Comparative Analysis of Clivus Morphology in Patients with Adenomas

Mousa Javidialsaadi[1], Alexi Obillo[2], Rajashree Sarkar[3], Andrew Pickles[2], Diego D Luy[1], Erin M. Davies[1], Aanya Agarwal[2], Julia Huang[2], Anand V. Germanwala[1]

[1]Department of Neurological Surgery, Loyola University Medical Center, Maywood, IL, USA, [2]Stritch School of Medicine, Loyola University Chicago, Maywood, IL, USA
[3] Department of Neurosurgery, Northwestern University, Chicago, IL, USA

Abstract

This study assessed clival anatomical changes in patients with hormone-secreting pituitary adenomas, nonfunctioning adenomas, and normal controls.

Retrospective imaging from 218 subjects was analyzed. Tumor size and clival morphometric measures, including depth, sellar depth, and pneumatization, were compared using one-way ANOVA.

Both adenoma groups showed significantly reduced clival depth and increased sellar depth compared with controls, independent of hormonal activity. Reduced clival pneumatization was observed only in nonfunctioning adenomas. These findings suggest tumor-driven clival remodeling. Clival measurements may provide useful adjuncts for preoperative evaluation and tumor characterization.

Introduction

Pituitary adenomas are common benign intracranial tumors arising from the anterior pituitary and are classified as hormone-secreting or nonfunctioning. Hormone-secreting adenomas are typically diagnosed earlier, while nonfunctioning tumors often present later due to mass effect.

Pituitary adenomas frequently extend into adjacent skull base structures, including the suprasellar region, cavernous sinus, sphenoid bone, and clivus. Although cortical bone erosion is uncommon, invasion of clival cancellous bone has been described.

Bone remodeling is well documented in other skull base tumors but remains poorly characterized in pituitary adenomas. Prior CT-based studies suggest clival involvement, though CT is not routinely used for pituitary lesion assessment. This study aimed to characterize clival morphologic variations in functional and nonfunctioning pituitary adenomas and compare them with normal controls to improve preoperative imaging assessment.

Methods and Materials

This retrospective study included adult patients (≥18 years) who underwent endoscopic endonasal transsphenoidal surgery for pituitary adenomas at a single institution between January 2007 and July 2023, following institutional review board approval. Preoperative high-resolution CT scans of the clivus and MRI for tumor visualization were required.

Clinical and demographic data were collected, including tumor type and hormone-secreting status based on preoperative endocrine evaluation. Tumor height, anterior–posterior depth, and transverse width were measured on contrast-enhanced T1-weighted MRI (Figure 1).

Clival morphometry was performed using multiplanar CT reconstructions to assess clival length and depth at multiple levels (Figure 2A), clival orientation and angles (Figure 2B–C), sellar depth (Figure 2D), and percent clival pneumatization (Figure 2E).

Measurements were obtained by multiple observers and averaged. Group comparisons were conducted using independent t-tests, one-way ANOVA, and Tukey post-hoc analyses, with statistical significance defined as $p < 0.05$.

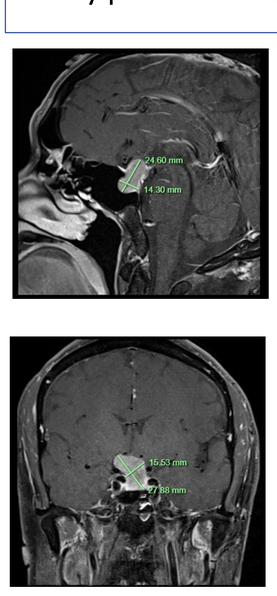
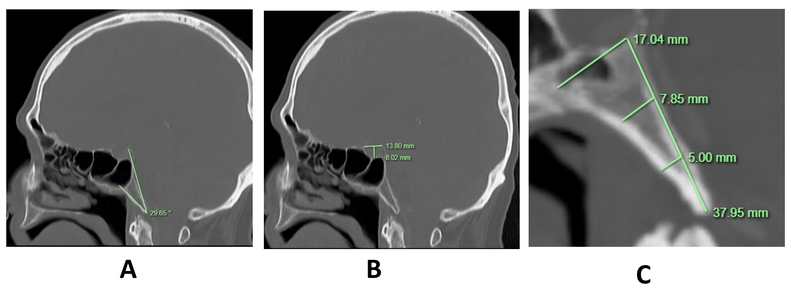
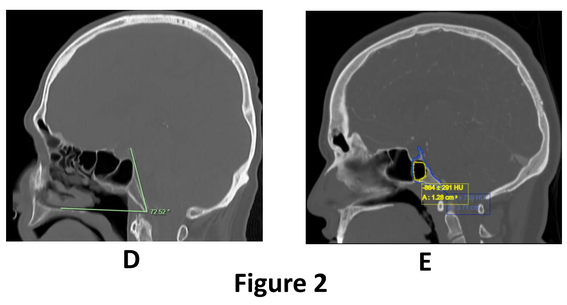


