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Cranioencephalic Topography of Sulcus Centralis by MRI

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Abstract: *Cranioencephalic topography is useful for the neurosurgeons to locate different structures on the skull surface. The aim of this study is to ascertain a simplified algorhitm to locate sulcus centralis. MATERIALS AND METHODS: we performed intrinsic cerebrometry and correlational cranio-cerebrometry on 228 RMN images, using CorelDraw 9 for image processing and IBM SPSS Statistics 20.0 for statistical analysis. RESULTS AND DISCUSSIONS data showed wide variation between absolute values, but constancy of relative values, with a slight, but distinct deviation of upper extremity of sulcus centralis towards occipital pole. In CONCLUSIONS, despite the fact that the only rigorous and definite way to locate projection of cortical sulci on calvaria external surface is medical imaging, we suggest an effective projection of upper extremity of sulcus centralis at a straight distance from Glabella representing 3/5 straight distance between Glabella and Inion.*
KEYWORDS*: cranio cerebral topography, morphometry, sulcus centralis cerebri, topography techniques.*

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I. Introduction

Cranio-cerebral topography is not just a simple scientifical or didactical exercise. Encephalic neurosurgery is like „fishing in ice hole" and surgeons are constrained to firmly locate the lesion due to its narrow and stiff transcranian admittance.

The work on craniocerebral topography reported to date has used anatomical dissections in the skull as a study material[1-5] ; the results show differences of just a few millimeters between the different classic craniocerebral topography methods and the conclusion is that these methods maintain their usefulness and specificity in locating the different brain grooves.

Today, magnetic resonance imaging can offer another method of study of the cranio-cerebral topography, given the possibility of detailed analysis of the anatomical structures[6].

The aim of this study is to simplify in an useful manner for the neurosurgeons this main cranioencefalic topography problem. In a previous work[7], we studied the variability of the craniometrical points classified on geometric, topologic and local extreme invariants criteria. Now, we go further to study the variability vs. stability of the cranioencephalical points and, finally, to lay down as a rule an algorithm both simple and useful to locate the sulcus centralis (described by Rolando).

The classical anthropometrical methods were combined with new imagistic ones.

II. Material And Methods

Magnetic resonance imaging was obtained from the Radiology Department of the Craiova Emergency Clinical Hospital.

Out of 2238 RMN images from 540 subjects, we selected only 228 on the following criteria: a) no suspicion of pathological changes and b) an adequate position, so we can perform precise morphometry.

Measurements were performed on sagittal T1 weighted spin echo with a GE Healthcare Signa Explorer, 1.5 Tesla MRI machine.

Intrinsic cerebrometry:

1. Three cerebrometrical points were identified: F = frontal pole, i.e. anterior extremity of the cerebral hemisphere; O = occipital pole, i.e. posterior extremity of the cerebral hemisphere and C = upper extremity of the sulcus centralis (Fig. 1).
2. A standard cerebral triangle ΔFCO was defined as a peculiar object (fig. 1).
3. The sides of ΔFCO were measured; though dedicated soft (eFilm Lite™) was able to perform them easily, we choused the common image processor CorelDraw 9 OEM, taking into account that we will work out further mathematical steps.
4. Morphometrical data were processed with tabelar calculus soft Microsoft Excell (in Office 2003) and extreme values (minimum, maximum) were identified.
5. For each triangle, absolute values were converted in relative values, i.e. F-O side = 1 unit.
6. We performed statically processing of relative values: minimum, maximum, median and quartiles.

Correlational cranio-cerebrometry:

1. Craniometrical points G = Glabella and I = Inion were identified (Fig. 2).
2. C* point was defined, as vertical projection of C on skull surface; then, similarly:
3. Standard cranian triangle ΔGC*I was defined as a peculiar object (fig. 2).
4. The sides of ΔGC*I were measured using image processor CorelDraw 9 OEM.
5. Morphometrical data were processed and extreme values (minimum, maximum) were identified.
6. For each triangle, absolute values were converted in relative values, i.e. G-I side = 1 unit.
7. We performed similarly processing of relative values: minimum, maximum, median and quartiles.

