± 4.4	50.0 ± 4.4	0.1 ± 0.3
Lower Incisor (v)	50.4 ± 3.3	50.5 ± 3.2	0.1 ± 0.3
Lower I-FH	59.8 ± 5.6	59.6 ± 5.6	-0.2 ± 1.4

*(h) = horizontal (v) = vertical
p<0.05; ** p<0.01; *** p<0.001

evaluators, consisting of two orthodontists and two lay people with no knowledge of orthodontics. Assessments were made of the nose, nasolabial angle, upper lip, lower lip, labiomental fold, chin, and the overall profile. On the video images, the evaluations were carried out using the visual analog scale with gradations ranging from poor to excellent on a 100-mm line. After a brief discussion on the use of the scale prior to the evaluation, each examiner was asked to mark a point on the line denoting his or her perception of the prediction's likeness to the actual result for each case. Measurements between zero and the point marked by the examiner were made and the distance in millimeters was recorded as the scored value. A two-way ANOVA with Student-Newman-Kents post-hoc comparisons of the means were employed to determine statistical significance.

Intraexaminer error was evaluated by the reexamination and rescoring of 10 patients by each member of the panel. The two scores were compared using paired *t*-tests. Out of the 28 areas scored by the four examiners, only three were found to be unreliable, with differences ranging from 9% to 13% between the two scores.

Results

Cephalometric (VTO) comparisons (Tables 2 to 6)

The amount and direction of growth were very similar for the mixed dentition and the adolescent groups (Table 2). In the horizontal plane, both groups had minimal maxillary growth of less than 0.5 mm. In the mixed dentition, there was significant mandibular growth, with an average of 4.4 mm of change at pogonion, reflecting an annualized rate of 2.1 mm/yr. Similarly, the adolescent group showed significant mandibular growth with an average of 4.0 mm of change at pogonion, resulting in an annualized rate of 2.7 mm/yr. In the vertical plane,

Table 5
Accuracy of soft tissue prediction in mm, mixed dentition sample

	Actual X ± SD	Predicted X ± SD	Difference X ± SD
Horizontal measurements			
Nose	79.5 ± 4.4	78.6 ± 4.7	-0.9 ± 3.3
Subnasale	67.8 ± 4.4	67.0 ± 3.9	-0.8 ± 3.1
Superior sulcus	64.5 ± 3.6	64.7 ± 3.7	0.2 ± 1.8
Upper lip	66.2 ± 4.5	66.5 ± 4.1	0.3 ± 1.9
Upper stomion	60.8 ± 4.4	60.2 ± 4.1	-0.6 ± 3.3
Lower stomion	58.7 ± 4.3	59.7 ± 4.6	1.0 ± 2.1*
Lower lip	62.5 ± 4.5	62.7 ± 4.4	0.2 ± 2.5
Inferior sulcus	53.3 ± 5.0	52.2 ± 4.2	-1.1 ± 1.9*
Chin	51.9 ± 6.9	51.3 ± 6.1	-0.6 ± 2.9
Menton	41.2 ± 6.6	39.2 ± 7.6	-2.0 ± 5.0
Vertical measurements			
Nose	22.5 ± 4.8	21.6 ± 4.6	-0.9 ± 2.3
Subnasale	30.1 ± 5.2	29.8 ± 4.1	-0.3 ± 3.6
Superior sulcus	37.0 ± 7.0	34.9 ± 5.8	-2.1 ± 3.1**
Upper lip	47.5 ± 5.1	46.8 ± 4.3	-0.7 ± 3.7
Upper stomion	51.7 ± 4.3	51.7 ± 4.0	0.0 ± 2.7
Lower stomion	53.5 ± 4.5	53.4 ± 4.3	-0.1 ± 2.4
Lower lip	58.5 ± 4.9	58.1 ± 4.6	-0.4 ± 2.2
Inferior sulcus	69.4 ± 5.3	69.2 ± 5.6	-0.2 ± 2.8
Chin	87.6 ± 6.4	86.2 ± 6.8	-1.4 ± 3.3
Menton	96.6 ± 5.8	95.8 ± 6.7	-0.8 ± 2.7

