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The importance of precise plane selection for female adult Chiari Type I malformation midsagittal morphometrics

Mark Morkos, Maggie Eppelheimer, Blaise ST Nwotchouang, Seyed A Ebrahimzadeh, Rafeeque A Bhadelia, Philip A Allen, Francis Loth

Purpose

CMI clinical and research imaging usually looks at a central MRI slice called the midsagittal plane. The goal of this study was to determine how much error is introduced if common CMI measurements are instead taken at parasagittal planes positioned at various lateral distances from the midsagittal plane.

Methods

A total of 30 adult female CMI subjects were involved in this study, ranging from 23 to 55 years of age (38.6 ± 7.3). Pre-operative MRI image sets were evaluated to assess 14 CMI morphometric parameters using a custom in-house software developed in MATLAB. Five CMI individuals were initially evaluated on 21 sagittal slices per subject. Based on the results of the initial set of five subjects, an additional sample of 25 CMI subjects were evaluated at the midsagittal and four parasagittal planes located 1 and 2 mm lateral (left and right) to the midsagittal plane. Two main statistical values were calculated. The mean individual absolute parasagittal error (MIAPE), defined as the mean value of the absolute parasagittal error for a given parameter; and the mean group parasagittal error (MGPE), defined as the mean value of a morphometric parameter at a particular lateral distance minus the mean value of the morphometric parameter at the midsagittal plane.

Results

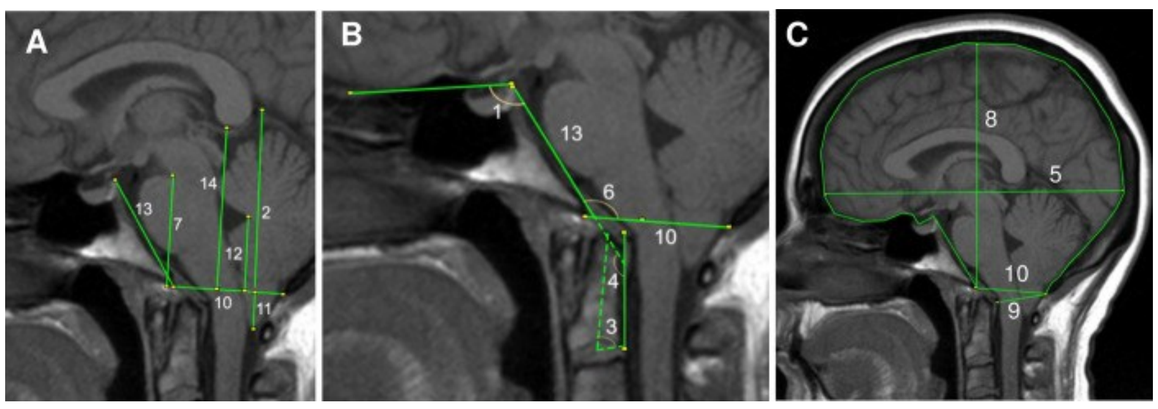
The results obtained from analyzing the MRI imaging data of five subjects demonstrated that for most of the parameters, the lateral distance at which the parasagittal error exceeds 1 unit (1 mm for lengths and 1 degree for angles) was approximately 2 mm. For this reason, the second group (n=25) was evaluated up to a parasagittal distance of 2 mm. The results of the second group illustrated that the mean individual absolute parasagittal error (MIAPE) was > 1 unit (1 mm for lengths and 1 degree for angles) for 9/14 parameters within a lateral distance of 2 mm, while the mean group parasagittal error (MGPE) was found to be < 1 unit for 14/14 parameters within a lateral distance of 2 mm.

Conclusions

Midsagittal morphometric measurements on an individual basis can have substantial parasagittal errors with imprecise midsagittal plane selection, whereas mean group error is relatively small within ±2 mm off the midsagittal plane. Thus, imprecise midsagittal plane selection may impact the clinical assessment of an individual patient. However, its impact on group measurements in a research setting will be minimal.

