Accuracy of a Computerized Method of Predicting Soft-Tissue Changes from Orthognathic Surgery

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Recent advances in computer technology and software have made it possible for orthodontists to simulate and predict facial soft-tissue changes from orthognathic surgery. Commercially available programs can now generate cephalometric and photographic predictions more quickly and easily than with traditional prediction methods.

Previous studies have examined the accuracy of a number of surgical prediction programs, including Dentofacial Planner Plus,* Quick Ceph,** and Prescription Planner/Portrait.***[1-9] The purpose of the present study was to assess the accuracy of a new program, Orthodontic Treatment Planner,† in the prediction of a variety of orthognathic surgical movements.

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**Orthodontic Processing, 12925 El Camino Real, Suite J-23, San Diego, CA 92130.

***Rx Data, Inc., Ooltewah, TN.

†Version 8.5.4, Pacific Coast Software, distributed by Ortho-Vision Technologies, Inc., 3701 Shoreline Drive, Suite 202B, Wayzata, MN 55391.

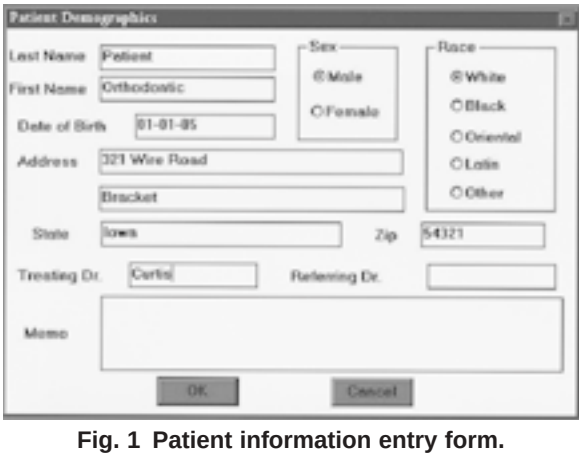

Fig. 1 Patient information entry form.

Materials and Methods

Surgical predictions were created for 28 patients who had previously been treated in the Departments of Orthodontics and Oral and Maxillofacial Surgery at the University of Iowa. The surgeries included seven maxillary impactions, two maxillary downgrafts, three mandibular setbacks, and 16 mandibular advancements. Seven of the nine patients who underwent maxillary surgeries also had mandibular advancement or setback surgery.

To minimize the effects of growth, the sample was limited to females over age 16 and males over age 18. Presurgical cephalograms and photographs were used to create the predictions. These were then compared to the actual postsurgical cephalograms and photographs, which were taken at least five months after surgery to minimize any effects of post-operative swelling on the comparisons.

Use of OTP

Creating a surgical prediction with OTP involves several steps. First, patient information

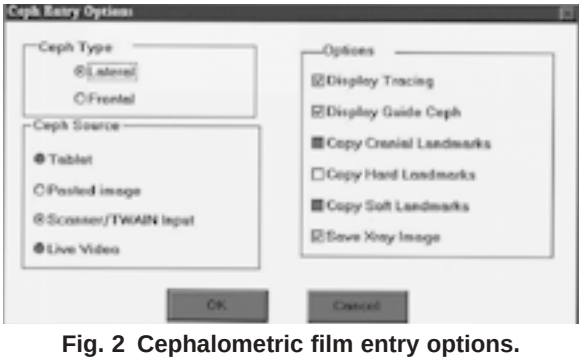

Fig. 2 Cephalometric film entry options.

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Fig. 3 Landmark identification.

