Radiological “Teddy Bear” Sign on CT Imaging to Aid Internal Carotid Artery Localization in Transsphenoidal Pituitary and Anterior Skull Base Surgery

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Abstract

Objectives Internal carotid artery (ICA) injury remains a rare but potentially fatal complication of transsphenoidal pituitary or anterior skull base surgery. Preoperative imaging must be scrutinized to minimize risk. On axial computed tomography (CT), the protrusions of the ICAs into the sphenoid resemble a “teddy bear.” This article aims to describe the sign, its grading system (0–2) and quantify its presence.

Design Retrospective review of preoperative CT imaging.

Setting Tertiary referral center in the United Kingdom.

Participants One hundred patients who underwent endoscopic transsphenoidal surgery for pituitary disease were enrolled.

Main Outcome Measure The presence and grading of the “teddy bear” sign were assessed on preoperative CT imaging.

Results A grade 2 (strongly positive) “teddy bear” sign was identified in 40% at the level of the superior pituitary fossa, 78% at the inferior pituitary fossa, and 59% at the clivus. A grade 1 (intermediate) sign was seen in 23.5, 7.5, and 10% of cases, respectively. In 5% of cases, the sign was grade 0 at all levels—indicating poor intraoperative localization of the ICA.

Conclusion The “teddy bear” sign is a useful preoperative tool for identification of anatomy predisposing patients to a higher risk of ICA injury. Those patients who have an absent or grade 0 “teddy bear” sign require extra care to ensure intraoperative localization of the ICAs which may include the use of neuronavigation or a Doppler probe. A grade 2 sign predicts good intraoperative localization of the ICA intraoperatively to inform the safe lateral limit of sellar bone resection.

Keywords

- pituitary disease
- pituitary gland
- sella bone
- sphenoid sinus
- endoscopic
- paranasal
- sella turcica
- carotid artery
- internal

Introduction

Transsphenoidal pituitary surgery was originally pioneered in the early 1900s. Its popularity proliferated with the introduction of endoscopic transsphenoidal surgery in the 1990s.^{1,2} It is now the standard technique used to access

pathology in the pituitary gland and the anterior skull base and the approach offers adequate surgical access while remaining minimally invasive. As the method requires no skin incision or external craniotomy, this translates to fewer complications, less discomfort, and speedier recovery in comparison to a traditional external approach.^{3–9} However,

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cavernous segment internal carotid artery (ICA) injury is recognized as a rare but potentially fatal complication^{10–12} with an incidence of 0.5 to 3.8%.^{13–15} To minimize the risk of complication, it is crucial for the operating surgeon to scrutinize the preoperative imaging studies to identify the necessary landmarks and important structures surrounding the sella turcica, as well as any anatomical variant, which may potentially be problematic. Although intraoperative imaging may be used to facilitate safe delineation of relevant anatomy, it is expensive, time consuming, not always available,¹⁶ and may not be reliable.

Several studies in the literature have correlated cadaveric and imaging findings to identify bony landmarks and the normal course of the ICA during endoscopic transsphenoidal surgery;^{17–20} nevertheless, work describing the anatomical relationship between the parasellar ICA and pituitary illustrates the enormous variation in anatomy between the patients.^{21–23} An attempt to establish a formalized approach for facilitating safe transsphenoidal pituitary surgery by way of a radiological anatomical landmark checklist has been presented introducing the radiological “teddy bear” sign.²³ The presence of this sign identifies whether the junction between the sella and ICAs will be visible endoscopically when the pituitary is approached transsphenoidally. In this study, we introduce a grading system of the “teddy bear” sign that can facilitate safer transsphenoidal surgery.