Fourteen morphometric measurements taken on a midsagittal T1-weighted MRI.

A: 2-Posterior cranial fossa height, 7-pons height, 10- McRae line length, 11-tonsillar position, 12- fastigium height, 13- clivus length, 14-corpus callosum height. **B:** 1-Basal angle, 3-odontoid angle, 4-Wackenheim angle, 6- Boogard angle. **C:** 5-intracranial diameter, 8- intracranial height, 9-anteroposterior diameter dura-opisthion.



Mean individual absolute differences between parasagittal and midsagittal plane measurements (MIAPE) on a given individual

Parameter	Left 2 mm	Left 1 mm	Right 1 mm	Right 2 mm
Basal angle (deg)	2.06 ± 2.81	2.02 ± 2.51	2.33 ± 3.20	2.19 ± 2.80
Boogard angle (deg)	1.55 ± 2.06	1.21 ± 1.64	1.24 ± 1.56	1.86 ± 2.41
Odontoid angle (deg)	2.99 ± 3.61	2.15 ± 2.67	2.91 ± 3.39	4.34 ± 7.72
Wackenheim angle (deg)	2.16 ± 3.01	1.72 ± 2.12	1.92 ± 2.85	1.89 ± 2.59
Intracranial diameter (mm)	1.88 ± 2.53	1.60 ± 2.10	1.42 ± 1.64	1.88 ± 2.37
Pons height (mm)	0.60 ± 0.76	0.41 ± 0.57	0.49 ± 0.61	0.69 ± 0.96
Intracranial height (mm)	0.93 ± 1.10	1.09 ± 1.64	0.60 ± 0.79	0.95 ± 1.19
Anteroposterior diameter dura-opisthion (mm)	1.13 ± 1.49	0.57 ± 0.67	0.49 ± 0.62	0.77 ± 0.96
McRae line length (mm)	0.74 ± 0.95	0.65 ± 0.83	0.57 ± 0.72	0.77 ± 0.94
Tonsillar position (mm)	1.28 ± 1.99	0.62 ± 1.01	0.52 ± 0.67	0.77 ± 1.03
Fastigium height (mm)	0.62 ± 0.74	0.45 ± 0.60	0.38 ± 0.49	0.57 ± 0.83
Clivus length (mm)	0.90 ± 1.20	0.53 ± 0.8	0.48 ± 0.65	0.76 ± 1.16
Corpus callosum height (mm)	0.40 ± 0.48	0.39 ± 0.5	0.37 ± 0.44	0.52 ± 0.67
Posterior cranial fossa height (mm)	1.18 ± 1.73	0.96 ± 1.16	1.02 ± 1.11	1.32 ± 1.61

Comparison between maximum mean individual absolute parasagittal error (MIAPE), maximum mean group parasagittal error (MGPE) for each morphometric parameter

Parameter	Maximum MIAPE		Maximum MGPE	
	within ± 2 mm	within ±1 mm	within ± 2 mm	within ±1 mm
Basal angle (deg)	2.19	2.33	0.81	0.59
Boogard angle (deg)	1.86	1.24	0.23	0.23
Odontoid angle (deg)	4.34	2.91	0.72	0.22
Wackenheim angle (deg)	2.16	1.92	0.22	0.22
Intracranial diameter (mm)	1.88	1.6	0.81	0.49
Pons height (mm)	0.69	0.49	0.31	0.03
Intracranial height (mm)	1.09	1.09	0.29	0.29
Anteroposterior diameter dura-opisthion (mm)	1.13	0.57	0.9	0.15
McRae line length (mm)	0.77	0.65	0.49	0.06
Tonsillar position (mm)	1.28	0.62	0.33	0.12
Fastigium height (mm)	0.62	0.45	0.21	0.04
Clivus length (mm)	0.9	0.53	0.23	0.09
Corpus callosum height (mm)	0.52	0.39	0.24	0.00
Posterior cranial fossa height (mm)	1.32	1.02	0.79	0.61