Video Imaging for Planning and Counseling in Orthognathic Surgery

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With the advancements of computer knowledge today, treatment planning and counseling are becoming more efficient by means of video imaging. Using a video image of a patient, esthetic and functional decisions can be made by the surgeon, orthodontist, and patient in a consensus manner. Distortion characteristics of video hardware, software, and the video camera are established, and adoption of imaging techniques is employed to maximize accuracy of the imaging process. Patients' attitudes toward video imaging concerning expectations, value of visual prediction, and degree of realism are also discussed. This study is intended to establish some of the basic goals of video imaging with general information in regard to hardware and software requirements.

Computer imaging has received considerable attention lately as a means of predicting results of orthognathic surgery. Currently, there are several computer software systems that are programmed for such planning. While there is still much room for improvement, imaging can play a vital role in surgical treatment plans. This report provides an introduction to computer imaging for patient consultation and treatment planning, and discusses both the positive and negative aspects of the technology.

With the ever increasing use of orthognathic surgical techniques for the correction of dentofacial deformities, the demands on the planning skills of the orthodontist and the surgeon have increased as well. The criteria for success of an orthognathic surgical experience are most certainly centered on the correction of skeletal and dental abnormalities that produce dysfunction of muscles, joints, and other broad functional complaints. However, there is no question that the overall success of a surgical case as judged by both patients and professionals must include accomplishment of aesthetic goals as well. Defining aesthetic goals with patients obviously involves the hazard of perception. What surgeons or orthodontists consider ideal may not be the same as the patient's desires. Any practitioner who has recommended and performed orthognathic surgery has most likely encountered patients with unrealistic aesthetic expectations. The surgical team most often accomplishes their functional and aesthetic goals, but, in this situation, the patient is disappointed. Function, aesthetics, and shaping the patient's expectations into reality must all be addressed while keeping in mind the patient's best interests and desires.

In the past few years, we have used such adjuncts as cephalograms, profile tracings, and photographs in an attempt to define our facial parameters in the planning of orthognathic cases. Like others, we have enlarged photographs and performed "photograph surgery" in an attempt to counsel patients on the aesthetic changes that may occur from surgery. It was therefore a natural progression to incorporate further technological advancements into the process of providing images to our patients that would give them information relative to their treatment options.

Lately, we have incorporated the use of video imaging hardware and software with the following goals in mind. (1) Provide a realistic image of the aesthetic treatment objective that the patient can visualize. (2) Provide the surgical planners with an image so that consensus decisions can be made, particularly in borderline situations. The patient in
whom there is indecision whether to perform a genioplasty is an excellent example. The imaging system provides an image that allows the surgeon, patient, and orthodontist to determine the patient’s desires and further define the surgery to meet these goals. (3) Provide coordination between the video image and the cephalometric radiograph so that the image can be a tool for planning. This allows quantification of treatment goals.

**Hardware**

In today’s environment, there are numerous computer choices that will ultimately capture and allow manipulation of patient images. The system we are currently using consists of the following:

1. IBM (International Business Machines, Inc.) compatible personal computer.
   A. 512K Random Access Memory (RAM) required to run AT&T Truevision Image Processing (TIPS) software
   B. 640K RAM required to run Orthographics (Orthographics Mathematica, Inc., Lakeland, FL) software 10 megabyte fixed disk storage
2. Truevision Advanced Raster Graphics Adapter (TARGA) 16 board (AT&T)
3. An 8087 math co-processor
4. An analog Red-Green-Blue (RGB) monitor or composite video color monitor
5. JVC video camera with RGB and composite output
6. Summagraphics 961 or 1201 graphics tablet

**Software**

We currently use two separate software packages for image gathering and analysis, TIPS by AT&T is written in “C,” a graphics software language, and allows the personal computer to capture digitized images from the video camera and facilitates modification of the image through its sophisticated drawing and editing features. Orthographics by Mathematica addresses a more specific set of applications for the orthodontist or surgeon as opposed to the wide range of applications of TIPS.

