Intraoperative acquisition of three-dimensional imaging for frameless stereotactic guidance during transsphenoidal pituitary surgery using the Arcadis Orbic System

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Object. Intraoperative fluoroscopy has long been used for anatomical localization in transsphenoidal pituitary surgery. More recently, frameless stereotaxy has been used to supplement 2D sagittal radiographs with 3D multiplanar reconstructions. Use of Arcadis Orbic allows both conventional fluoroscopic views and multiplanar reconstructions to be acquired intraoperatively without need for preoperative planning studies. The authors report their initial experience using Arcadis Orbic during transsphenoidal pituitary surgery.

Methods. To test the system, the authors placed a dehydrated human skull in a radiolucent head holder, and obtained standard 2D fluoroscopic images of the skull base and sella turcica. Arcadis Orbic was then used with frameless stereotaxy to register 3D multiplanar reconstructed images of skull base anatomy. The authors then used Arcadis Orbic in 26 transsphenoidal pituitary tumor resections and compared image quality, accuracy, and ease-of-use to standard techniques.

Results. Arcadis Orbic 2D fluoroscopic images matched or exceeded the quality of images acquired by standard C-arm machines. Arcadis Orbic multiplanar reconstructions provided excellent images of the skull base when compared with preoperative Stealth computed tomography (CT) studies. Intraoperative frameless stereotactic navigation using Arcadis Orbic was highly accurate and more reliable than registering preoperative CT images.

Conclusions. Arcadis Orbic provides excellent quality 2- and 3D images during transsphenoidal pituitary surgery, and intraoperative frameless navigation using these images is highly accurate. Arcadis Orbic is easy to use, even in patients with large body habitus, and image acquisition takes no longer than registration during a frameless stereotactic case. Based upon our preliminary experience, Arcadis Orbic precludes the need for preoperative CT studies in patients with pituitary lesions requiring frameless stereotactic navigation. (DOI: 10.3171/JNS/2008/108/4/0746)

KEY WORDS • intraoperative imaging • pituitary tumor • transsphenoidal approach

TRANSPHENOIdAL surgery for pituitary tumor resection presents challenges in localizing the sphenoid sinus, sella, and the pituitary tumor itself. Neurosurgeons have used a variety of techniques, including fluoroscopy, endoscopy, and frameless stereotaxy to optimize visualization during the transsphenoidal approach.¹,4–6,10,11,14 We use lateral fluoroscopy for every transsphenoidal surgery case and routinely use the Stealth (Medtronic Sofamor Danek) frameless stereotactic technology when dealing with microadenomas and for recurrent tumor operations.

Arcadis Orbic (Siemens Medical Solutions) technology allows both conventional fluoroscopic views and multiplanar reconstructions to be acquired intraoperatively, and in combination with the Stealth station, these “CT” images can be used for intraoperative guidance.

Arcadis Orbic technology was initially developed for dental imaging and has been commercially available since the 1990s. Neurosurgically, Arcadis Orbic has been used primarily to confirm hardware placement in spine cases.⁸,⁹ We believe that Arcadis Orbic technology has proven to be very useful during transsphenoidal pituitary surgery as well.

Clinical Materials and Methods

We first tested the Arcadis Orbic machine on a dehydrated human skull placed in a radiolucent head holder (Fig. 1). We obtained standard lateral fluoroscopic images of the sella turcica and skull base to determine if we could adequately visualize these structures using new equipment compared with our standard protocol (Fig. 2). We then used the Arcadis Orbic in combination with Stealth frameless stereotaxy to determine if the clarity of “CT” images acquired using the Arcadis Orbic machine were sufficient to justify its use during transsphenoidal surgery (Fig. 3). Since these images compared favorably with conventionally obtained Stealth CT scans, we used Arcadis Orbic technology during 26 transsphenoidal pituitary tumor resections using the transnasal microscopic approach. Each of the 26 operations was for either recurrent tumor or microadenoma; we prefer image-guidance for such cases, given their potential difficulty in terms of anatomy and localizing the tumor. Institutional review board approval was obtained to

Abbreviation used in this paper: CT = computed tomography.
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Using the radiolucent head holder did not alter our standard patient positioning. Arcadis Orbic 2D fluoroscopic images matched or exceeded the quality of images acquired by standard C-arm machines (Fig. 2), and visualization of the sella turcica and skull base was excellent using the 2D capability of the Arcadis Orbic machine. Similarly, when used in concert with Stealth technology, multiplanar reconstructed “CT” images of the dehydrated skull obtained by the Arcadis Orbic machine were excellent (Fig. 3).

After only a few cases, setting up the equipment did not add any significant time to the operation (Fig. 4). In fact, when compared with registering a preoperative Stealth scan, using the Arcadis Orbic machine took less time. After initial assistance from the Siemens representative, our radiology technologists have been running the system independently.

Intraoperative Arcadis Orbic multiplanar reconstructions provided excellent views of the osseous anatomy of the skull base when compared with conventional preoperative Stealth CT studies (Fig. 5). Frameless stereotactic navigation using Arcadis Orbic technology was highly accurate, and, in fact, we found it to be more reliable than registering preoperative CT images. There were no complications related to the use of Arcadis Orbic technology, and we did not need to resort to conventional CT imaging of the skull base in any case.

Discussion

In 1957, French neurosurgeon Gerard Guiot began to retrospectively review the records of patients who underwent transsphenoidal surgery with intraoperative use of the Arcadis Orbic system.