* p<0.05; ** p<0.01; *** p<0.001

Table 6
Accuracy of soft tissue prediction in mm, adolescent sample

	Actual X ± SD	Predicted X ± SD	Difference X ± SD
Horizontal measurements			
Nose	81.2 ± 5.6	80.6 ± 6.2	-0.6 ± 2.7
Subnasale	69.4 ± 7.1	68.1 ± 5.7	-1.3 ± 5.5
Superior sulcus	64.9 ± 5.0	65.7 ± 5.3	0.8 ± 1.7*
Upper lip	65.9 ± 5.2	66.9 ± 5.9	1.0 ± 1.9*
Upper stomion	60.6 ± 4.4	62.5 ± 6.8	1.9 ± 4.5
Lower stomion	59.9 ± 6.1	60.7 ± 6.6	0.8 ± 1.9
Lower lip	63.3 ± 5.6	63.8 ± 6.2	0.5 ± 1.8
Inferior sulcus	55.1 ± 5.8	54.0 ± 5.4	-1.1 ± 2.0*
Chin	55.8 ± 7.2	55.4 ± 6.8	-0.4 ± 2.1
Menton	45.3 ± 6.2	42.0 ± 7.1	-3.3 ± 5.6*
Vertical measurements			
Nose	21.2 ± 4.0	19.7 ± 3.0	-1.5 ± 2.8*
Subnasale	29.5 ± 3.7	29.1 ± 2.9	-0.4 ± 3.3
Superior sulcus	36.5 ± 4.0	34.7 ± 3.6	-1.8 ± 2.8*
Upper lip	45.8 ± 4.1	45.0 ± 3.5	-0.8 ± 3.3
Upper stomion	50.2 ± 4.1	48.9 ± 2.6	-1.3 ± 2.7*
Lower stomion	51.3 ± 3.7	49.9 ± 3.2	-1.4 ± 2.9*
Lower lip	56.2 ± 4.4	54.5 ± 3.4	-1.7 ± 3.0*
Inferior sulcus	66.4 ± 4.6	66.7 ± 4.8	0.3 ± 1.9
Chin	84.2 ± 5.4	83.3 ± 6.0	-0.9 ± 2.9
Menton	93.2 ± 5.3	92.6 ± 6.2	-0.6 ± 3.7

* p<0.05; ** p<0.01; *** p<0.001

the maxilla and the mandible showed similar amounts of significant (p<0.001 by paired *t*-tests) growth in both the mixed dentition and the adolescent groups.

The hard tissue superimpositions (Tables 3 and 4) were found to be very accurate with only three out of 14 mixed dentition parameters and two out of 14 adolescent parameters showing significant differences (p<0.01) between the actual outcome and the predicted (VTO) outcome. Additionally, four of these five errors were noted to be less than 0.6 mm and can be considered to be clinically insignificant.

When comparing the actual and predicted soft tissue parameters (Tables 5 and 6), it was clear that predictions were notably better in the mixed dentition group, with only three out of 20 parameters showing significant differences (p<0.05) between the actual and the computer predicted outcomes, while in the adolescent group nine out of 20 parameters had significant mean differences between the actual outcome and the computer generated VTOs.

In the mixed dentition, the principle problem area in the horizontal plane was the lower lip, with the computer VTO showing mean errors of 1.0 mm for lower stomion and 1.1 mm for inferior sulcus (Table 5) In addition to these areas around the lower lip, soft tissue menton was predicted to be too far posterior by 2.0 mm, although this error was statistically insignificant. In the vertical plane, superior labial sulcus was the only area that was significantly (p<0.01) underpredicted, being superior to the actual outcome by 2.1 mm.