Figure 1



A B C



D E

Figure 2

Results

Study cohort: A total of 218 subjects were analyzed, including 41 patients with hormone-secreting pituitary adenomas, 94 with nonfunctioning pituitary adenomas, and 83 normal controls.

Tumor size: Nonfunctioning adenomas were significantly larger than hormone-secreting adenomas across all dimensions, including tumor height (21.35 vs. 15.35 mm), anterior–posterior depth (17.91 vs. 14.11 mm), and transverse width (21.51 vs. 17.05 mm; all $p < 0.001$).

Clival depth: Both hormone-secreting and nonfunctioning adenomas were associated with significantly reduced clival depth compared with controls at the upper, middle, and lower thirds of the clivus, indicating consistent clival narrowing across tumor types (all $p < 0.001$).

Sellar depth: Sellar depth was significantly greater in patients with pituitary adenomas compared with controls. Nonfunctioning adenomas demonstrated greater sellar depth than hormone-secreting adenomas, consistent with their larger tumor size ($p = 0.007$).

Clival pneumatization: Percent clival pneumatization was significantly lower in patients with nonfunctioning adenomas compared with controls ($p = 0.003$). No significant difference was observed between hormone-secreting adenomas and controls.

Stable features: No significant differences were observed in clival length, clival angle, or clivopalatal angle among the three groups.

Discussion

This study demonstrates that pituitary adenomas are associated with region-specific remodeling of the clivus. While clival length and orientation remained stable, significant differences were observed in clival depth, sellar depth, and clival pneumatization, suggesting selective bony remodeling rather than global skull base alteration.

Reduced clival depth across all thirds was observed in both hormone-secreting and nonfunctioning adenomas, indicating that clival narrowing is likely driven by tumor presence rather than hormonal activity. Prior work suggests pituitary adenomas may promote osteoclast-mediated bone resorption through inflammatory and molecular pathways, providing a potential biological basis for these findings.

Sellar depth was significantly increased in adenoma patients, particularly in nonfunctioning tumors, supporting a model of chronic expansile pressure on adjacent bone. Similar pressure-driven bony remodeling has been described in other slowly progressive intracranial pathologies.

Lower clival pneumatization in nonfunctioning adenomas may reflect preferential tumor expansion into air-filled spaces rather than altered developmental pneumatization. Longitudinal imaging may clarify whether this represents a true remodeling process or a path of least resistance.

Overall, this study provides the first quantitative evidence of clival morphological differences associated with pituitary adenomas. These findings may have implications for diagnosis, surgical planning, and the use of bony imaging features as adjunctive markers of tumor presence.

Conclusions

Pituitary adenomas are associated with region-specific statistically significant dimensional differences within the clivus, particularly in depth throughout the clivus and sella. These changes appear to occur regardless of hormonal activity, suggesting clival resorption and sellar expansion from tumor mass effect.

Further studies may help explain the pathophysiology behind these morphological changes associated with adenomas. Clival measurements on imaging may serve as useful adjuncts in preoperative evaluation and tumor identification and classification.

Contact

[Mousa Javidialsaadi]
[Loyola Medicine Chicago]
[2160 South First Avenue, Maguire Building 105, Maywood, IL 60153]
[Mousa.Javidialsaadi@luhs.org]
[4145224259]

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