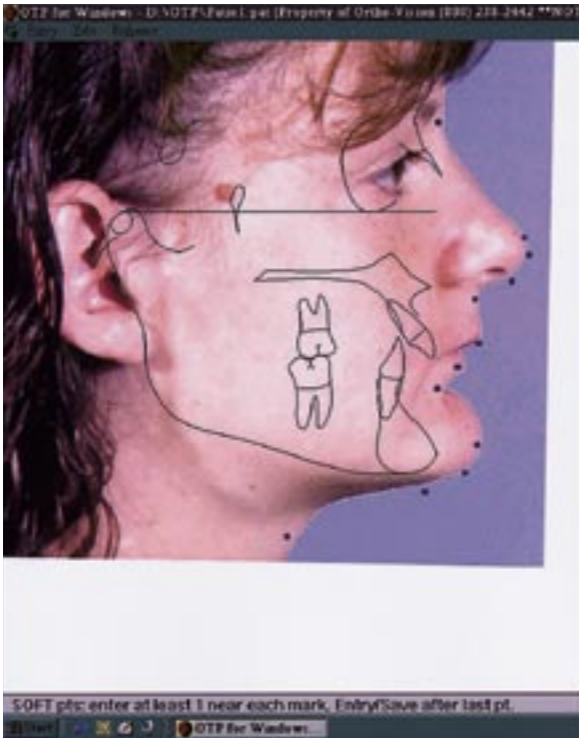

Fig. 4 Soft-tissue identification.

is entered into the program (Fig. 1). The patient's lateral cephalogram is either taken from a previously captured file or scanned into the computer (Fig. 2). The software then prompts the user to click on a series of landmarks, and a tracing is made based on these landmarks (Fig. 3).

The patient's lateral photograph is captured on the computer in similar fashion, and the user traces the soft-tissue outline with the mouse (Fig. 4). OTP then modifies the cephalometric tracing to conform to the photograph (Fig. 5).

The surgical movements are simulated by clicking on the maxilla or mandible with the mouse and manually moving the jaws to the desired locations (Fig. 6). The maxillary and mandibular incisors can be adjusted, and genioplasty movements can also be simulated. In the

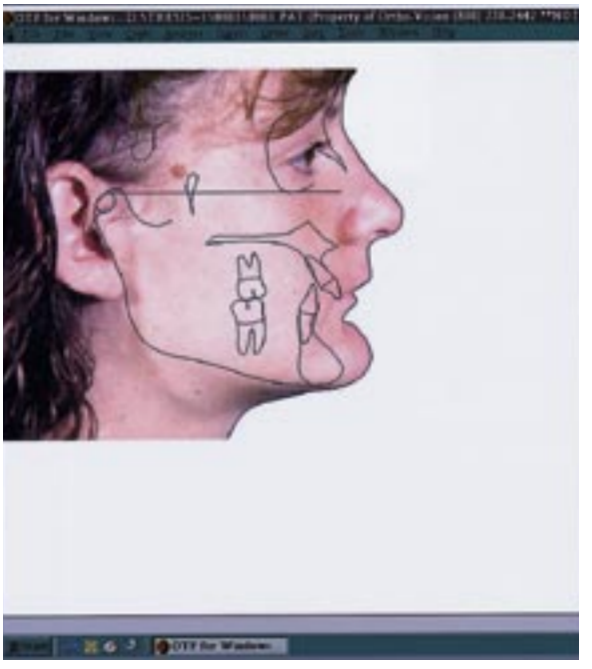

Fig. 5 Overlay of tracing on photograph.

Fig. 6 Profile tracing adjusted as hard-tissue positions change.

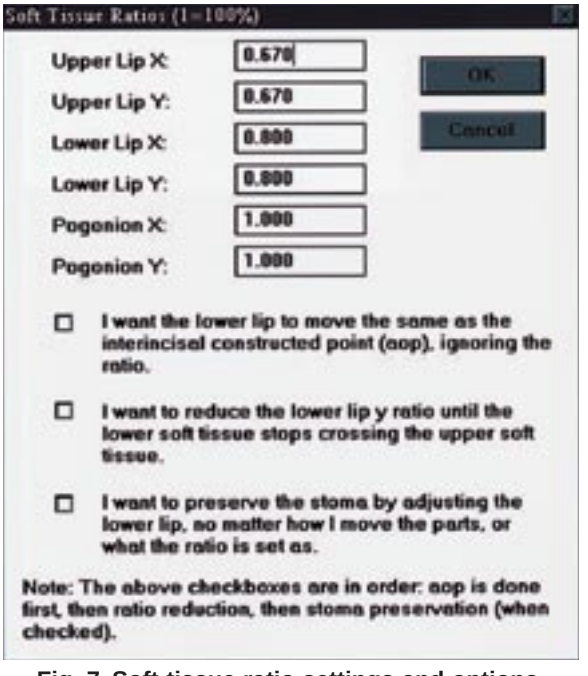

Fig. 7 Soft-tissue ratio settings and options.