In the adolescent group, inferior labial sulcus and soft tissue menton were predicted to be too far posterior in the horizontal plane by 1.1 mm and 3.3 mm, respectively (Table 6). Additionally, the areas surrounding the upper lip had significant errors in the computer generated VTOs, with both the superior sulcus and the

Table 7
Visual analog scale scores in the mixed dentition sample

Measurement	Lay people	Orthodontists	Difference
Nose	49.7 ± 14.8	51.0 ± 10.2	-1.3 ± 13.2
Nasolabial angle	46.4 ± 14.9	42.0 ± 17.3	4.4 ± 17.3
Upper lip	42.8 ± 14.0	29.8 ± 19.1	13.0 ± 15.3***
Lower lip	43.6 ± 15.2	32.9 ± 14.9	10.7 ± 10.9***
Labiomental fold	46.7 ± 11.0	37.2 ± 17.4	9.5 ± 14.6**
Chin	53.4 ± 15.2	49.7 ± 13.4	3.7 ± 12.1
Overall profile	48.4 ± 12.2	31.9 ± 13.9	16.5 ± 13.3***

* $p<0.05$; ** $p<0.01$; *** $p<0.001$

Table 8
Visual analog scale scores in the adolescent sample

Measurement	Lay people	Orthodontists	Difference
Nose	53.8 ± 15.2	53.2 ± 22.0	0.6 ± 20.6
Nasolabial angle	54.9 ± 14.8	56.6 ± 20.9	-1.7 ± 17.0
Upper lip	54.3 ± 18.3	48.1 ± 18.0	6.2 ± 17.6
Lower lip	43.7 ± 14.4	39.6 ± 11.5	4.1 ± 14.7
Labiomental fold	46.4 ± 18.1	40.4 ± 15.9	6.1 ± 17.3
Chin	51.8 ± 19.2	53.7 ± 15.1	-1.9 ± 13.8
Overall profile	50.9 ± 14.3	43.4 ± 14.4	7.5 ± 14.6*

* $p<0.05$; ** $p<0.01$; *** $p<0.001$

Table 9
VAS scores: Frequency distributions

	Mixed dentition sample				Adolescent sample			
	Lay people		Orthodontists		Lay people		Orthodontists	
	VG+E (%)	G+VG+E (%)	VG+E (%)	G+VG+E (%)	VG+E (%)	G+VG+E (%)	VG+E (%)	G+VG+E (%)
Nose	30	73	40	65	35	83	45	65
Nasolabial angle	25	65	28	45	17	70	55	68
Upper lip	15	60	14	26	33	70	38	60
Lower lip	20	54	12	32	18	38	10	35
Labiomental fold	18	60	15	35	25	50	20	40
Chin	33	67	37	60	30	60	30	75
Overall	33	80	8	33	30	78	17	70

G (Good, 40-60): Profiles similar, but with noticeable differences
VG (Very good, 60-80): Profiles similar, with only minor differences
E (Excellent, 80-100): Profiles similar, with no differences

upper lip being predicted significantly ($p<0.05$) anterior to the actual outcome by 0.8 mm and 1.0 mm, respectively, and upper stomion being too far anterior by 1.9 mm (although this error was statistically insignificant). Vertically, 50% of the areas showed statistically significant differences ($p<0.05$), with all the predicted measurements being superior to the actual outcomes by 1.3 to 1.8 mm.

Video image comparisons (Tables 7 to 9)

For the overall profile, the adolescent group was rated slightly better on the visual analog scale than the mixed dentition group, with scores of 50.9 (lay people) and 43.4 (orthodontists), as against 48.4 (lay people) and 31.9 (orthodontists), respectively (Tables 7 and 8). Furthermore, in both groups, whenever a significant difference existed between the two panels, the orthodontists always scored lower.

In the mixed dentition group, 33% of the overall profiles were scored as being very good or better (VAS scores above 60) by the lay people, while orthodontists scored only 8% of the cases in this category (Table 9). When the 40-to-60 range (good) scores were included, 80% of the lay people, but still only 33% or orthodontists, were happy with the predicted images. Additionally, when the scores for individual areas were evaluated, the upper and lower lips scored lowest, while the chin and the nose were scored highest by both panels of raters (Table 7).

