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Optic Chiasm Position on MR Images

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This article describes the results of a study of the distance from the optic chiasm to the tuberculum sellae as seen on sagittal MR images. Measurements revealed an average chiasm-tuberculum distance of 3.8 mm (2.6 mm for females, 4.3 mm for males) and a sizable group in whom the distance was effectively zero. These results show a fairly close correlation with previous anatomic studies. The closer the chiasm is to the tuberculum, the earlier one may expect clinical manifestations of pituitary disease and the more difficult an intracranial surgical approach to the pituitary will be.

The optic chiasm occupies a central place in the suprasellar cistern and is frequently involved in processes affecting this area. Its position with respect to the sella in cadaver specimens has been described as normal, prefixed, or postfixed [1, 2]. The intention of the present study was to investigate this relationship in live subjects by means of sagittal MR imaging. From the results obtained it seems that chiasms fall into two groups, one in which the chiasm closely abuts the tuberculum sellae and another in which the chiasm-tuberculum distance averages 3.8 mm with a roughly normal distribution.

Materials and Methods

Over a 4-month period, 131 cases were assessed on sagittal MR views for chiasm-tuberculum distance. Patients with pituitary or chiasmal lesions, hydrocephalus, mass lesions, or other abnormalities likely to affect the chiasm-tuberculum distance were excluded. The criterion used to identify the anterior margin of the chiasm was the presence of a well-defined, oval, high-intensity structure on the same cut as the pituitary stalk and third ventricle (Fig. 1). The tuberculum was defined as a low signal line corresponding to cortical bone with or without high-intensity fat adjacent to it (Fig. 1). The measurement made was the shortest distance between these two structures. Since it was only infrequently possible to positively identify the dorsum or diaphragma sellae, the distance of the chiasm from these structures was not measured.

Imaging was performed on a 1.5-T superconducting magnet (Signa, GE Medical Systems, Milwaukee) with T1-weighted 5-mm slices, 600/20/1 (TR/TE/excitations), at a matrix of 256 × 256 and field of view of 24 cm giving 0.9-mm spatial resolution. A few patients had thinner slices (3 mm) performed in a pituitary study with the same TR and TE. Six measurements were made in each case with electronic calipers and then averaged.