**Distortion Characteristics**

Gathering the patient’s image for presurgical planning has a set of requirements that is not particularly different from the requirements of cephalometric radiography. The same principles of head position, magnification, and standardization are important to produce reasonably precise images. Obviously, distorted images introduce inaccuracies in treatment planning that are intolerable. To standardize images and reduce magnification problems, we selected a camera to object distance of 7 feet. This distance is practical due to the space limitations of most offices, but, when possible, the further the camera is from the subject, the less distortion is introduced. To use the system with confidence as a diagnostic tool, any possible causes of distortion should be identified and minimized. The amount of distortion with our system was tested with a series of experiments using various distances and magnifications. Areas examined included the monitor (with a curved screen), the software, and the camera. Three rectangles were drawn with a diameter of 52 mm each. Their horizontal diameters were measured on the monitor with the camera at 12, 9, and 6 feet from the target. The telephoto adjustment on the camera was maximized at each distance, while still following all three rectangles to be viewed on the monitor simultaneously. The diameters were measured with a millimeter ruler directly on the monitor to simulate what the viewer would visualize. This test evaluated whether changes in magnification incorporated various amounts of distortion.

Table 1 shows that the greater the camera to subject distance, the less magnification distortion was seen on the monitor. The focal length is the distance from the center element of the lens to the film plane when focused on infinity. This (focal length) number will vary (in correlation to distortion) from one system to another, but the principle will remain the same. Simply, an increase in telephoto (or focal length) will decrease distortion. To minimize distortion of the picture seen on the monitor, the distance from the object to camera and focal length should be addressed.

Three-dimensional objects were also evaluated for distortion. Three spheres (actual diameter 42 mm) were placed 7 feet from the camera, and approximately 70 mm apart. The magnification was adjusted to two different focal lengths. As before, the greater the focal length, the less the amount of distortion incorporated. However, a greater camera to object distance is required. Measurements were taken directly from the monitor and also through

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<tr>
<th>Feet</th>
<th>Focal Length (mm)</th>
<th>Left Rectangle (mm)</th>
<th>Middle Rectangle (mm)</th>
<th>Right Rectangle (mm)</th>
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The results of the questionnaire show that our patient sample had a positive attitude towards the imaging process. Eighty-nine percent felt the predicted images were realistic and that the desired results were achieved. The fear that a patient's expectations might become too great if provided a presurgical video prediction did not appear to be supported. However, of differences in individual response, we require the patient to sign a disclaimer indicating that they are aware of the variables of prediction and that it does not imply a guaranteed final result. This is emphasized during the imaging session.

**Strengths and Weaknesses of Video Imaging**

Video imaging has become an integral part of our planning and counseling procedures in orthognathic surgical cases. We use the imager not only to assist in the planning of surgical movements, but also to help illustrate to the patient potential aesthetic considerations and define our aesthetic goals. The advantages offered by the present imaging software systems that we use can be summarized as follows:

1. Provide an image from which the patient and surgeon can visualize the aesthetic treatment objectives.
2. They give the surgeon the ability to retrospectively measure soft tissue changes.
3. They provide the capability to measure calibrated distances and angles on the planning image.
4. They allow the placement of grids for symmetry analysis, profile analysis, or vertical proportional analysis.

5. They allow direct screen windows for comparison of different treatment plan options.

Most of the advantages of the imager in its present state are primarily in the area of patient counseling. Very accurate planning of dental and skeletal movements has not been perfected at this point. The weaknesses of our present system can therefore be summarized as:

1. Tooth position and its relation to the face is relatively unknown. However, we are presently working with the superimposition of the lateral cephalogram on the video screen to address this problem.

2. Some distortional factors are present, but these can somewhat be compensated for by placing the profile of the planning image in the middle of the screen. Distortion can almost be completely eliminated through different hardware selection.

3. Predictions have the same soft tissue uncertainty as do hand-drawn cephalometric prediction tracings.
compensating for distortion with various degrees of magnification.

Both TIPS and Orthographics can be manipulated to be helpful tools when the distortion is recognized and appropriate compensations are made.

Obtaining the Planning Image

In gathering the planning image of the surgical candidate, the camera is permanently placed 7 feet from the patient (Fig 2). The calibration object is a 1-cm disc attached to a retractable rod connected to the ceiling (Fig 3). This object, being of known size, allows us to adjust the size scale with various degrees of magnification. This is useful in measuring distances on the planning image needed for quantitative movements desired on the patient, and is accomplished through the Orthographics software.

Proper lighting is achieved with photographic umbrellas using flood lamps of 150 to 300 watts. Head positioning is determined by visual axis: the patients orient themselves with a natural head position while looking directly into mirror. Frontal images are rarely taken due to the limitations of the two-dimensional system.

