# Endoscopic Endonasal Transsphenoidal Surgery using a Skull Reference Array and Laser Surface Scanning

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- pituitary surgery
- endoscopic surgery
- laser surface scanning

## Abstract

Lesions of the skull base are increasingly being resected via the endoscopic, endonasal, transphenoidal approach. We have successfully treated 33 consecutive patients with pituitary lesions using this technique in combination with BrainLAB skull reference array and laser surface scanning for surgical navigation. This technique affords several advantages over neuronavigation based on adhesive-mounted fiducial registration. Rigid fixation in a Mayfield clamp is not required, which allows for flexibility with respect to positioning of the head during the procedure. This is particularly important as extension and flexion of the head provide greater exposure to the clivus and anterior skull base respectively. Also, this technique obviates the need for additional preoperative MRI, thereby reducing cost and delays.

## Introduction

The entirely endoscopic endonasal approach to lesions of the skull base is increasingly being used by neurosurgeons [1,2,5–7]. Numerous reports describe neuronavigation as a useful adjunct to endoscopic endonasal transsphenoidal pituitary surgery [4,6]. For accuracy of the surgical navigation system, registration is often done with adhesive-mounted fiducials. Although this method is widely used, artificial fiducials remain cumbersome and often require an additional preoperative magnetic resonance image (MRI), which is not always cost effective [3]. Surgery often entails immobilization of the head by use of a Mayfield clamp which limits any movement of the head during endonasal surgery. The new skull reference array allows for free movement of the patient's head during the procedure, which may be helpful for exposure of lesions of the skull base.

Because previous studies have shown the target localization error (LE) was smallest and application accuracy was highest for lesions located frontally [3], we hypothesized that the new BrainLAB skull reference array when combined with laser surface scanning would be ideal for endoscopic endonasal transsphenoidal skull base surgery. Herein, we report our clinical experience with this technique and show it to be an accurate, safe, and easy-to-use method of neuronavigation and registration for endoscopic endonasal transsphenoidal surgery.

## Patients and Methods

### Patient population

This prospective study included 33 consecutive patients with different sellar or suprasellar pathologies including 27 pituitary tumors, 3 Rathke cleft cysts, and 3 craniopharyngiomas. There were 19 males and 14 female patients ranging in age from 20–82 (mean: 51) years.

### Skull fixation, laser surface registration and application accuracy

Image-guided surgery was performed by use of a passive infrared VectorVision surgical navigation system (BrainLAB®, Heimstetten, Germany). All surgical procedures were performed with the patient under general anesthesia. The patient was positioned supine on a doughnut with the head in slight extension. The BrainLAB® bone anchored reference star was then affixed to the patient using a scalpel and the self-taping screw that was inserted through the three-point anchor (**Fig. 1**). The reference array was placed on the patient's left frontal-temporal area behind the hairline and in view of the Polaris camera system

**Bibliography**
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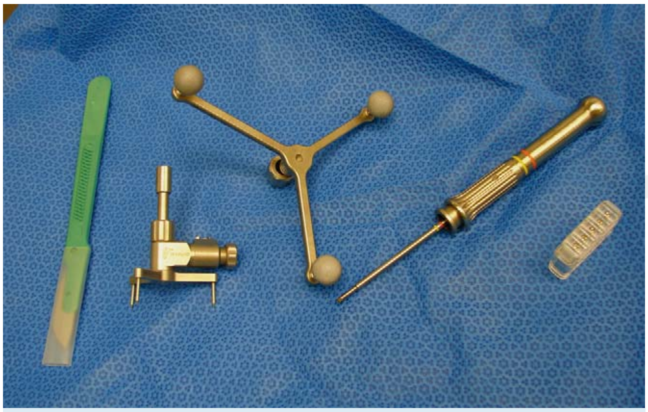

**Fig. 1** Skull reference array set. The materials required include (from left to right) a scalpel to nick the scalp, the three-point skull anchor, the star navigation receiver with balls, a screwdriver, and scalp screws.

**Fig. 2** Scalp insertion of reference array. After a nick incision is made in the scalp, the reference array is inserted into the left frontal (says "frontal temporal" in body of text for this reference) area behind the hairline, and affixed to the scalp with the screwdriver inserted through the three-point anchor.

**Fig. 3** Intraoperative positioning and referencing points. The patient is positioned on a doughnut with the star receiver facing the BrainLAB camera. Z-touch® is used to reference points around the eyes and brow in this position. All adhesive tape is removed from the eyes prior to laser surface scanning

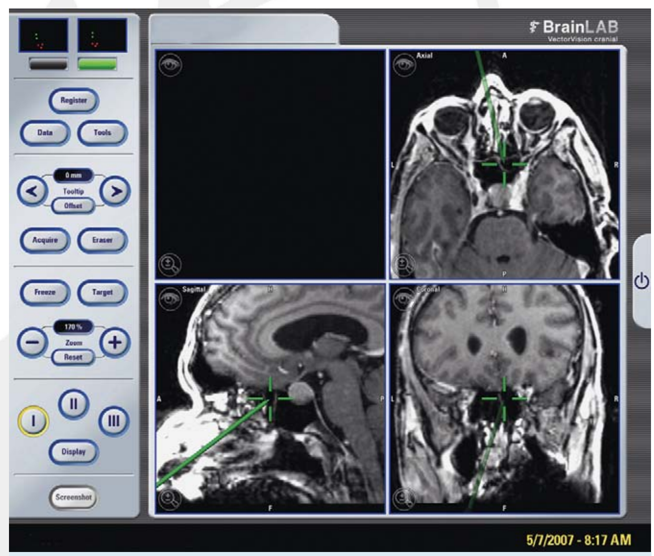


**Fig. 4** Flexion of the head and planum sphenoidal exposure. Movement of the head in flexion during the operation can increase exposure of the anterior skull base (green arrow).