Results

All chiasms studied lay on a line at roughly 45° posterosuperior to the tuberculum. None was observed to lie wholly anterior to the tuberculum Although in four cases (Fig. 1D) there was probably slight overlap, it is difficult to determine the posterior margin of the tuberculum in these few instances. The distribution of results for the
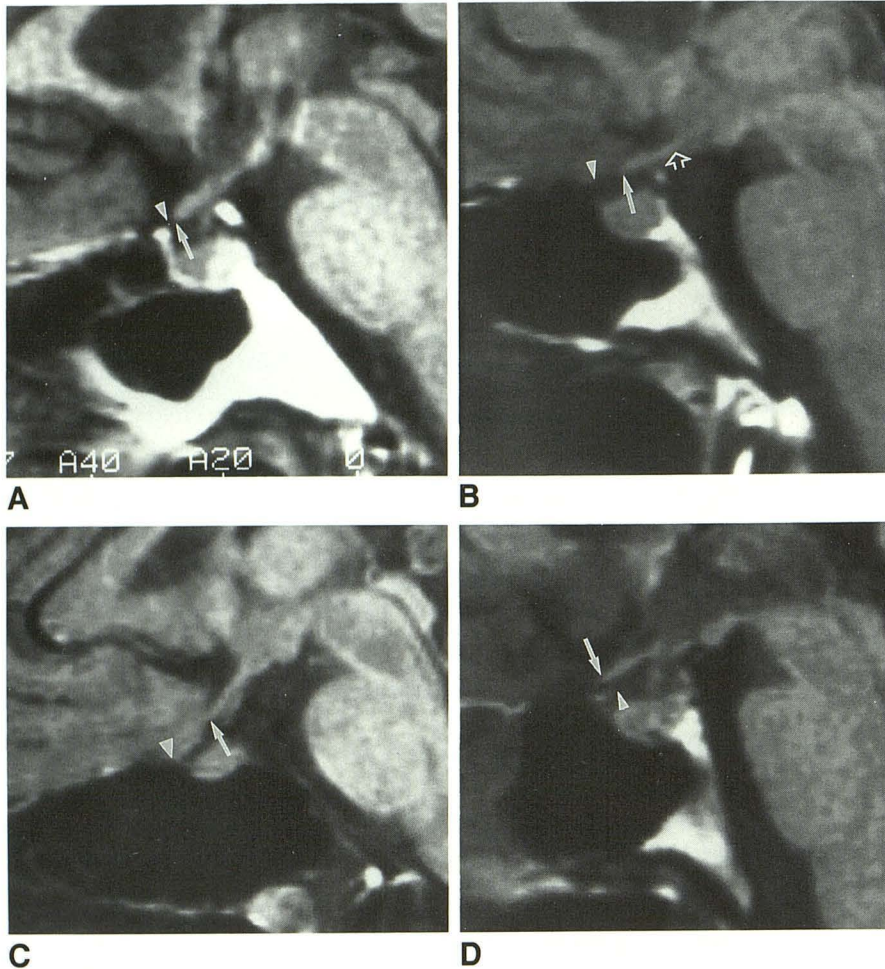
Fig. 1.—Sagittal T1-weighted MR image of four typical chiasm positions. The tuberculum (*arrowhead*) and anterior border of the chiasm (*arrow*) are indicated on each image.
A, Prefixed chiasm.
B, Normal position—chiasmal point is indicated by *open arrow*.
C, Postfixed chiasm.
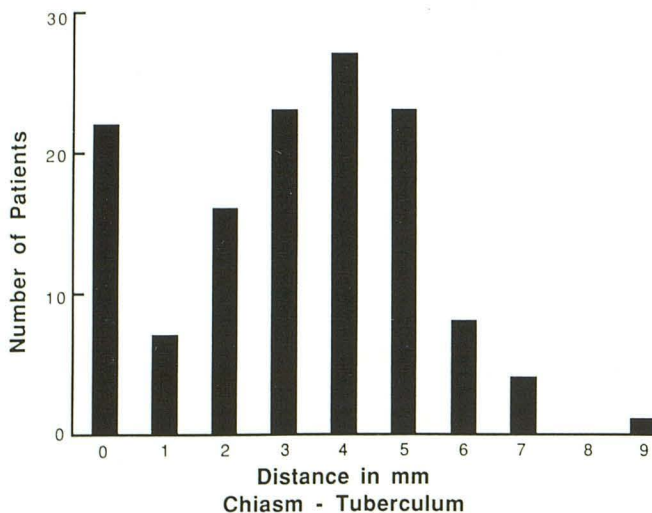*D*, One of a few cases in which chiasm appears to overlap the tuberculum slightly.

Fig. 2.—Histogram of the distribution of chiasm-tuberculum distance.

131 cases is seen in Fig. 2. In 20 cases the chiasm-tuberculum distance was effectively zero as measured on MR. The other 111 were distributed in a roughly normal distribution with a mean of 3.8 mm and standard deviation of 1.6 mm. Dividing this group by sex yielded a mean of 2.6 mm for females ($n = 65$) and of 4.3 mm for males ($n = 37$) (in nine cases sexual identification was not available). Subdivision by age did not yield any significant differences; children under 10 years old had a mean of 3.3 mm with two values of zero ($n = 12$).

Discussion

The terms prefixed and postfixed were first applied to the position of the optic chiasm in 1924 [1]. The study by Bergland et al. in 1968 [2] confirmed the existence of pre- and postfixed chiasms on autopsy specimens. These investigators designated prefixed chiasms as those overlying the tuberculum sellae and postfixed as those overlying the dorsum sellae. Their measurement criteria for prefixed chiasms (9% of specimens) were those on which the tuberculum equaled or exceeded the length of the prechiasmal space. For a postfixed chiasm (11% of specimens) the tuberculum was shorter than the prechiasmal space by 6 mm or more. It seemed of interest to correlate this with findings in vivo, and the present study has essentially confirmed the normal position of the chiasm as being about 3–4 mm posterosuperior to the tuberculum,

slightly more in males than in females, with a significant subgroup (about 15%) prefixed (i.e., abutting the tuberculum). It was difficult to assess the number of postfixed chiasms in this study by using Bergland's criteria, since neither the dorsum sellae nor the prechiasmal space was reliably defined on MR.

