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EXPERIMENTAL RESEARCH - NEUROSURGICAL ANATOMY

Relationship between the pituitary stalk angle in prefixed, normal, and postfixed optic chiasmata: an anatomic study with microsurgical application

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Abstract
Background The relationship between the optic apparatus and the skull base is important during approaches near the sella turcica. One relationship that dictates which approach is taken is whether the optic chiasm is prefixed or postfixed or in a "normal" location, (centered over the diaphragma sella). The relationship between the position of the chiasm and the angulation of the pituitary stalk has not been investigated.
Methods Forty adult cadavers without intracranial pathology were dissected and parasagitally hemisected lateral to the sella turcica. The angulations between the pre- and postfixed and normal chiasm and the pituitary stalk were evaluated under magnification. Additionally, 50 MRIs performed among patients evaluating headache were analyzed for these relationships.
Results For cadavers, the chiasm was prefixed in 7.5 % (n = 3), normal in 85 % (n = 34), and postfixed in 7.5 % (n = 3). On imaging, the chiasm was prefixed in 4 % (n = 2), normal in 88 % (n = 44), and postfixed in 8 % (n = 4). For all, the relation between the type of chiasm and the pituitary stalk was more often (p < 0.05) 90° or greater for prefixed chiasmata and acute angles for normal or postfixed chiasmata.
Conclusions These data may assist skull base surgeons when approaching pathology near the optic chiasm and pituitary stalk.

Keywords Headache · Neurosurgical procedures · Optic chiasm · Pituitary gland · Skull base

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Abbreviations

ICA	Internal carotid artery
MR	Magnetic resonance
MRIs	Magnetic resonance images

Introduction

The optic chiasm is formed from the intersection of the two optic nerves with the subsequent formation of the two optic tracts [4, 14]. Axons from the ganglion cell layer of the retina leave via the optic nerve of each eye and travel posteromedially into the middle cranial fossa [1, 4, 6, 7]. The axons representing the nasal visual field decussate, whereas the axons of the temporal field continue uncrossed

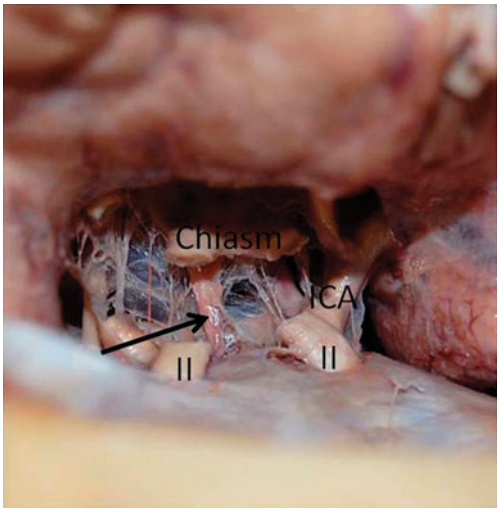

Fig. 1 Subfrontal cadaveric dissection in a specimen found to have a prefixed chiasm. Note the anterior location of the pituitary stalk (*arrow*). For reference, note the optic nerves (II) and left internal carotid artery (ICA)

and leave through one of two optic tracts on the posterior portion of the optic chiasm [1, 6, 7, 9]. Because of this divergence, each optic tract contains axons from the ipsilateral temporal hemiretina of one eye and contralateral nasal hemiretina of the other [1, 4, 7, 9].

The optic chiasm is most commonly positioned over the diaphragma sellae and pituitary gland. In about 10 % to 30 % of cases, the location of the chiasm exhibits some variation in the horizontal plane. The osseous structures that make up the sella turcica thus serve as reference points. The optic chiasm is referred to as prefixed when it is located above the tuberculum sellae and as a postfixed chiasm when it is situated superior to the dorsum sellae [5]. Prefixed and postfixed configurations are roughly equally common.

