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METHODS - ACQUISITION

Use of Cerebellar Landmarks To Define a Coordinate System and an Isolation Strategy

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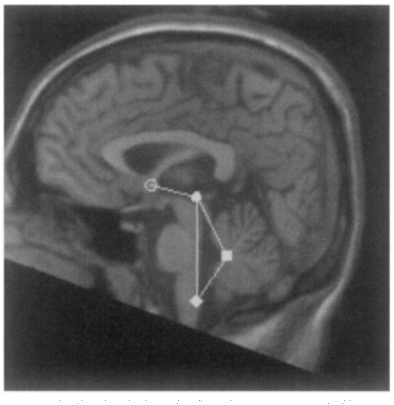
A coordinate system encompassing the cerebellum is necessary for comparing structure and function across subjects. The widely-used Talairach system is often extended to the cerebellum, but this can result in poor structural registration. We propose a cerebellar coordinate system that is based on readily-identifiable landmarks in the brainstem and cerebellum, shares a reference point - the posterior commissure (PC) - with the Talairach coordinate system, and is compatible with current anatomical atlases (1). We discuss a strategy for isolating the cerebellum using this coordinate system - which is a prerequisite for 2D surface mapping (2). Use of this cerebellar-based coordinate system improved the localization of landmarks such as the lingula and the bases of the horizontal and primary fissures as compared to an extended-Talairach coordinate system.



Methods

Coordinate system

A line joining the PC and obex forms the basis for the proposed coordinate system. The PC, obex and the apex of the fourth ventricle (V4) define the cerebellar midplane. A transformed volume is created by rigid-body rotation and translation (transform **CB**) that places the three principal landmarks in the midplane and the PC-obex line in the same quasi-coronal plane (Figure 1). A further one-dimensional rescaling (transform **CBS**) standardizes the distance between the PC and obex. Cerebellar landmarks are then located: the tip of the lingula, the bases of the primary and horizontal fissures, and the maximal extent.

Isolation

Given a strip mask for the whole brain (3), we designed a strategy to isolate the cerebellum in a consistent manner across subjects. The cerebrum is removed by cutting the brainstem above the most rostral extent of the cerebellum and defining the boundary of the occipital lobes. The brainstem and peduncles are cut away on a slice-by-slice basis starting at the anterior surface and ending adjacent to the lingula. For each successive coronal slice, only tissue unobscured by cerebellar cortex is removed. This strategy results in angled cuts of the cerebellar peduncles analogous to those produced by dissection (1). At present, operator supervision is required for this procedure.

Table 1. Landmark Localization. Distances Are in Millimeters [Sigma]

Landmark	TAL	CB	CBS
AC-PC distance	23.0 [0.0]	27.2 [0.9]	27.2 [0.9]
Obex-PC distance	54.1 [2.4]	54.4 [2.9]	54.0 [0.0]
AC localization	NA	2.3 [1.1]	2.3 [1.1]
Obex localization	3.5 [2.3]	2.5 [1.3]	NA
V4 apex localization	3.6 [1.9]	3.3 [1.6]	2.6 [1.9]
Lingula localization	2.9 [1.4]	2.6 [1.3]	2.3 [1.3]
Primary fiss. localization	3.2 [1.9]	3.0 [1.9]	2.5 [1.9]
Horizontal fiss. localization	4.0 [2.0]	3.4 [1.9]	2.8 [2.0]

Results

We identified anatomical landmarks in ten T1-weighted MRI volumes (.86 x .86 x 1.0 mm voxels) acquired from a group of young normal subjects. Each raw scan underwent three transformations: to both cerebellar coordinate systems (**CB** and **CBS**) and to extended Talairach coordinates (**TAL**). Localization of landmarks was evaluated by calculating the distance (in millimeters) of each from its average location.

The mean ratio of the AC-PC and obex-PC distances in the unscaled CB volumes was 0.50 (sigma 0.03). The cerebral and cerebellar midplanes were different for all subjects - the angle between the planes varied from 0.7 to 8.1 degrees, and included both a yaw and a roll component in 80% of the subjects.

Conclusions

Like the anterior and posterior commissures, the obex is a primitive structure that can support a stable coordinate system. The mismatch of cerebral and cerebellar midplanes, in addition to the variance in obex-PC distance remaining after transformation to extended Talairach coordinates reinforces our belief that cerebella require a distinct coordinate system. The preliminary 1D rescaling strategy that was investigated had the desired effect of improving the localization of cerebellar landmarks (latter four rows in Table 1.). Though the PC and obex are removed by the cerebellar isolation strategy, the remaining landmarks are retained and can be visualized in both volume and surface representations of cerebellar structure and function.

Acknowledgments

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References

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