(Northern Digital, Waterloo, ON, Canada; ▶ **Fig. 2**). Three support pins anchor in the skin to prevent rotation of the array. During evaluation of laser surface registration, the preoperative images usually were acquired with skin fiducials. Although this is not necessary for laser surface registration, we had both fiducials and laser surface registration ready for use to eliminate the potential risk for registration failure. The Z-touch® laser device is a commercially available non-contact digitizer for matching the coordinate systems of the surgical field and the three-dimensional imaging data [3]. The laser emits a visible laser beam, which appears as a red point on the skin of the patient for planning and guidance. The laser beam is visible to the camera. This infrared laser pointer allows the BrainLAB® VectorVision Image-Guided Surgery System to utilize the surface anatomy of the patient's face and head to calculate an advanced surface-matching algorithm. After attaching the reference star to the patient and before draping, the surgeon simply 'Z-touches' the patient by 'virtually' scanning the surface of the patients face and/or head (▶ **Fig. 3**). Typical target areas for laser surface scanning are the nasion, forehead, medial, superior and lateral rim of the orbita. We avoided areas of hair or mobile skin and the eye, eyelid and eyebrows were spared. Because the target areas for collecting surface points with the laser are situated frontally, there is increasing accuracy for lesions of the anterior skull base. To further minimize our LE, we obtained four additional points with our pointer. We used the lateral and medial canthus bilaterally as additional points for our registration. Once laser scanning was completed, the patient was registered within seconds. The endoscope, suction or pointer was used as an intraoperative navigation tool. The head of the patient was flexed, extended or rotated freely during surgery without losing navigational accuracy. Flexion allowed for exposure of the anterior skull base and extension allowed increased exposure of the clivus (▶ **Fig. 4**). To test "true" application accuracy, we used three landmarks that were not involved in the registration procedure. Application accuracy or LE was assessed by placing the pointer on the patient and measuring the distance to the image for the tip of the nose, the nasion, and the right tragus.

## Results

The time required to place the skull reference array ranged from 3–12 minutes. In one case, excessive scalp bleeding required pressure application. There was no technical failure and laser surface registration was successful in all cases. Because of the basal frontal location of all lesions, the calculated registration error calculated by the computer was "good" or better in all cases. The LE or application accuracy as determined by our additional three landmarks was less than 3 mm in all cases. Intraoperative accuracy in all cases was excellent. Removal of the skull reference array was uncomplicated in all cases.

## Discussion

The BrainLAB® skull reference array and laser surface scanner's utility in endoscopic endonasal transsphenoidal surgery has not been previously reported. Because of the frontal basal location of sellar lesions, this surgery is ideal for use of the array and laser surface scanner. A small LE within the surgical field is paramount in pituitary surgery to avoid vascular structures and the optic apparatus. Therefore, it is a fundamental requirement not to rely only on the computer's registration error but to check application accuracy before starting image-guided pituitary surgery. Although previous reports have shown that laser surface scanning is less accurate than adhesive fiducial registration [8, 9], we used a method to allow for the acquisition of additional surface points by use of the pointer. We acquired four additional points in the frontal region and this contributed to our high application accuracy. Two points to remember when performing laser surface scanning are to avoid skin movement in the scanning target areas and to remove any adhesive tape covering the eyes. By performing laser surface scanning we can eliminate preoperative MRIs solely for the use of fiducial registration. This reduces cost and conserves time and resources. Additionally, patients and physicians will not have to worry about losing fiducials prior to successful registration.

Affixing the head with the skull reference array instead of the Mayfield clamp requires only one point of fixation and is of little risk to the patient. The benefit of this tool is that the head can remain positioned on a doughnut in slight extension. Depending on the location of the lesion, the head can be extended, flexed or rotated during the course of the procedure to facilitate exposure of lesions of the cranial base. This will allow surgeons to not rely on a fixed angle of inclination as one approaches the lesion of interest.

## Conclusion

Use of the BrainLAB® skull reference array and Z-touch® offers several advantages to the surgeon. The skull reference array allows stable patient referencing without three-point skull fixation. This enables greater surgeon flexibility and comfort with respect to patient head movement and dynamic tracking during the procedure. This is especially important during endoscopic endonasal surgery as extension of the head can allow for increased exposure of the clivus and flexion can allow for visualization of the anterior skull base. The unprecedented speed at which Z-touch® registers patient landmarks provides increased scheduling flexibility and simplifies the process of diagnostic examinations as patients no longer require same day fiducial-based MRI before surgery. Because Z-touch® registers CT/MR images without headsets, diagnostic re-scans taken simply for registration purposes can be avoided, helping to reduce costs and delays. We have successfully used the new BrainLAB® skull reference array and Z-touch® for endoscopic endonasal transsphenoidal surgery and have found it accurate and fast while preserving the ability to move the patient's head during the procedure.

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