3-D Guided Endoscopic Surgery of Paranasal Sinuses

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The endoscopic approach to surgery of paranasal sinuses has become the state-of-the-art treatment of chronic sinusitis.[1] A significant disadvantage of the common endoscope is its monocular (two-dimensional) view, as the depth of the sinus system must then be estimated primarily on operating experience and continuous training. A stereoendoscope, on the other hand, has significant advantages. A stereoendoscope can produce a three-dimensional image and thereby emulate the physiological process of vision. The surgeon, therefore, need no longer rely on operating experience to determine the depth of various structures.

In regard to this process, three components should be considered: (1) the interocular distance of the observer is different from individual to individual (average: 65 mm); (2) through the convergence of both eyes, a nearby object can be sharply focused; and (3) the accommodation accompanies convergence.

3-D ENDOSCOPES

Stereoendoscopes have been developed by various manufacturers in recent years. They consist, in principle, of the assemblage of two angled-lens systems with a common focus at a defined range (Fig. 1). For paranasal surgery, optimal 3-D effect generally ranges between 15 mm and 35 mm focal distance.

The endoscope should not exceed 4.5 mm in diameter. Stereoendoscopes with smaller diameters must overcome two technical problems. Firstly, the number of light-transmitting cables must be reduced, which results in poorer lighting of the surgical field. Secondly, the distance between the two optical channels is smaller. Unfortunately, the 3-D effect is better when the channels are farther apart.

For the transmission of images, a stereoendoscope must be equipped with two light-sensitive CCD cameras. The two parts of the endoscope, the optical portion and the camera portion, must fit together into a stable unit.

3-D DISPLAY

The critical area of 3-D technology is its display medium. A 100-Hz (120 Hz) television monitor is recommended, and it is an inexpensive, mobile sys-

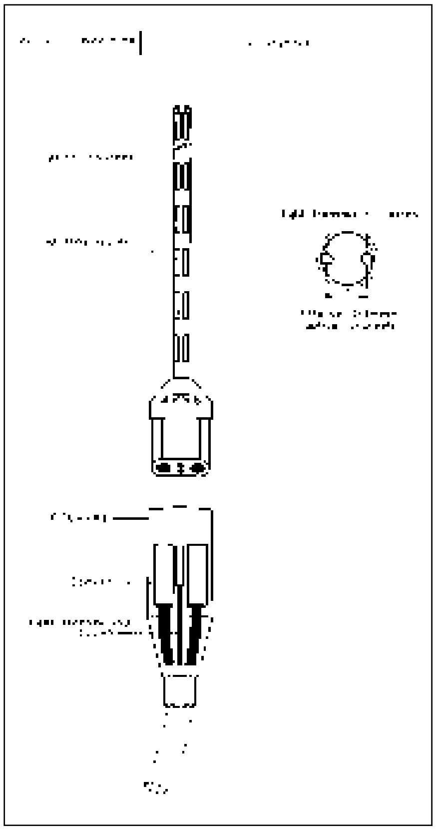

Figure 1. Schematic drawing of a 3-D endoscope. Note the two CCD cameras, two rod-lens systems, and the depth of (nearly) focused area.

tem. The sequential projection of right and left partial images on the monitor leads to stereoscopic vision when the view from the right and left eyes of the observer are similarly synchronized. The right eye must be allowed to see the monitor when the right channel is displayed, and the left eye must get a clear view only when the left channel is on the monitor. In other words, a stereoscopic impression relies on the sequential projection of the right and left partial images on the monitor. The view from the right and left eyes is controlled by an active shutter placed in front of the screen. This allows the surgeon and the scrub nurse to wear comfortable (passive) glasses, fitted with a circular polarization (Fig. 2).

CLINICAL EXPERIENCE

To obtain a high-quality 3-D image, the alignment of the two optical channels needs to be adjustable by electronic processing. Misalignment of the two optical images on the monitor, in both the horizontal and vertical planes, can be compensated by the surgeon only within narrow boundaries. Moreover, the color display of the two channels with regard to luminance (brightness) or chrominance (color) needs to be identical.

As a result of our experience with different stereoendoscopes, we recommend that the diameter of the 3-D endoscope not exceed 4.5 mm. Larger diameters frequently cause direct contact of one optical channel with the nasal walls. The result is the halving of the lux yield and suspension of the 3-D effect. Moreover, the danger of contamination by blood or secretion is also a function of the endoscope's diameter.

We performed more than 300 3-D surgeries of the paranasal sinuses (Fig. 3). These were routinely done under general anesthesia. Topical decongestion and controlled blood pressure reduction led to significant reduction of bleeding from the mucous membranes. The endoscopes were used in combination with self-holding specula. This arrangement is advantageous in widening the surgical space and in reducing lens contamination. A self-holding endoscope frees the surgeon to perform the surgery with both hands.