An attempt was made to define the position of the optic chiasm in live subjects by James Bull in 1956 [3]. He defined the upper posterior border of the chiasm by identifying the optic recess of the third ventricle on pneumoencephalograms. He defined the chiasmal point as the point of deepest insertion of the wall of the third ventricle between the optic and infundibular recesses. One objection to this definition is that it is a very indirect measurement of chiasm position. Also, introduction of air into the ventricles is not a physiologically normal situation. Bull refuted this in part by noting that the optic recess did not move between examinations conducted with air in the supine position and positive contrast medium in the prone position. However, MR examination of the undisturbed chiasm should be a more accurate reflection of normal anatomy.

Comparison with Bull's results is made difficult by the fact that on MR we are measuring the inferior anterior border of the chiasm. In my experience it is difficult to define the chiasmal point described by Bull on MR. In an attempt to do this in a limited series of 25 patients, measurement of the chiasm from anterior inferior border to chiasmal point (Fig. 1B) yielded an average chiasm length of 9.3 mm. Bull's average distance from chiasmal point to tuberculum in his series of 117 patients was 16.5 mm. Subtracting these two measurements would yield an average chiasm-tuberculum distance of 7.2 mm. This is not the same as my measured average chiasm-tuberculum of 3.8 mm, indicating that either the chiasmal point measured on MR is not the same as that measured by Bull or that the position of the chiasm varies between the two studies. In view of the difficulty in establishing the chiasmal point on MR and of Bull's finding that the chiasmal point did not vary between the prone and supine positions, it seems that the former is more likely.

That there is a systematic difference in the placement of the chiasmal point on MR and pneumoencephalography is supported by two further observations. First, the chiasmal point-tuberculum distance measured by Bull follows a normal distribution similar in shape to that found on the present study. Second, the average chiasm length of 9.3 mm measured on MR is similar to that found anatomically by Zander in 1896 (Zander R, quoted by Bull [3]) of 8.04 mm. This suggests that the MR assessment of chiasmal length is fairly close to being anatomically correct and that the larger average chiasm-tuberculum distance measured more indirectly by Bull reflects a systematic difference in the means of measurement, in part the radiographic magnification, which Bull was unable to assess accurately.

Although it would seem both from the above discussion and because of the more direct visualization of structures that MR is more accurate than pneumoencephalography in absolute terms, the distribution of chiasm relationships to the tuberculum as assessed by Bull is essentially confirmed in this study. Bull was of course unable to directly assess the relationship of the anterior border of the chiasm to the tuberculum, so the subgroup of chiasms with a close relation to the tuberculum does not show up in his data. This phenomenon was, however, noted by Schaeffer [1], who found in his postmortem study that in five (4%) of 125 bodies the chiasm overlapped the tuberculum slightly and that in a further 12% or so the chiasm is in close relation to the tuberculum but not resting on it. The point that Schaeffer was making is that the chiasm only seldom even contacts the chiasmatic sulcus and is never observed to lie wholly upon it. That observation is definitely substantiated in vivo by the present study.

The position of the chiasm with respect to the sella is of clinical significance, since a pituitary lesion is more likely to compress a prefixed chiasm than a postfixed one [4]. It is thus useful to know the range of normal chiasmal positions in vivo. Interestingly, 15% of chiasms in this study were positioned very close to the tuberculum, making early involvement and hence symptomatology in patients with pituitary or tuberculum lesions more likely in this group. Likewise, a significant number were positioned well to the posterior (up to 9 mm), in which case only very advanced lesions would be likely to cause symptoms. It may be of interest to study the relationship of chiasm position to the size of pituitary tumors at presentation. It is also of some interest anatomically that a significant subgroup of chiasms remain closely apposed to the tuberculum sellae during life. The forebrain is believed to be induced by the prechordal mesoderm, which later evolves into the facial bones [5]. Studies of the relationship of the chiasm to the sphenoid in forebrain malformations may be interesting in this regard.

The utility to the neurosurgeon of knowing whether the chiasm is normal, prefixed, or postfixed relates mostly to pituitary operations performed via an intracranial approach, in which case it is critical [6]. It is of less concern in the transsphenoidal approach, in which the shape of the sphenoid sinus is more important. However, chiasmal position may still be relevant to such surgical concerns as postoperative subsidence and the degree of separation of the sella from the subarachnoid space.

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