High Resolution MR Imaging of the Parasellar Ligaments

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ABSTRACT
The parasellar ligaments have been previously described in cadaver specimens and intra-operatively, but identification on MR imaging has eluded radiologists. Using high resolution T2-weighted MR imaging, we identified the parasellar ligaments as T2 hypointense, bandlike structures that emanate from the medial wall of the cavernous sinus. Subsequent dissection of the same specimen provided matching anatomical images of the parasellar ligaments identified on MRI. This imaging finding is important as resection of the medical wall of the cavernous sinus has been tied to improved outcomes for gross total resection and endocrinological remission of functioning pituitary adenomas.

ABBREVIATIONS:
MCWS = medial wall of the cavernous sinus, NEX = number of excitations.

INTRODUCTION

The cavernous sinus is a complex structure that houses critical anatomy such as the internal carotid arteries and cranial nerves.(1) Recent studies have underscored the importance of the medial wall of the cavernous sinus (MWCS) in improving outcomes for functional pituitary adenoma surgery.(2) Within the cavernous sinus, the parasellar ligaments are important structures that extend from the MWCS to the internal carotid arteries and cranial nerves.(3) Despite their anatomical significance, the parasellar ligaments have remained elusive on MR imaging. The purpose of this report is to describe the imaging appearance of the parasellar ligaments on MR imaging.

Imaging

All imaging was performed on a research only compact 3T scanner (GE Healthcare).(4) A standard coronal T2-weighted sequence that mimics our clinically utilized protocol was initially run (slice thickness 3 mm, TR 3025 ms, TE 101 ms, 160 mm field of view, NEX of 1, acquisition time 55 seconds). This clinical sequence demonstrated hazy T2 isointense signal in the cavernous sinus, immediately adjacent to the pituitary (Fig 1A). In our experience, ill-defined signal in the cavernous sinuses on the coronal T2-weighted sequence is a typical finding, without having sufficient spatial resolution to identify the parasellar ligaments.

An additional high resolution T2-weighted sequence was then performed to further resolve the structures within the cavernous sinus (slice thickness 0.5 mm, TR 4372 ms, TE 100 ms, 160 mm field of view, NEX of 6, acquisition time 21 minutes 13 seconds).

The higher resolution imaging further resolved the ill-defined signal in the cavernous sinus as distinct T2 hypointense bands (Fig 1B). The bands run from the medial wall of the cavernous sinus that directly abuts the lateral aspect of the pituitary and fan outward as they extend laterally towards the internal carotid artery and the lateral wall of the cavernous sinus. These distinct bands correlate with the parasellar ligaments (Fig 2), specifically the anterior horizontal ligament and periosteal ligament.

Anatomy Report

For this study we used one embalmed cadaveric specimen prepared as previously described.(5) Briefly, for the latex injection both the common carotid and vertebral arteries as well as internal jugular veins were isolated and cannulated with stainless steel cannulas and perfused with red and blue latex, respectively.

To expose and describe the pituitary region and ligaments a regular transsphenoidal approach was performed. Using a 0-degree endoscope both middle and superior turbinates on both sides of the nasal cavity were lateralized revealing the ostium of the sphenoid sinus. A kerrison rongeur was used to enlarge the ostium and enter the sphenoid sinus cavity. Within the sphenoid sinus the septum was drilled and the bony landmarks, recesses, and prominences were exposed. The dissection proceeded by drilling the sellar prominence moving laterally to the carotid prominence. Once the dura covering the pituitary gland and anterior bend of the internal carotid artery were exposed a retractable knife was used to incise and expose dura. The incision was performed at the level of the anterior intercavernous sinus moving laterally to open the anterior wall of the cavernous sinus and its contents. Lastly, using 0- and 30-degree scopes the pituitary region and cavernous sinus were dissected and photo documented preserving the pituitary ligaments and their landmarks, in particular their origins and insertions in the surrounding structures (Fig 3, supplemental Figs 1-3).

DISCUSSION

The cavernous sinus is an important anatomic region to understand during resection of functioning pituitary adenomas. Resection of the MWCS, even in the absence of macroscopic invasion, has been shown to be associated with improved outcomes including gross total resection and endocrinological remission.(2) Surgical resection of the MWCS is not without risk, with many important structures including the internal carotid artery and cranial nerves, residing in the cavernous sinus. The parasellar ligaments have been described as key anatomic structures that connect the MWCS to the ICA, and are therefore required to be transected during MWCS resection. Pre-operative identification of the parasellar ligaments could therefore help with surgical planning as to avoid carotid artery injury. While these structures have been described in cadaver specimens, we present a case of MR imaging of the parasellar ligaments with anatomic correlation.

The MWCS is a thin single layer structure comprised of the meningeal dura that it difficult to see on MRI.(3) The resection of the MWCS has been shown to be of increasing importance in achieving biochemical cure of functioning pituitary adenomas and to prevent recurrence in non-functioning adenomas.(6-8) Parasellar ligament transection is important in resection of the MWCS from the surrounding neurovascular structures.(3)

Kehrli et al(9) theorized that the fetal pituitary gland is wrapped by a mesenchymal mass, of which the parasellar ligaments are remnants, a process that leads to variability in the ligaments. The parasellar ligaments are fan-shaped structures originating from the MWCS and extending to the tunica adventitia of the internal carotid arteries and laterally to the cranial nerves in what has been described as a “candy-wrapper” configuration.(3) The parasellar ligaments, when studied in cadaver models, have a variable configuration but are grossly organized into anterior and posterior groups. The anterior horizontal ligament and posterior horizontal ligament, identified on our specimen, resident in the anterior and posterior groups, respectively.

Case Summary

We present high resolution MR imaging of the parasellar ligaments. These ligaments are important structures that connect the MWCS to the internal carotid arteries and cranial nerves, and have previously been described with gross visualization in cadaver models and intraoperatively, but not previously with MR imaging. The MWCS is an increasingly important structure in achieving endocrinological remission following the resection of functioning pituitary adenomas, and therefore, the parasellar ligaments have newly recognized signifiance for surgical planning.

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FIG 1. (A) A standard 3 mm thick coronal T2-weighted sequence shows hazy signal (arrows) in the cavernous sinuses. (B) High resolution 0.5 mm slice thickness imaging resolves these hazy structures as distinct T2 hypointense bands that represent the parasellar ligaments (top arrow = anterior horizontal ligament, bottom arrow = periosteal ligament).

FIG 2. Illustration of the parasellar ligaments demonstrate the "candy wrapper" configuration that originate on the medial wall of the cavernous sinus and fan out laterally as they extend to the cavernous segment of the internal carotid artery and the lateral wall of the cavernous sinus. CCL = carotid-clinoid ligament, AHL = anterior horizontal ligament and the associated SB = superior branch and IB = inferior branch, Periost. L. = periosteal ligament, MWCS = medial wall of the cavernous sinus, ICL = interclinoid ligament, PHL = posterior horizontal ligament, IHL = interclinoid ligament. This illustration has been modified from the original version.(3)

FIG 3. Endoscopic image from the same cadaver specimen from Fig 1. The distinct T2 hypointense bands in the right cavernous sinus seen on MRI correspond to the right parasellar ligaments. Specifically the anterior horizontal ligament (upper arrow) and the periosteal ligament (lower arrow).