The “Teddy Bear” Sign

During endoscopic transsphenoidal approaches to anterior skull base lesions, a window is created within the bony sella for access to the pituitary with the ICA as its lateral limits. At the level of the pituitary gland, the ICAs may produce protuberances on either side of the sella turcica into the sphenoid sinuses. Intraoperatively, the observation of the

carotid prominence is particularly useful when the bulge of the sella is present. When viewed together with the bony sella and dorsum sella on axial planes of computed tomography (CT) imaging, this constellation of structures resembles the outline of the head of a “teddy bear,” forming the radiological “teddy bear” sign. The bilateral ICAs represent the ears of the “teddy bear,” while the bony outline of the sella turcica on the posterior sphenoid wall appears as its head. When discerning the “teddy bear” sign, the junction where the “ears” meet the “head” of the “teddy bear” corresponds to the junction between the carotid artery and the pituitary (►Fig. 1).

“Teddy Bear” Sign Grading System

The radiological “teddy bear” sign is more readily visible in some cases than in others. As the angle increases between the sella bone and the protuberance of the ICA into the sphenoid, the “teddy bear” sign will also become more apparent (see ►Table 1). The “teddy bear” sign is most visible when the angle between the sella bone and the bulge of the carotid into the sphenoid is more than 45 degrees. The sign is less obvious, but still noticeable when this angle is less than 45 degrees (►Fig. 2).

Based on the earlier observations, the “teddy bear” sign can be classified as follows: (1) Grade 0: not visible, (2) Grade 1: angle deemed noticeable but less than 45 degrees, and (3) Grade 2: angle readily noticeable and is more than 45 degrees.

The presence and grading of the “teddy bear” sign were assessed on axial planes of CT imaging at three anatomical levels: the superior aspect of the pituitary gland, the inferior aspect of the pituitary gland, and at the level of the clivus (►Table 2). ►Fig. 3 illustrates a case where the “teddy bear” sign is grade 0.

Fig. 1 CT paranasal sinuses in the axial plane exhibiting a positive “teddy bear” sign along with corresponding endoscopic views showing protuberances of ICAs into the sphenoid on either side of the sella. The black lines show the lateral limit of sella bone removal just short of the junction between the ICAs and the sella. CT, computed tomography; ICA, internal carotid artery.

Table 1 Description of the "teddy bear" sign grading and corresponding visibility of ICA–sella junction at operation

Grade	Angle between ICA and sella	ICA–sella junction visible endoscopically?
0	No angle/minimal	Not visible
1	<45 deg	Visible
2	>45 deg	Readily visible

Abbreviation: ICA, internal carotid artery.

Method

A retrospective review was performed on preoperative CT sinus imaging studies of 100 adult patients who underwent endoscopic transsphenoidal surgery for pituitary disease at our institution (Royal Hallamshire Hospital, Sheffield, UK). Images were reviewed to assess the grading of the radiological "teddy bear" sign in the noncontrast axial CT sinus.

Results

Of the 100 patients enrolled, 53 were male and 47 were female. The mean age at the time of surgery was 57 years

Fig. 3 Example of bilateral Grade 0 "teddy bear" sign with absent protrusion of ICAs into the sphenoid sinus (axial CT sinus). CT, computed tomography; ICA, internal carotid artery.

Fig. 2 Schematic diagram of the "teddy bear" sign, illustrating the angle between the posterior wall of the sphenoid sinus in the transverse plane and where the carotid may bulge into the sphenoid. The blue curve represents Grade 2 "teddy bear" sign, where the angle is more than 45 degrees, the red curve demonstrates Grade 1 "teddy bear" sign, where the angle is less than 45 degrees but the sign is still visible, and the purple line demonstrates Grade 0 where there is no discernible angle between the carotid and the posterior wall of the sphenoid sinus in the transverse plane.

Table 2 Percentage of cases where Grades 2 to 0 "teddy bear" sign can be identified on axial planes of CT imaging at the levels of the superior aspect of the pituitary fossa, inferior aspect of the pituitary fossa, and the clivus

	Right	Left	Mean
Superior aspect of the pituitary fossa			
Grade 2: Angle more than 45 deg (%)	44	36	40
Grade 1: Angle less than 45 deg but visible (%)	21	26	23.5
Grade 0: No obvious angle (%)	35	38	36.5
Inferior aspect of the pituitary fossa			
Grade 2: Angle more than 45 deg (%)	78	78	78
Grade 1: Angle less than 45 deg but visible (%)	5	10	7.5
Grade 0: No obvious angle (%)	17	11	14
Level of the clivus			
Grade 2: Angle more than 45 deg (%)	65	53	59
Grade 1: Angle less than 45 deg but visible (%)	6	14	10
Grade 0: No obvious angle	29	33	31

Abbreviation: CT, computed tomography.