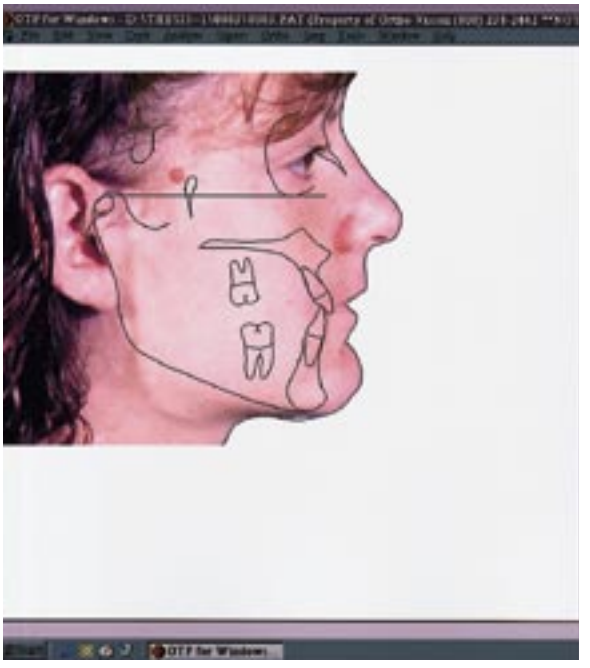

Fig. 8 Prediction tracing and photograph based on hard-tissue movements.

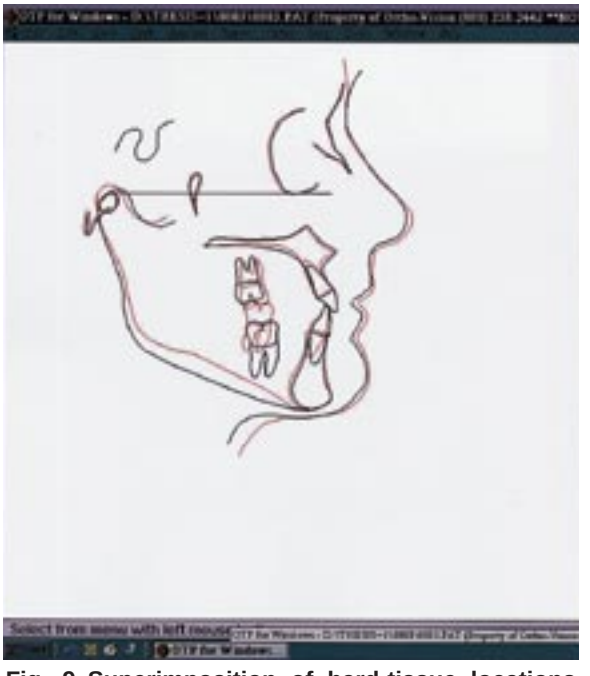

Fig. 9 Superimposition of hard-tissue locations from prediction and actual postsurgical tracings.

present study, to eliminate the possibility that prediction errors could be caused by a failure to achieve surgical treatment goals, the surgical movements were performed by moving the hard tissues on the presurgical tracing to their actual postsurgical locations.

OTP automatically adjusts the soft tissues, based on predetermined ratios (Fig. 7), to create a prediction tracing and photograph (Fig. 8). In this study, a superimposition of the prediction tracing and the postsurgical tracing was made for each patient to verify the accuracy of the hard-tissue movements (Fig. 9).

A custom cephalometric analysis can be created with OTP. We selected a horizontal reference line from porion to orbitale (the Frankfort horizontal), and calculated the vertical distance from each soft-tissue landmark to this line. A vertical reference line was drawn from nasion, perpendicular to Frankfort horizontal, and the horizontal distance from each soft-tissue landmark to this line was calculated. The custom analysis was applied to the presurgical, postsurgical, and prediction tracings.