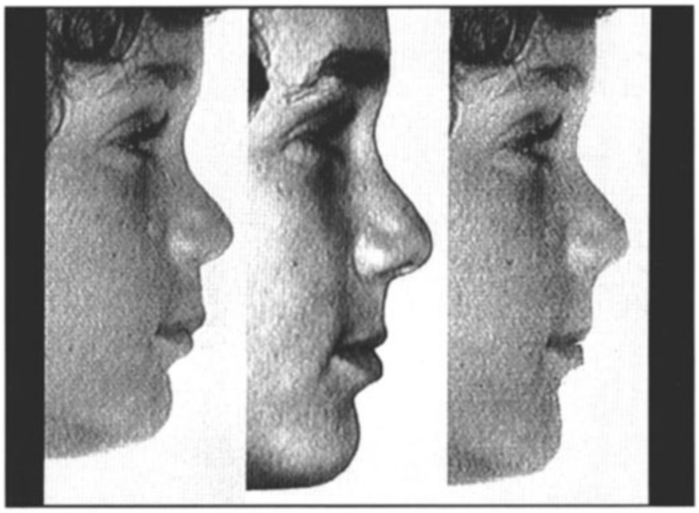

Figure 1

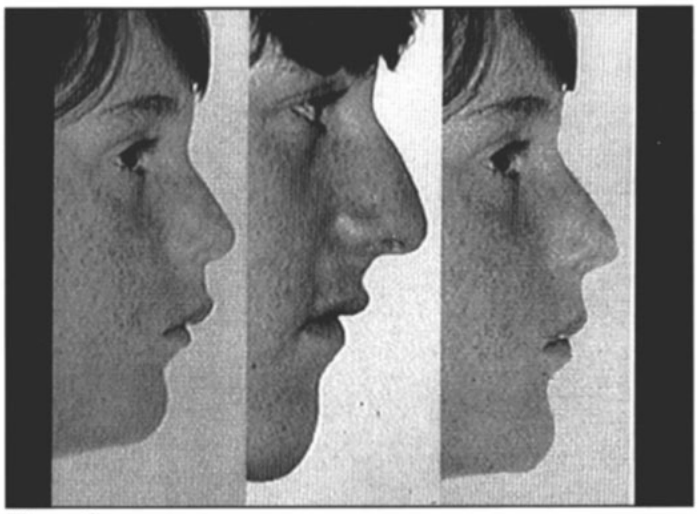

Figure 2

In the adolescent group, the lay people rated 30% of the overall profiles as being very good or better (VAS scores above 60), while only 17% were similarly rated by the orthodontists. (Table 9). However, the ratings were very similar—78% for lay people and 70% for orthodontists—when scores in the "good" category (i.e., 40 to 60) were included. Evaluating specific areas, the lowest scores in the adolescent group were noted for the lower lip and labiomental fold, while the nasolabial angle was scored highest by both panels (Table 8).

Discussion

The overall impression gained from this study was that when it comes to growth modification, computerized video imaging may play its most important role in the consultation room as a communication medium between orthodontist and patient, and not in the private office as a reliable tool in diagnosis and treatment planning.

In the mixed dentition, although the majority of soft tissue (VTO) predictions were quite accurate in the horizontal plane, the areas surrounding the lower lip, namely lower stomion and inferior labial sulcus, were predicted to be 1.0 mm anterior and 1.1 mm posterior, respectively, to their actual outcomes. The lower lip has been the most problematic area for prediction in many studies, and despite numerous attempts, there still are no acceptable soft-to-hard-tissue ratios for the lower lip's response to treatment.[32,33] The problem with the lower lip prediction is multifactorial and may include, but is not limited to, its position prior to treatment (whether it is trapped by the upper lip), its support (by the upper incisors, lower incisors, or both), its thickness, its tonicity, the treatment modality used, and the ethnic origin of the patient.

The VTO predictions were found to be less accurate for the adolescent group than for the mixed dentition group; almost half of the areas in the adolescent group had predictions that were significantly different ($p<0.05$) from the actual treatment outcomes. In addition to the lower lip area, which was inaccurately predicted (especially in the vertical plane), the upper lip also became a problem area in this age group, with the predictions often being inferior and anterior to the actual outcome by up to 1.9 mm.

The fact that the video image predictions were reasonably accurate in the mixed dentition group (Figure 1)—as they have been in studies of adults undergoing camouflage or surgical orthodontic treatment[29,34]—but were less accurate in adolescents even though both groups underwent similar amounts of skeletal growth (Table 2), leads one to speculate on the uniqueness of the adolescent group. It should be noted that many of the patients in the adolescent group went through puberty, which involves significant changes in soft tissue thickness and tonicity, concurrent with treatment, and this may have made predicting soft tissue changes considerably more difficult (Figure 2) This appears to be the most logical explanation, since the soft tissue predictions were only conducted after accurate hard tissue superimpositions of the underlying structures had been performed to match the known treatment outcomes.