(range: 23–85 years). All images were assessed for the presence and grading of the radiological “teddy bear” sign (see ►Table 2).

Superior Aspect of the Pituitary Fossa

At the level of the superior aspect of the pituitary fossa, an average of 40% of CT images demonstrated the Grade 2 “teddy bear” sign where the angle between the sella and the carotid bulge was more than 45 degrees. The Grade 1 “teddy bear” sign was observed in 23.5% of images. There was no obvious angle between the posterior wall of the sphenoid and the ICA (Grade 0 “teddy bear” sign) in 36.5% of CT scans.

Inferior Aspect of Pituitary Fossa

At the level of the inferior aspect of the pituitary fossa, 78% of the CT scans reviewed demonstrated the Grade 2 “teddy bear” sign. The Grade 1 sign was recognized on only 7.5% of the images reviewed. Fourteen percent of scans showed no obvious angle between the sella and the carotid bulge.

Level of the Clivus

Finally at the level of the clivus, the Grade 2 “teddy bear” sign was discernible in 59% of CT scans. The Grade 1 sign was seen in 10% of images. Almost one-third, 31%, revealed no angle between the sella and the carotid bulge.

In 5% of cases, the teddy bear sign was “Grade 0” at all levels bilaterally. This comprised 2% of cases where there was no protrusion of the carotid into the sphenoid at any level and 3% of cases owing to tumor destruction of the sphenoid sinus.

In 90% of cases, there was a “Grade 2” sign visible at some level, either on the left or right. In 35% of cases, grading at both sides and all levels was “Grade 1” or “Grade 2” meaning that the carotid is visible throughout the sphenoid. In 16% of cases, “Grade 2” “teddy bear” sign was seen bilaterally at all levels. ►Fig. 4 illustrates the findings.

Discussion

The sphenoid sinus is surrounded by vital anatomical structures, injury to which may result in severe morbidity or

mortality.^{8,9,13–15} Although rates of injury to the ICAs are low, surgeons need to minimize these risks as far as possible to prevent significant complications. In the case where injury does occur, there is a mortality rate of 14% and a morbidity rate of 24%.^{14,24,25} Familiarity with the position of the ICAs within a limited surgical field is paramount for safe trans-sphenoidal surgery. This study describes the grading system of the radiological “teddy bear” sign to facilitate the localization of the ICAs during endoscopic approach to the pituitary.

Relevance of the “Teddy Bear” Sign

Existing studies have attempted to characterize the anatomical relationship between the ICA and the sphenoid^{26–28} along with their associated surgical implications. These have observed the potential importance of the carotid protuberance into the posterior sphenoid wall for surgical planning.^{26,27} In addition, they have attempted to quantify protrusion of neurovascular structures into the sinus^{21,27} defined as >50% of the diameter of a neurovascular structure protruding into the sphenoid. However, it is the authors’ opinion that this is not sensitive in discerning, the often visible ICA that does not protrude more than 50% of its diameter. Studies have shown that a reduced intercarotid distance indicates a higher risk procedure,^{22,29,30} but neglects to take into account individual alterations in anatomy that still mean that the bulge of the ICA is visible intraoperatively.

In the authors’ experience, the “teddy bear” sign is indeed sensitive enough to determine whether the prominences of the ICAs will be visible endoscopically within the sphenoid sinus. The most important aspect of whether the prominence of the carotid artery is visible is the angle that is formed between the sella and the protrusion of the carotid artery into the sinus as indicated by the “teddy bear” sign.

The advantage of the “teddy bear” sign is that it is a specific, quantifiable, and reproducible radiological sign that can be measured on axial CT cross-sections, providing useful information for clinical correlation intraoperatively. In its grading, it provides direction to surgeons on how high risk the procedure is, and advice on the use of intraoperative adjuncts for localization of the ICA.

