Endoscopic Anterior Skull Base Surgery: Intraoperative Considerations of the Crista Galli

John M. Lee, M.D., F.R.C.S.C.,¹ Evan Ransom, M.D.,² John Y.K. Lee, M.D.,³ James N. Palmer, M.D.,⁴ and Alexander G. Chiu, M.D.⁴

ABSTRACT

We sought to measure the anatomic dimensions of the crista galli in a consecutive series of patients undergoing the endoscopic transcribriform approach for anterior skull base tumors at a tertiary academic university hospital. We performed a retrospective chart review of patients undergoing purely endoscopic transcribriform surgery for sinonasal and skull base lesions. Main outcome measures included radiological dimensions of the crista galli. A total of 12 patients were identified and treated by the senior authors at the University of Pennsylvania. The average crista galli dimensions were 12.7 ± 2.4 mm (anterior-posterior) and 12.9 ± 2.5 mm (cranial-caudal dimension). Knowledge of the dimensions of the crista galli is important in preoperative planning for both instrumentation and access.

KEYWORDS: Endoscopic skull base surgery, transcribriform, crista galli, radiology, anatomy

Over the last decade, the scope of endoscopic sinus surgery has continued to grow, expanding to address tumors of the anterior cranial base. Multiple modules or approaches have been described to provide direct access to various skull base pathologies.^{1,2} Considered to be one of the more advanced techniques, the endoscopic transcribriform approach is the standard corridor when performing an endoscopic craniofacial resection for malignant etiologies of the sinonasal tract.^{3,4} The anterior limit of bone removal during this procedure is marked by the anatomic boundary of the crista galli along with the posterior table of the frontal sinus. In addition to being the thickest portion of the

cribriform plate, the crista galli's pyramidal structure and attachments to the falx cerebri enhance the difficulty of obtaining adequate dural and intracranial access in this region. These concerns have important implications in both instrumentation and access as further evolution continues in endoscopic transnasal intracranial surgery. Thus, the goal of this study was to perform a radiological anatomic analysis of the dimensions of the crista galli in a consecutive series of patients undergoing purely endoscopic transcribriform surgery for anterior skull base tumors. In addition, we measured the crista galli in a series of patients undergoing endoscopic sinus surgery for inflammatory disease as a comparison group

¹Department of Otolaryngology–Head & Neck Surgery, University of Toronto, St. Michael's Hospital, Toronto, Ontario, Canada; Departments of ²Otorhinolaryngology–Head and Neck Surgery and, ³Neurosurgery, and ⁴Division of Rhinology, Department of Otorhinolaryngology–Head and Neck Surgery, University of Pennsylvania Health System, Philadelphia, Pennsylvania.

Address for correspondence and reprint requests: John M. Lee, M.D., F.R.C.S.C., Department of Otolaryngology–Head & Neck Surgery, University of Toronto, St. Michael's Hospital, 30 Bond

Street, 8C-118 Toronto, Ontario M5B 1W8, Canada (e-mail: jlee.ut@gmail.com).

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Figure 1 Radiological anatomic measurements of the crista galli.

to account for any bony erosion secondary to tumor pathology.

METHODS

This was a retrospective chart review of consecutive patients who underwent purely endoscopic transcribri-form surgery for skull base lesions with dural involvement and/or intracranial extension between 2005 and 2009 by the senior authors at the Hospital of the University of Pennsylvania. Clinical details including sinonasal pathology were recorded from patient records.

For measurements of the crista galli, preoperative image guidance computed tomography scans of the maxillofacial region for each patient were loaded into a BrainLab iPlan computer station (BrainLab AG, Feldkirchen, Germany). Sagittal reconstruction images were then reviewed and the slice with the maximal anterior-posterior (A-P) and cranial-caudal (C-C) dimensions of the crista galli was identified (Fig. 1). The iPlan measurement tool was then used to record these dimensions of the crista galli. A single author (J.M.L.) performed all measurements for consistency. For comparison, crista galli measurements were also taken from a randomly selected series of patients undergoing endoscopic sinus surgery for inflammatory disease during the same time period as the transcribri-form patients. Student *t* test was used to compare the mean A-P and C-C lengths of the crista galli for each subgroup. Statistical analyses were performed using Microsoft Windows Excel (Microsoft Corporation, Seattle, WA).

RESULTS

A total of 12 patients were identified and treated by the senior authors at the University of Pennsylvania between 2005 and 2009. Eleven patients (91.7%) had malignant etiologies with only one patient having a benign skull base tumor. The most common etiology was esthesioneuroblastoma followed by adenocarcinoma. The spectrum of pathologies is shown in Table 1. Complete resection with negative dural margins was accomplished in all patients via the endoscopic transcribri-form approach.

With regards to the radioanatomic analysis of the crista galli, the average A-P dimension was 12.7 ± 2.4 mm (range: 8.8 to 16.8 mm), and the average C-C length was 12.9 ± 2.5 mm (range: 9.1 to 16.3 mm).