A surprising and unexpected finding of this study was that the orthodontists gave the adolescent group consistently higher subjective

Figure 1
A typical mixed dentition video image prediction, from left to right: initial image, actual final image, and computer-generated prediction.

Figure 2
Video images of an adolescent patient, from left to right: initial image, actual final image, and computer-generated prediction. This prediction was not able to take into account the considerable vertical growth and nasal development that occurred at the onset of puberty.

(video imaging) scores in every area, including the overall profile (Tables 7 and 8), despite the fact that these patients' underlying soft tissue predictions (VTOs) were substantially less accurate than those for the mixed dentition group (Tables 5 and 6).

Comparing the two groups of judges in their ratings of the predicted video images, it was interesting to note that lay people were always less critical than orthodontists in rating both the overall images as well as specific regions of the images, for both the mixed dentition and the adolescent groups. In fact, lay people rated 80% of the sample in the mixed dentition and 78% of the sample in the adolescent group as "good" or better for the overall profile. These findings are similar to those reported in other studies, where panels of judges rated the video image predictions of surgical or camouflage treatments.[29,34] These results suggest that lay people may be more forgiving and understanding of the limitations and shortcomings of video imaging technology than professionals, and they further support the use of video imaging as a communication tool for patient education.

However, if we are to make assessments about the accuracy of the soft tissue predictions, and if we are to draw any conclusions about the diagnostic applications of VTOs in growing patients, we must consider the potential outcome with realism. In a real scenario, the final hard tissue and dental outcomes are unknown and need to be predicted by the orthodontist by taking into consideration factors such as variability in the patient's growth pattern, uncertainty about patient cooperation, and the potential effects of different appliances. Under such circumstances, the current problems with the soft tissue predictions in both age groups will probably be further magnified. Therefore, it seems probable that the application of video imaging as a reliable, accurate tool in the diagnosis and treatment planning of growing patients is questionable and should only be carried out with a clear understanding of its capabilities and limitations.

Conclusions

1. In mixed dentition patients undergoing Class II growth modification treatment, facial profile outcomes were accurately predicted using current video imaging techniques, with the

exception of the lower lip area.

2. In adolescents, however, the video image predictions were not accurate, no matter how well the orthodontist forecast the hard tissue outcomes, due to the unpredictable nature of soft tissue maturation that occurs during puberty.

3. Orthodontists were more critical than lay people in judging the predicted video images for both the mixed dentition and adolescent groups. In contrast, lay people felt that the predicted video images adequately resembled the actual posttreatment outcomes for both groups.

4. Computerized video imaging can currently be used as a communication tool between orthodontists and patients in Class II growth modification treatment. However, its inaccuracy in predicting growth and treatment outcomes makes it a questionable technology for definitive diagnostic and treatment planning in growing patients.