Fig. 2 Parasagittal cadaveric specimen with a normally positioned optic chiasm. For reference, note the right optic nerve (II)

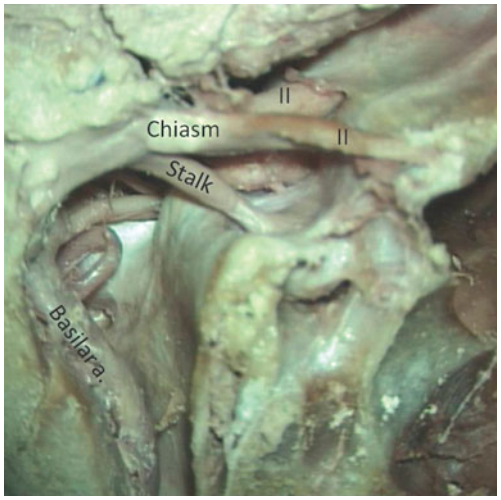

Fig. 3 Parasagittal cadaveric specimen with a postfixed chiasm. Note the more inclined pituitary stalk (stalk). For reference, note the left and right optic nerves

Knowledge of the anatomical relationship of the optic chiasm and pituitary gland are of great importance for resection of pituitary lesions because a prefixed optic chiasm will greatly limit accessibility through a transcranial, transfrontal approach. To our knowledge, the angulation of the pituitary stalk in cases of normal, prefixed, and postfixed optic chiasmata has not been studied. As the position of the chiasm is important in approaches to pathology of the parasellar region and because damage to the pituitary stalk results in morbidity, we performed the present study to better elucidate this anatomy.

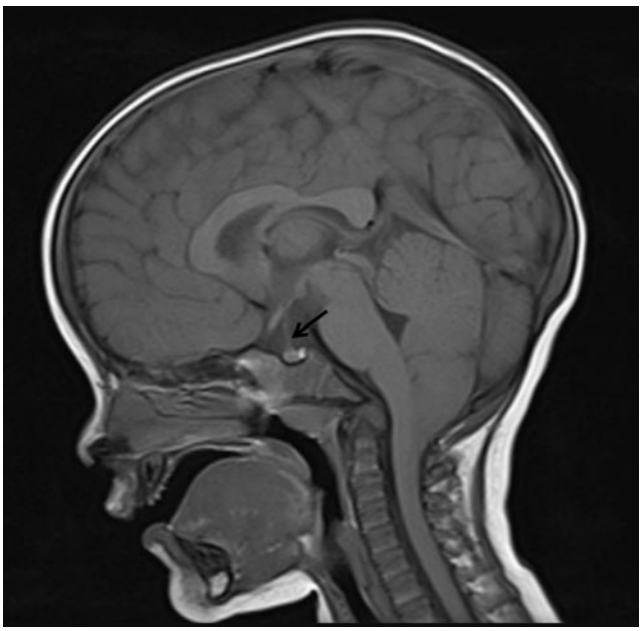

Fig. 4 Sagittal T1-weighted MRI in a patient with a prefixed optic chiasm. Note the more anteriorly positioned pituitary stalk (*arrow*)

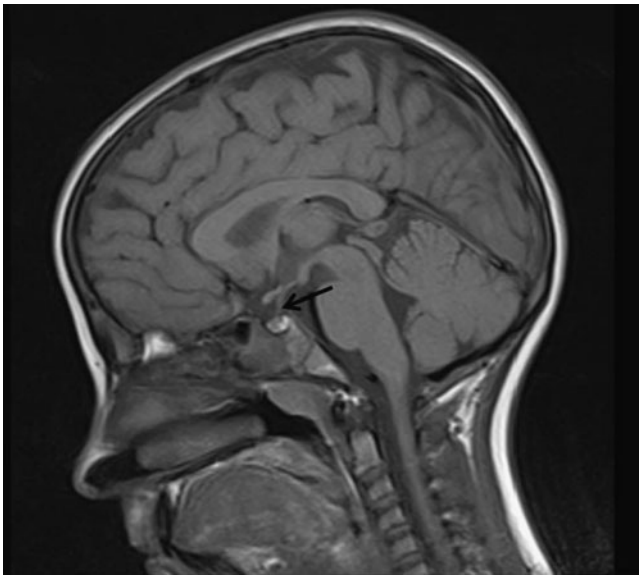

Fig. 5 Sagittal T1-weighted MRI of a patient with a normally positioned optic chiasm. Note the slight inclination of the pituitary stalk (*arrow*)