Table 1 Anterior Skull Base Pathologies

Patient	Pathology
1	Adenoid cystic carcinoma
2	Adenocarcinoma
3	Esthesioneuroblastoma
4	Mucosal melanoma
5	Adenocarcinoma
6	Teratocarcinoma
7	Sinonasal undifferentiated carcinoma
8	Esthesioneuroblastoma
9	Schwannoma
10	Esthesioneuroblastoma
11	Esthesioneuroblastoma
12	Esthesioneuroblastoma

Table 2 Crista Galli Measurements

	Patients Undergoing Transcribriiform Approach for Skull Base Tumors	Patients Undergoing Endoscopic Sinus Surgery for Inflammatory Disease	p Value
Crista galli anterior-posterior dimension (mm)	12.7 ± 2.4	14.8 ± 2.8	0.10
Crista galli cranial-caudal dimension (mm)	12.9 ± 2.5	13.9 ± 2.4	0.33

in this series of patients undergoing the endoscopic transcribriiform approach. In a cohort of 12 patients undergoing endoscopic sinus surgery for inflammatory disease, the crista galli dimensions were 14.8 ± 2.8 mm (A-P) and 13.9 ± 2.4 mm (C-C), respectively. There was no statistically significant difference in the crista galli dimensions between these two groups of patients (see Table 2).

DISCUSSION

During the growth of endoscopic sinus surgery, numerous studies were performed to measure various anatomic landmarks of the sinonasal cavity. These included the height of the ethmoid roof, the location of the anterior ethmoidal artery, the diameter of the frontal recess, as well as pneumatization of the sphenoid sinus.⁵⁻¹⁰ All of these studies contributed to the knowledge and understanding of the sinonasal cavity, helping endoscopic surgeons safely navigate the paranasal sinuses. As endoscopic surgery has expanded to the skull base and intracranial cavity, new landmarks and anatomic boundaries are encountered. One such structure that is critical in obtaining surgical access in the anterior skull base is the crista galli.

This is the first radiological anatomic study specifically measuring the dimensions of the crista galli in a series of patients undergoing the endoscopic transcribriiform approach. In this series, we found that the mean A-P and C-C lengths of the crista galli were 12.7 mm and 12.9 mm, respectively. Although there was no radiological evidence of bony erosion in the crista galli from tumor, we also performed measurements in a series of patients undergoing endoscopic sinus surgery for inflammatory disease to assess for any possible variability. These crista galli dimensions were not statistically significantly different from those patients who underwent transcribriiform surgery.

The importance of the crista galli is rooted in the location and shape of this anatomic structure. In Latin, *crista galli* translates into “crest of the cock,” which gives an accurate depiction of its three-dimensional pyramidal shape. It projects superiorly into the intracranial cavity from the cribriform plate of the ethmoid bone and has several key relationships. The most important is the attachment of the falx cerebri, the fold of dura mater that divides the right and left

cerebral hemispheres.¹¹ As a consequence of this attachment and the shape of the crista galli, the dura in this region is tented superiorly, creating an invagination of dura folding away from the sinonasal cavity.

Surgically, this has important implications in the transcribriiform approach, especially when treating malignant tumors with intracranial extension. To mobilize the dura in this region, a portion of the crista galli must be removed such that its attachment to the falx cerebri can be divided. It is through this maneuver that the dura is no longer “tented” away from the surgeon, thus permitting safe and adequate dural incisions.⁴ In our experience, the safest way to remove the bony crista galli is with the use of an angled irrigating, diamond burr under endoscopic visualization (Fig. 2). Intraoperatively, we often remarked on how superior the crista galli extended, and this ultimately piqued our interest in the dimensions of this bony structure. Certainly, the extent of crista galli removal depends on the anterior and superior extent of the intracranial pathology. However, as this study has shown, the mean C-C length of the crista galli is almost 13 mm and the maximum height in one patient was 16.3 mm. This vertical thickness is significant especially if one considers that much of the anterior ethmoid skull base is only a few millimeters thick. We certainly feel that having the appropriate length and angle of drill bit is important in safe crista galli removal.

A second important anatomic relationship of the crista galli is its relative proximity to the superior sagittal sinus. This venous sinus is formed in between

Figure 2 Endoscopic view of drilling the crista galli.

the upper edges of the falx cerebri as it attaches to the sagittal groove on the inner aspect of the cranial vault. Because the falx cerebri has attachments to the crista galli, the superior sagittal sinus can begin just anterior to the crista before it continues along the inner aspect of the bony skull.¹¹ Given this location, there is a potential risk of significant vascular injury if one ventures beyond the anterior, superior limit of the crista galli with a powered instrument. This type of venous injury would be complicated by the fact that the cribriform plate is a difficult region to pack or tamponade. In our series of patients, there were no major intraoperative vascular injuries and there are no case reports of superior sagittal sinus injury with this type of endoscopic approach. However, as the limits of endoscopic intracranial surgery continue to be expanded, appreciating the dimensions of the crista galli preoperatively may be a useful guide to avoid such injury.

CONCLUSION

The growth of endoscopic skull base surgery has required a new understanding of anatomic landmarks within the intracranial cavity. One such structure is the crista galli, an important surgical boundary when performing the endoscopic transcribriform approach. To the best of our knowledge, this is the first radiological anatomic study describing the dimensions of the crista galli. Given its location and its surrounding attachments, having an appreciation of the length and height of this bony structure may have important implications for both instrumentation and safe dural access.

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