The operations performed included

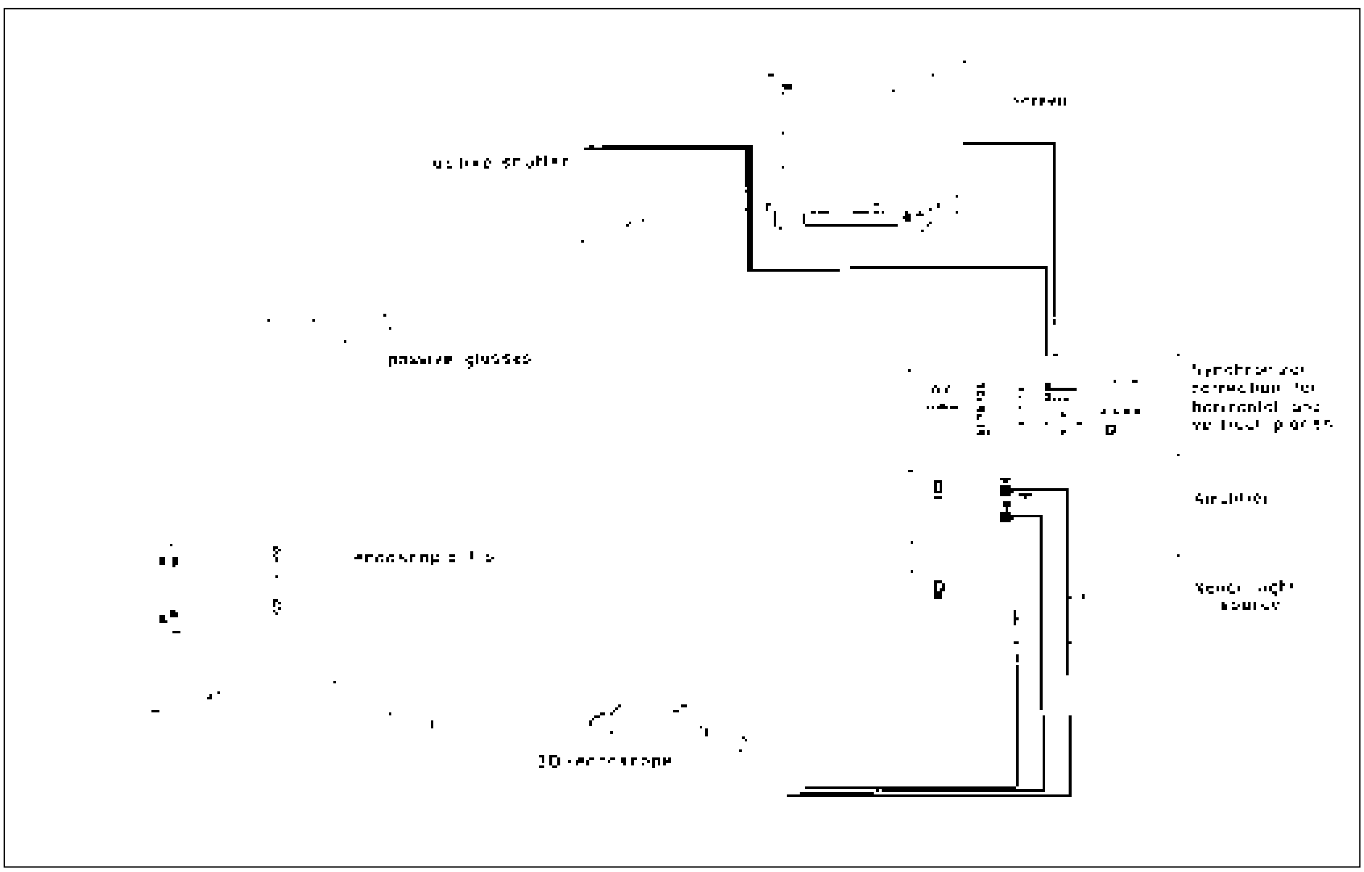

Figure 2. Schematic drawing of the 3-D display consisting of a 100-Hz screen (fitted with an active shutter), amplifier, and a synchronizer (fitted with settings for horizontal and vertical correction). Note the tip of the 0° and 30° 3-D endoscopes.

Figure 3. 3-D display in the operating room.

simple opening and enlargement of the infundibulum, similar to the surgery developed by Messerklinger and Stammberger. Moreover, complete resection of the ethmoid sinus and functional surgery of the sphenoid and maxillary sinus were routinely performed with the aid of the 3-D endoscope. Both 0° and 30° endoscopes were used. The 0° endoscope is of superior quality because it better illuminates the opened cavities.

However the optical quality of the endoscope depends greatly on the definition of the CCD cameras. This definition is the limiting factor in paranasal surgery with regard to accurate location and identification of anatomical structures. Significant improvements in 3-D endoscopic surgery of the paranasal sinuses will be based on improvements in camera definition.

Nonetheless, the author foresees a great future for 3-D surgery. Advantages include the natural physiological and, therefore, relaxed vision of the operating physican and, notably, the increased safety of the operation resulting from the return of depth perception. STI

REFERENCE

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