Methods

Forty formalin-fixed adult cadaver heads without intracranial pathology were dissected and then parasagitally hemisected just lateral to the sella turcica. In this group, there were 25 women and 15 men with an age range at death of 39 to 89 years (mean 75 years). In each specimen, the angulation between the prefixed and postfixed and normal chiasm and the pituitary stalk was evaluated under surgical magnification. We used the definition of normal, pre and postfixed chiasmata as determined by Gulsen et al. [5]. The optic chiasm was defined as prefixed when it was located above the tuberculum sellae and as a postfixed chiasm when it is situated superior to the dorsum sellae. Chiasmata located above the sella turcica were defined as normal in their position. All observations were made with the aid of a surgical microscope (Zeiss, Germany). Additionally, 50 MRIs performed on patients for evaluation of headache were observed for these relationships. This group, with no intracranial pathology, comprised 25 men and 25 women with a mean age of 42 years. T2-weighted axial images were used to identify each chiasm as normal, prefixed, or postfixed. Sagittal T1-weighted images were then used to observe for pituitary stalk to optic chiasm relationships/angulation. Digital images were made of both cadaveric and radiologic images. Angles were measured between the pituitary stalk and the optic chiasm using analytical postprocessing software (ImageJ 1.46;http://rsb.info.nih.gov/ij/download.html). Statistical analysis was performed using Statistica for Windows with significance set at $p < .05$.

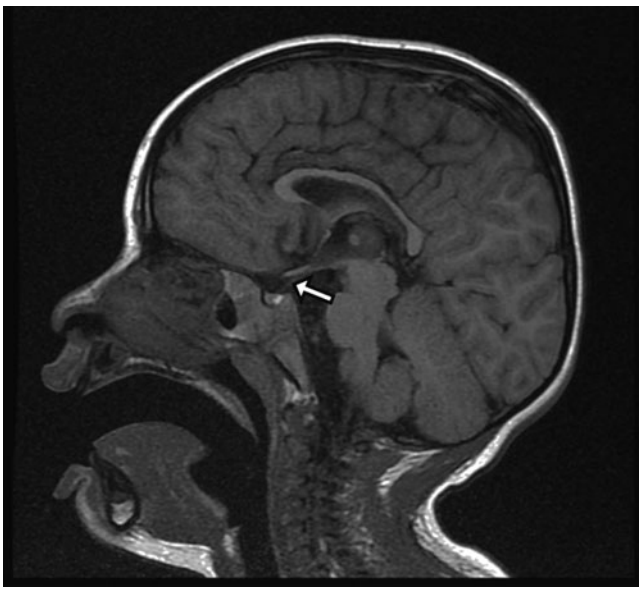

Fig. 6 Sagittal T1-weighted MRI of a patient with a postfixed chiasm and significantly inclined pituitary stalk (*arrow*)

Results

For cadavers, we found that the chiasm was prefixed in 7.5 % ($n = 3$) (Fig. 1), normal in 85 % ($n = 34$) (Fig. 2), and postfixed in 7.5 % ($n = 3$) (Fig. 3). On imaging, the chiasm was prefixed in 4 % ($n = 2$) (Fig. 4), normal in 88 % ($n = 44$) (Fig. 5), and postfixed in 8 % ($n = 4$) (Fig. 6). Among all groups (cadavers and imaging), the relation between the type of chiasm and the pituitary stalk was most often less than 90° for prefixed chiasmata and an obtuse angle for a normal or postfixed chiasmata. More or less, chiasmata that were prefixed resulted in a pituitary stalk that was nearer the tuberculum sella and were more vertical in nature, and postfixed chiasmata resulted in stalks that came closer to the dorsum sellae and were more acute in angulation in their relationship to the optic chiasm.

Table 1 Overview of results from current study

Total cadaver specimens=40
Prefixed chiasmata 7.5 % ($n = 3$),
Normal chiasmata 85 % ($n = 34$)
Postfixed chiasmata 7.5 % ($n = 3$).
Total MRI=50
Prefixed chiasmata 4 % ($n = 2$)
Normal chiasmata 88 % ($n = 44$)
Postfixed chiasmata in 8 % ($n = 4$)
Angulation of Pituitary Stalk in Both Groups
Prefixed chiasmata 90 to 114° (mean 100°)
Normal chiasmata 45–70° (mean 59°)
Postfixed chiasmata 10–30° (mean 15°)

(Angulation for prefixed chiasmata ranged from 90 to 114° (mean 100°), for normal chiasmata 45–70° (mean 59°), and for postfixed chiasmata 10–30° (mean 15°). No statistical significance was found between angles and gender or age. However, $p < 0.05$ when grouping angulation of the pituitary stalk and type of optic chiasm. All results are summarized in Table 1.