The mean differences between the predicted and actual postsurgical landmark positions were calculated and compared, using paired t-tests on all patients and on subgroups of patients who underwent maxillary surgery (with or without mandibular surgery) or who underwent

TABLE 1
DIFFERENCES BETWEEN PREDICTED AND ACTUAL SOFT-TISSUE MEASUREMENTS (MM)

	Mean	S.D.	"t"	"p"
Horizontal				
Powel nasal tip	–0.32	1.06	–1.41	0.17
Nasal tip	–0.32	1.32	–1.13	0.27
Anterior columella	–0.11	1.49	–0.36	0.73
Posterior columella	–0.73	1.11	–3.07	0.00**
Upper lip	–0.85	1.21	–3.31	0.00**
Lower lip	–0.38	1.71	–1.04	0.31
Infralabiale	–0.57	1.44	–1.84	0.08
Soft-tissue pogonion	0.07	1.75	0.19	0.85
Soft-tissue gnathion	–0.01	2.25	–0.03	0.98
Soft-tissue menton	–0.10	3.78	–0.12	0.91
Vertical				
Powel nasal tip	–0.24	0.95	–1.17	0.26
Nasal tip	–0.35	1.28	–1.26	0.22
Anterior columella	–0.51	1.18	–2.04	0.05
Posterior columella	–0.20	1.08	–0.85	0.40
Upper lip	–0.21	1.68	–0.60	0.56
Lower lip	1.12	1.57	3.35	0.00**
Infralabiale	–0.50	1.37	–1.72	0.10
Soft-tissue pogonion	–1.35	1.94	–3.26	0.00**
Soft-tissue gnathion	–0.57	2.29	–1.17	0.26
Soft-tissue menton	0.11	2.40	0.22	0.83

*p < .05; **p < .01; ***p < .001.