Results

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![Fig. 1. Photograph of a dehydrated human skull in a radiolucent head holder, used for initial testing of Arcadis Orbic equipment.](image1.jpg)

![Fig. 2. Fluoroscopic 2D view of the dehydrated human skull using the Arcadis Orbic machine.](image2.jpg)
supplement his direct vision of the sella with intraoperative fluoroscopy. Jules Hardy of Montreal, a fellow of Dr. Guiot, expanded on Guiot’s use of intraoperative fluoroscopy, evaluated pituitary tumors with preoperative angiograms, routinely used intraoperative air encephalograms, and first used the operating microscope in transsphenoidal operations.

For experienced surgeons, the use of lateral fluoroscopy to identify the appropriate trajectory through the sphenoid sinus to the sella and pituitary is often sufficient for safe exposure. This method provides an anatomical view in the sagittal plane only, however, and one of the major risks of the transsphenoidal approach is venturing too far laterally and injuring the carotid artery. Some pituitary surgeons do not use any intraoperative imaging or rely on the endoscope for anatomical localization.

The development of frameless stereotaxy over the past decade and its use in combination with fluoroscopy helps the surgeon stay safely in the midline. Intraoperative frameless navigation is also useful in the localization and resection of microadenomas when the sella is of normal size. Frameless navigation during transsphenoidal surgery has been shown in multiple studies to be safe, accurate, and applicable with only minimal additional cost and time requirements. We, and others, especially advocate the use of frameless stereotaxy in recurrent tumor surgery.

Arcadis Orbic technology is another recent addition to the intraoperative imaging armamentarium. The use of Arcadis Orbic allows both conventional fluoroscopic views and multiplanar reconstructions to be acquired during the operation. With Arcadis Orbic, multiple short-exposure fluoroscopic radiographs obtained around an isometric point in space are converted to 3D CT-quality multiplanar reconstructions. By directly importing this data into a frameless system such as Stealth, these “CT” images can be used for intraoperative guidance. No preoperative planning studies are required, and patients are exposed to 80% less radiation than during a standard CT scan (Siemens, unpublished data). This entire image acquisition procedure can be repeated under sterile conditions during the surgical procedure, if needed.

Arcadis Orbic technology was initially developed for dental imaging and has been commercially available since the 1990s. Two papers in the craniofacial literature show, using a dehydrated skull, that Arcadis Orbic is suitable for imaging of the face. Neurosurgically, Arcadis Orbic has been primarily used to confirm hardware placement in

Fig. 3. Coronal (left) and sagittal (right) 3D multiplanar reconstructions obtained using Arcadis Orbic technology combined with Stealth frameless stereotaxy on a dehydrated human skull.

Fig. 4. Intraoperative setup of the Arcadis Orbic machine.
spine cases. Because of the ability of the system to obtain lateral fluoroscopic views, something we use in every transsphenoidal procedure, and multiplanar CT-quality reconstructions, which we use during repeated surgery and for microadenomas, we reasoned that Arcadis Orbic technology would be highly useful during transsphenoidal pituitary approaches.

Arcadis Orbic technology works quite well during transsphenoidal pituitary surgery for a number of reasons. First, it is easy to use. During our initial series of 20 cases in which we used Arcadis Orbic, we had no technical malfunctions with the machine. Setup is essentially identical to the standard fluoroscopic C-arm, with the exception that there must be enough room for the Arcadis Orbic to rotate around the patient. Initially, a Siemens’ representative and x-ray technician were present for each case; after a half dozen cases, we and our institutional technicians were comfortable running the machine independently.

Second, the quality of the images, both 2- and 3D, obtained using Arcadis Orbic was excellent. When we used the Arcadis Orbic machine to obtain standard sagittal views, the images were identical to, if not slightly improved over, those obtained using our standard fluoroscopic unit. With respect to 3D multiplanar reconstructions, we were initially concerned that the Arcadis Orbic’s primary ability to image osseous structures would be more affected by the soft tissues of the human head during surgery than standard CT would be. Based upon our initial results using the dehydrated skull and the excellent 3D images we obtained during testing, however, we felt confident using this technology during pituitary tumor resection. Intraoperatively, the multiplanar reconstructions obtained using Arcadis Orbic were excellent. In this series, we were never forced to stop an operation or convert to the standard Stealth system because of poor 3D Arcadis Orbic imaging. We found the images obtained using Arcadis Orbic to be highly consistent throughout our series. Arcadis Orbic may be used in obese patients without compromising image quality as long as the rotational component of the machine has sufficient clearance to rotate around the patient.

Third, using the Arcadis Orbic system does not add time or inconvenience to a transsphenoidal pituitary tumor resection. When compared with the setup of a traditional frameless stereotaxy case, using the Arcadis Orbic machine is faster.

Most importantly, using Arcadis Orbic does not compromise patient safety, and we did not experience any complications related to Arcadis Orbic use.

For all of these reasons, we now use Arcadis Orbic as our standard when frameless stereotaxy is required during a transsphenoidal procedure. Patients appreciate the fact that an additional visit to the hospital for a preoperative Stealth CT scan is no longer required.

It should be emphasized that this system generates 3D images of the osseous anatomy to assist in locating the midline, but does not show soft tissue and cannot identify residual tumor. If the extent of soft tissue is critical, either a preoperative magnetic resonance imaging study for neuronavigation or intraoperative magnetic resonance imaging is necessary.

Conclusions

Arcadis Orbic technology provides excellent 2- and 3D views of the osseous anatomy relevant to transsphenoidal pituitary surgery. Use of Arcadis Orbic along with stereotactic systems such as Stealth allows highly accurate intraoperative navigation, especially in cases of recurrent tumors and for microadenomas. Images are easy to acquire intraoperatively, and patients experience less radiation than with a standard preoperative planning CT scan. In our experience, Arcadis Orbic precludes the need for preoperative CT studies in patients with pituitary lesions requiring frameless stereotactic navigation.

Disclaimer

None of the authors has any financial interest in any device discussed in this paper.

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