Discussion

Forming part of the anterior wall and floor of the third ventricle, the optic chiasm lies below the lamina terminalis. Both the anterior communicating and anterior cerebral arteries lie superior to it, whereas the tuber cinereum lies posterior and the internal carotid arteries run along its side [8, 11]. Below the optic chiasm lies the diaphragma sellae and pituitary gland [11]. The anatomic relationship of the optic chiasm to the diaphragma sellae and pituitary gland was originally described by Schaeffer [13] and later defined by criteria put forth by Bergland et al. [2]. Since the tuberculum sellae varies in length, Bergland et al. used the prechiasmal space in relation to the tuberculum sellae to determine the anatomical relationship of the optic chiasm to its surrounding structures. In 80 % of their cadaveric dissections in 225 human specimens, the optic chiasm was in the normal position over the diaphragma sellae and pituitary gland. In 9 % of the specimens, the optic chiasm was located above the tuberculum sellae with a smaller prechiasmal space, thus considered prefixed. Conversely, in 11 % of the specimens, the optic chiasm was situated superior to the dorsum sellae with a larger prechiasmal space, therefore, it was deemed postfixed [2]. Renn and Rhoton [10] found that of the 50 specimens they dissected, 10 % had a prefixed chiasm and 15 % had a postfixed chiasm, whereas the optic chiasms of the remaining 75 % were in the normal position [10].

Recently, Gulsen et al. [5] studied 60 cadaveric specimens and found that only 5 % contained prefixed chiasms, but 17 % contained postfixed chiasms, whereas the other 78 % of the specimens had normally positioned optic chiasms [5]. Similar to these anatomical studies, an in vivo MR study of 131 patients revealed about 15 % of cases contained prefixed chiasms. Although no postfixed chiasms were observed because neither the dorsum sellae nor the prechiasmal space could be clearly defined by MR, a significant number of optic chiasmata were positioned more posterior in relation to the tuberculum sellae [3].

Currently, research demonstrates the occurrence of prefixed and postfixed chiasmata varies between 5 to 15 % and 11 to 17 %, respectively. In cadavers, we identified a prefixed, normal, and postfixed chiasmata in 7.5 %, 85 %, and 7.5 % of specimens, respectively. On imaging, the chiasm was prefixed in 4 %, normal in 88 %, and postfixed in 8 %.

The anatomic relationship of the optic chiasm to these structures is critically important for surgical intervention in the vicinity [5, 10–12, 14]. Of the three anatomic positions of the optic chiasm, a prefixed chiasm provides the greatest challenge for surgical intervention. A prefixed chiasm, along with a superiorly prominent tuberculum sellae or a small distance between a normal optic chiasm and the tuberculum sellae, creates a small operative corridor and limits access through a transcranial, transfrontal approach to the pituitary, while not necessarily limiting exposure through a transsphenoidal approach [5, 10–12, 14]. For the size of tumor that would require a craniotomy rather than an endoscopic transsphenoidal approach, the presence of a postfixed chiasm is unlikely to provide enough space for removal of the mass from between the optic nerves without traversing the lamina terminalis. Therefore, knowledge of the chiasmal position is crucial to determine the correct surgical approaches to the sellar and parasellar areas and to prevent any damage to surrounding nerves, arteries, or other structures [5, 11]. Based on our study, a prefixed chiasm will place the pituitary stalk in a more anterior position and in greater danger of injury with anterior approaches to the midline skull base. This information is also potentially useful during expanded transsphenoidal exposures where the preoperative knowledge of the location and trajectory of the pituitary stalk can prevent its injury during surgical manipulation.

Conclusions

Such data as found in the present study may be useful to the skull base surgeon during the planning of approaches to pathology near the optic chiasm and pituitary stalk. Knowledge that the pituitary stalk is likely to be more anteriorly located with a prefixed chiasm and more posteriorly located with a postfixed chiasm may decrease the potential for intraoperative injury.

Conflicts of interest None

Funding received for this study None

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