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References

1. Burstone CJ. Process of maturation and growth prediction. Am J Orthod 49:907-919, 1963.
2. Ricketts RM. Philosophies & methods of facial growth prediction. Proc Found Orthod Res 1971;4:11-30.
3. Hirschfeld W, Moyers, R. Prediction of craniofacial growth: the state of the art. Am J Orthod 1975;67:243-252.
4. Sarver DM, Johnston MW, Matukas VJ. Video imaging for planning and counseling in orthognathic surgery. J Oral and Maxillofacial Surgery 1988;46:939-945.
5. Harradine NWT, Birnie DJ. Computerized prediction of the results of orthognathic surgery. J Maxfac Surg 1985;13:245-249.
6. Ackerman JH, Proffit WR. Communication in orthodontic treatment planning : bioethical and informal consent issues. Angle Orthod 1995;65:253-262.
7. Sarver DM. Video cephalometric diagnosis (VC D): a new concept in treatment planning? Am J Orthod Dentofac Orthop 1996;110:128-136.
8. Proffit WR. Contemporary orthodontics. Chapter 8, St. Louis: Mosby Year Book, 1993: 229.
9. King GJ, Keeling SD, Hocever RA, Wheeler TA. The timing for treatment for Class II malocclusion in children: a literature review. Angle Orthod 1990;60:87-97.
10. Livieratos FA, Johnston LE Jr. A comparison of one-stage and two-stage nonextraction alternatives in matched Class II samples. Am J Orthod Dentofac Orthop 1995;108:118-131, 1995.
11. Johnston LE Jr. A comparative analysis of Class II treatments. In: McNamara JA Jr., Carlson DS, Vig PS, Ribbens KA eds. Science and clinical judgment in orthodontics. Craniofacial growth series, Volume 19, Ann Arbor: Center for Human Growth and Development, The University of Michigan, 1986:103-148,.
12. Solow B, Nilsen S. Cervical & craniocervical posture as predictors of craniofacial growth. Am J Orthod Dentofac Orthop 1992;101:449-58.
13. Brodie AG. On the growth pattern of the human head, from the third month to the eighth year of life. Amer J of Anat 1941;68:209-262.
14. Nanda RS. The rates of growth of several facial components measured from serial cephalometric roentgenograms. Am J Orthod Dentofac Orthop 1995;41:658-673.
15. Bjork A, Skieller V. Facial development & tooth eruption. Am J Orthod 1972;62:339-382.
16. Bjork A. Prediction of mandibular growth rotation. Am J Orthod 1969;55:585-99.
17. Singer CP, Manandras AH, Hunter WS. The depth of the mandibular antegonial notch as an indicator of mandibular growth potential. Am J Orthod 1987;91:117-24.
18. Baumrind S, Korn E, West EE. Prediction of mandibular rotation: an empirical test of clinician performance. Am J Orthod 1984;86:371-85.
19. Johnston LE Jr. A simplified approach to prediction Am J Orthod 1975;67:253-257.
20. Popovich F, Thompson GW: Craniofacial templates for orthodontic case diagnosis. Am J Orthod 1977;71:406-420.
21. Hixon EH. Prediction of facial growth. Trans Eur Orthod Soc 1968;44:127-139.
22. Ricketts RM. A principle of arcial growth of the mandible. Angle Orthod 1972;42:368-386.
23. Schulhof RJ, Bagha L. A statistical evaluation of the Ricketts and Johnston growth forecasting methods. Am J Orthod 1975;67:258-276.
24. Thames TL, Sinclair PM, Alexander RG. The accuracy of computerized growth prediction in Class II high-angle cases. Am J Orthod 1985;87:398-405.
25. DiCiccio P. Assessment of the accuracy of three methods of computerized growth prediction of the soft tissue profile, in untreated individuals. Loma Linda, Calif: Loma Linda University; 1993. Thesis.
26. Kinnebrew MC, Hoffman DR, Carlton DM. Projecting the soft-tissue outcome of surgical and orthodontic manipulation of the maxillofacial skeleton. Am J Orthod 1983;84:508-519.
27. Sarver DM. Video imaging-a computer facilitated approach to communication and planning in orthognathic surgery. Br J Orthod 1993;20:187-191.
28. Sinclair PM, Kilpelainen P, Phillips C, White RP, Rogers L, Sarver DM. The accuracy of video imaging in orthognathic surgery. Am J Orthod Dentofac Orthop 1995;107:177-185.
29. Giangreco TA, Forbes DP, Jacobson RS, Kallal RH, Moretti RJ, Marshall SD. Subjective evaluation of profile prediction using video imaging. Int J Adult Orthod Orthognath Surg 1995;10:211-217.
30. Sarver DM. Videoimaging: the pros and cons. Angle Orthod 1993;63:167-170.
31. Blasieo G. QuickCeph: A computer program for cephalometric analysis and treatment planning. Loma Linda, Calif: Loma Linda University; 1986. Thesis.
32. Hing R. The accuracy of computer generated prediction tracings. Int J oral Maxillofac Surg 1989;18:151-158.
33. Lew K. The reliability of computerized cephalometric soft tissue prediction following bimaxillary anterior subapical osteotomy. Int J Adult Orthod Orthognath Surg 1992;7:97-101.
34. Le TN. The accuracy of computerized soft tissue prediction associated with adult four bicuspid extraction treatment. Master's Thesis, University of Southern California, 1996.