The Importance of Identifying the Grade of “Teddy Bear” Sign

The higher the grade of the “teddy bear” sign, the more obvious the carotid protuberance on the posterior wall of the sphenoid will be in the endoscopic view. It is the authors’ experience that the presence of a Grade 2 “teddy bear” sign (obvious, with an angle of more than 45 degrees) is sensitive enough to determine whether the prominences of the ICAs will be visible endoscopically. This does not need any further adjunct to facilitate visualization. The data presented here reveal it is most likely to be visible at the inferior pituitary (78% of patients). A Grade 1 sign (visible, but angle less than 45 degrees) denotes where recognizing the carotids is likely but may be more technically challenging. This is most visible at the level of the superior pituitary (23.5% of patients). Thirty-five percent of patients were found to have a Grade 1

Fig. 4 The percentage visibility of the different grades of the “teddy bear” sign by anatomical levels on axial CT images. CT, computed tomography.

or 2 “teddy bear” sign at all three levels of the sphenoid, indicating that they will not require intraoperative adjuncts to visualize the ICAs. In the case of a Grade 0 sign (not noticeable), further adjuncts will likely be required which are discussed later. Most patients have a visible teddy bear sign at least unilaterally at some level (95%), but particular care needs to be taken with 5% of patients with a Grade 0 sign bilaterally at all three levels.

When There Is a Grade 0 “Teddy Bear” Sign

In the cases where patients have an absent or Grade 0 “teddy bear” sign, they may be at higher risk of intraoperative injury to the ICA and thereby potentially life-threatening consequences. In these instances, the surgeon should consider the use of other methods to improve localization of the ICAs intraoperatively. Other anatomical landmarks may help identify the junction between the sella and the ICAs such as the intersphenoid septation and other septations seen on the CT. The distance between the septation and the ICA may also be used. Popular adjuncts include neuronavigation or intraoperative imaging modalities of CT, magnetic resonance imaging (MRI), or ultrasound Doppler probes can be utilized to localize the ICA. In some cases, surgeons may choose to use instruments that may place less risk to injury of the ICA, such as microhook blades.¹⁴

Computer-guided neuronavigation is frequently employed in endoscopic sinus surgery. It allows detection and delineation of landmarks^{31,32} by way of a “three-dimensional roadmap” created from individual preoperative imaging. These “roadmaps” are usually extrapolated from CT images with the use of contrast, permitting localization of vascular structures such as the ICAs.³³ In addition, “roadmaps” can also be created from the fusion of both MRI and CT imaging for accurate identification of both bony and soft tissue structures.^{34,35}

There has been limited use of real-time intraoperative C-arm CT imaging to confirm identity of anatomical landmarks such as the ICAs, as well as completeness of tumor resection.³⁶ Drawbacks of this technique include difficulty differentiating among carotid arteries, cavernous sinus, and residual tumor even with the injection of contrast. With the introduction of open MRI, there have been reports of this technique being deployed to assess intraoperative completeness of resection of pituitary tumors.³² With minor adjustments, this could feasibly be used to assess location of ICAs in particularly difficult cases. Shortcomings of this method are mainly due to a high cost and added surgical time.^{32,37}

A further option to consider in the case of a Grade 0 “teddy bear” sign is intraoperative Doppler ultrasound. Ultrasound alone can be associated with a significant learning curve with poor definition of soft tissue components,³⁷ but intraoperative ultrasound with Doppler capabilities has reported good success in minimizing the risk of ICA injury.^{14,38}

Conclusion

The “teddy bear” sign, discerned on axial CT cross-sections, can be used to assist the surgeon to appreciate the junction between the ICAs and the sella, which aids the optimal safe

lateral opening of the sella in pituitary and anterior skull base surgery. The sign represents a novel method of approaching preoperative planning for these patients with potential to reduce the morbidity and mortality of transsphenoidal pituitary and anterior skull base surgery. In 5% of cases, the sign is absent at all levels bilaterally and other techniques must be employed to optimize access and avoid ICA injury.

Ethics Approval

Not required.

Conflict of Interest

None declared.

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