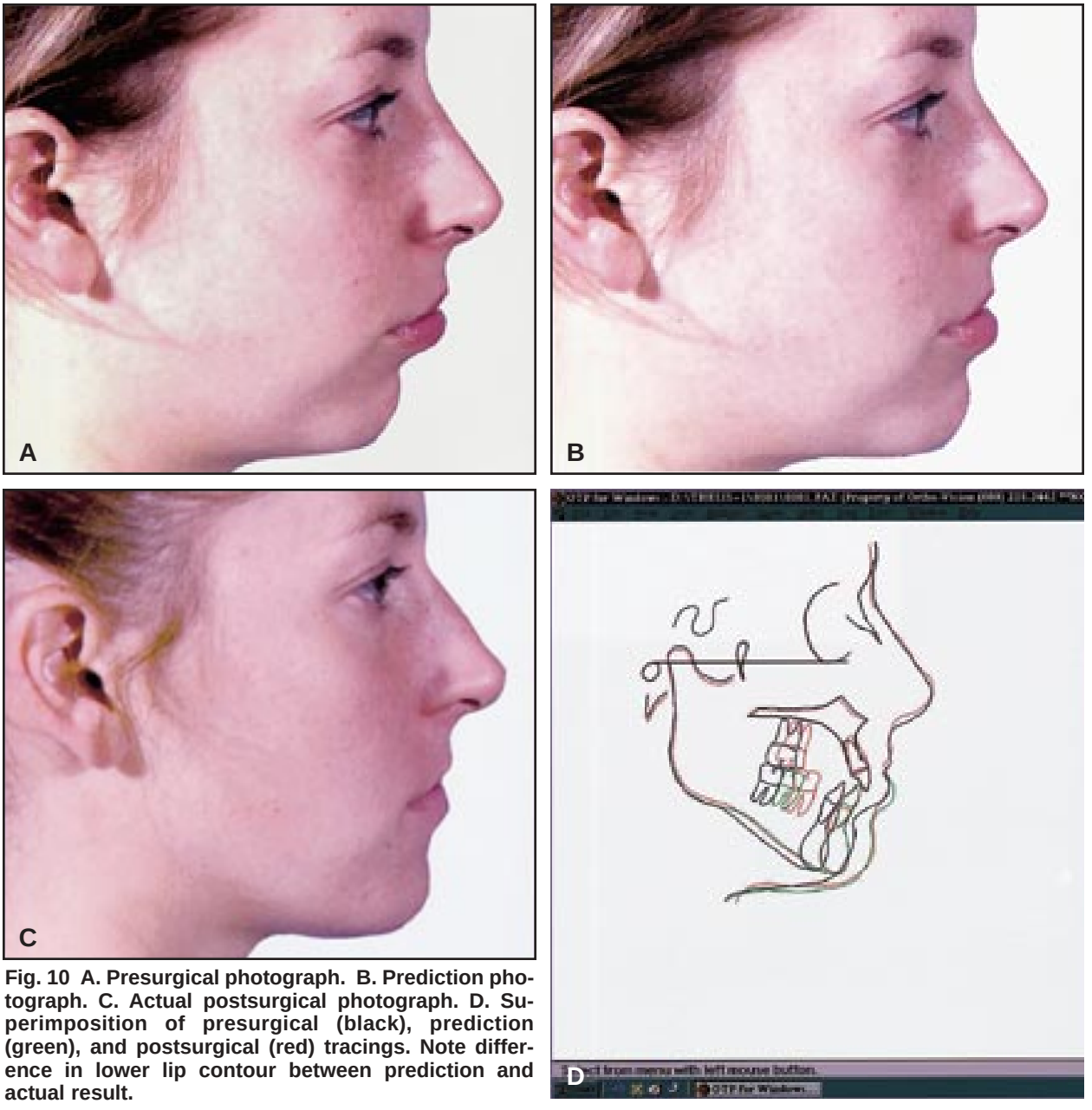

Fig. 10 A. Presurgical photograph. B. Prediction photograph. C. Actual postsurgical photograph. D. Superimposition of presurgical (black), prediction (green), and postsurgical (red) tracings. Note difference in lower lip contour between prediction and actual result.

mandibular surgery alone.

Results

Six patients were excluded from the statistical analysis after visual inspection showed that the postsurgical position of the head did not match the presurgical position of the head. This causes extreme differences in the positions of the nasal dorsum and the lip embrasure, making comparisons impractical. The problem results from the way OTP superimposes the patient's lateral photograph on the lateral cephalogram, as well as from differences between patients' head

TABLE 2
DIFFERENCES BETWEEN PREDICTED AND ACTUAL SOFT-TISSUE MEASUREMENTS BY MAGNITUDE

	0-1mm	1-2mm	2-3mm	3+mm
Horizontal				
Powel nasal tip	15	4	3	0
Nasal tip	14	4	4	0
Anterior columella	12	5	4	1
Posterior columella	11	7	3	1
Upper lip	9	10	2	1
Lower lip	8	9	3	2
Infralabiale	11	5	5	1
Soft-tissue pognonion	9	8	2	3
Soft-tissue gnathion	11	3	6	2
Soft-tissue menton	8	3	3	8
Vertical				
Powel nasal tip	15	4	3	0
Nasal tip	14	4	4	0
Anterior columella	12	5	4	1
Posterior columella	11	7	3	1
Upper lip	9	10	2	1
Lower lip	8	9	3	2
Infralabiale	11	5	5	1
Soft-tissue pognonion	9	8	2	3
Soft-tissue gnathion	11	3	6	2
Soft-tissue menton	8	3	3	8
Overall Percentage	50%	28%	13%	9%

positions and in the magnification of the photographs compared to the cephalograms.

In all groups, the simulated surgical positions of the hard-tissue landmarks were close to their actual postsurgical positions (mean difference < .25mm), with no statistically significant differences. This indicates that the surgical movements were accurately recreated.

OTP was also found to be reasonably accurate in predicting postsurgical soft-tissue positions, with a difference of less than 1mm for half of the landmarks (Table 1). Significant differences were found only for posterior columella and upper lip horizontally, and for lower lip and soft-tissue pogonion vertically.

In general, the predicted soft-tissue points were positioned superiorly and posteriorly to their actual postsurgical locations—except for the lower lip, where the predicted position was inferior to the postsurgical position by an average of more than 1mm. This difference may be due to changes in lip contour following mandibular advancement, because OTP does not compensate for lower-lip trapping (Fig. 10). The difference in lower-lip position was not noted in the patients who had only maxillary surgery. Similar results have been found in studies of other prediction systems.[1,3,7,8]

Even though the mean differences in landmark placement were reasonable for most measurements, the variability in accuracy could be a concern. There was a 50% chance that a predicted soft-tissue landmark could be more than 1mm from its actual postsurgical location (Table 2).

Conclusion

With an understanding of the limitations of computerized surgical prediction, and the ability to alter the predictions based on experience, the clinician may be able to use software-generated predictions in place of traditional methods.

Strengths of OTP include its ability to create surgical prediction profile photographs with relative ease, its flexibility in allowing image modifications, and its capability of altering the default soft-to-hard-tissue movement ratios. Drawbacks include variable accuracy and the lack of a frontal-view prediction.

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