When the subject's image is frozen in place, planning screens are made by cut and paste through the TIPS software system. This allows identification of the portion of the image to be used for surgical planning so that it can be placed on the screen in sections for relative comparison. Figure 4 (A and B) illustrates the basic image setup used for planning and consultation. We normally use the left image for this purpose because that places the profile closest to the middle of the screen which, from our previous data, has less distortion than the periphery.

Simulation of surgical movements are accomplished by using the movement features of the software programs. Figure 4 demonstrates the various steps for a patient with class III malocclusion and mandibular prognathism. This patient has already been dentally decompensated in preparation for surgical mandibular reduction. She has a midface deficiency, with a round nasal tip and a mildly prominent nasal dorsum. Our functional goal is to correct the mandibular prognathism through posterior movement of the mandible. Surgically aesthetic options include some midface augmentation and the possibility of a rhinoplasty. Our consultation includes these options for consideration, and the imager is used to visually explain our proposals to the patient.

Patient Response

While video imaging offers the many advantages we have already discussed, many surgeons have expressed misgivings as to the potential problems created with an image that the patient may interpret as an implied guarantee of a treatment result. In an effort to evaluate patients' comparisons of video imaging with their surgical result, we asked 18 of our patients to respond to a questionnaire postoperatively. All patients were at least 4 months after surgery and were allowed to answer the question-
Table 2. Evaluation of Distortion With Three-Dimensional Objects With Various Magnifications and Means of Measurement

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<tr>
<th>Focal Length (mm)</th>
<th>Means of Measurement</th>
<th>Diameter of Left Sphere (mm)</th>
<th>Diameter of Middle Sphere (mm)</th>
<th>Diameter of Right Sphere (mm)</th>
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<tbody>
<tr>
<td>50</td>
<td>On monitor</td>
<td>49</td>
<td>44</td>
<td>47</td>
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<td>50</td>
<td>Orthographics</td>
<td>41.9</td>
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<tr>
<td>40</td>
<td>Orthographics</td>
<td>42.1</td>
<td>42</td>
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Orthographics after calibration adjustments available in the software.

Table 2 indicates that there was approximately 16.6% magnification of the left sphere, 4.7% magnification of the center sphere, and 11.9% of the right sphere with a focal length of 50 mm. Measurement of object size was very accurate when done through the Orthographics software.

The “move” icon in TIPS was also evaluated to determine whether the monitor and camera were responsible for the distortion or if the software was also a factor. An evaluation was necessary to see if distortion was incorporated when objects were moved in a “cut and paste” fashion to various areas of the monitor by the software. A sphere (42 mm diameter) was moved laterally left and right approximately 70 mm and measurements were made. Similar distances, magnifications, and means of measurement as in the previous tests were used.

The data in Table 3 indicate that distortion was seen when objects were moved to various areas of the monitor with options of the software. With our monitor, greater distortion was noted on the left side than the right, with both being significantly larger than the center image.

In order to be more specific as to where distortion was the greatest, a grid of 10-mm squares was captured at 7 feet with a focal length 40 mm (Fig 1). Measurements were made on three horizontal rows of the monitor (top, middle, and bottom). As noted in previous trials, distortion increased toward the periphery and was greatest on the left side of the monitor.

The results of these studies indicate that distortion associated with magnification increases toward the periphery of the monitor. However, measurement through Orthographics is not affected, because the system is able to compensate (with human error) for the distortion. The probable sources of distortion are primarily in the monitor and the video camera. Because the image is projected onto the curved screen of the monitor, distortion should be expected. One could speculate that the elongation might be corrected with the use of a flat-screened monitor. Unfortunately, such monitors are scarce and the cost is several times that of the curved screen monitor.

Distortion may also originate from the RGB camera and lens. As in the case of the monitor, a flatfield lens may decrease this problem, but it has the same drawbacks of availability and cost. It is expected that distortion would be further decreased if the telephoto adjustment could be further increased. Unfortunately, this would also require a greater camera to object distance.

Distortion produced by the software appears to be minimal. The amount of distortion produced by direct imaging was about the same as that produced by the cut and paste or modification of images.

While the distortion on the monitor with our system is notable, there does not appear to be a problem with Orthographics after calibration. The calibration adjustment is helpful in measuring and in

Table 3. Evaluation of Distortion Using “Move” Option

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Note. When the middle sphere was moved to various areas of the monitor in a cut and paste fashion, distortion was incorporated into the periphery of the monitor but was minimized in the Orthographics software.