Fig.1. Cerebrometrical points

Fig.2. Craniometrical points

Statistical analysis was performed using Microsoft Excel 2010 (Microsoft Corp., Redmond, WA, USA), together with the XLSTAT 2014 add-on for MS Excel (Addinsoft SARL, Paris, France), and IBM SPSS Statistics 20.0 (IBM Corporation, Armonk, NY, USA), for processing the data.

III. Results

Because the distributions of the data sets were not Gaussian we used non-parametric tests to compare the paired measurements.

First we compared the eccentricity indices of the cerebrometrical and cranio-cerebrometical relative measurements (FC/CO versus GC*/C*I), to determine if the relative position of the upper extremity of the sulcus centralis and its projection on the skull surface are the same.

By comparing eccentricity index measured for the cerebrometrical and cranio-cerebrometrical measurements, we found there are statistically significant differences ($p<0.05$),as proven by the Wilcoxon's signed-rank test for paired samples (Table 1, Fig. 3).

Table 1. Eccentrical index

Eccenctricity index	Cerebrometrical measurements	Cranio-cerebrometrical measurements
Minimum	1.018	0.950
1st quartile	1.107	1.049
Median	1.158	1.102
3rd quartile	1.219	1.154
Maximum	1.372	1.413
p Wilcoxon=	0.008<0.05	

Fig.3. Eccentricity index – graphical representation

Because we observed a statistically significant difference we proceeded to compare the anterior and the posterior relative distances to the central sulcus upper extremity.

By comparing the anterior and posterior relative measurements for the upper extremity of the sulcus centralis, and it's vertical projection C on skull surface relative to the frontal - occipital poles distance or glabella-inion distance we found there are statistically significant differences for the posterior position($p<0.05$), and no significant differences for the anterior position ($p<0.05$), as proven by the Wilcoxon's signed-rank test for paired samples (Table 2, Fig. 4, Table 3, Fig. 5).

Table 2. Anterior relative distance

Anterior relative distance	F – C	G – C*
Minimum	71.59%	71.16%
1st quartile	77.71%	79.74%
Median	79.46%	81.01%
3rd quartile	82.68%	84.35%
Maximum	86.27%	87.95%
p Wilcoxon=	0.345 >0.05	

Fig.4. Anterior relative distance – graphical representation

Table 3. Posterior relative distance

Posterior relative distance	C – O	C* – I
Minimum	61.38%	61.36%
1st quartile	65.61%	69.70%
Median	68.21%	73.70%
3rd quartile	70.67%	75.89%
Maximum	76.05%	81.12%
p Wilcoxon=	0.012<0.05	

Fig.5. Posterior relative distance – graphical representation

Thus, we observed that the eccentricity indices are different mainly because of the posterior relative distances. This can be due to the inion position being lower than the projecton of the occipital pole on the skull.

IV. **Discussion**

Our previous paper[7] emphasised the constancy of those craniometrical points that we call geometrical bioinvariants (obvious changes of the osseous relief), as Glabella and Inion.

Cerebrometrical results analysis reveals a restricted variability, especially when those values are converted to relative ones. Eccentricity index showed a gentle, but distinct deviation of upper extremity of sulcus centralis towards occipital pole. To find exactly its projection is naively, but a suitable approximation is available when cerebrometrical measurements are correlated with craniometrical geometrical bioinvariants, i.e Glabella and Inion, as correlational cranio-cerebrometry proved.

Skull development is stimulated first by brain spread[8,9] through dura mater [10,11]. As brain spreads, skull sutures respond by desmal bone adding and skull adapt itself to growing brain. Interestingly, cell divisions take place not in the middle of the suture, but in the osteogenical front of bones[12-14].

V. **Conclusions**

The only rigorous and definite way to locate projection of cortical sulci on calvaria external surface is medical imaging. Craniometrical points as Glabella and Inion are useful in proportional algorithms by approximation.

In case of necessity, we suggest an effective projection of upper extremity of sulcus centralis at a straight distance from Glabella representing 3/5 straight distance between Glabella and Inion, because the Inion position is usually lower than the projection of the occipital pole on the skull, thus approximating the position of the upper extremity of the sulcus centralis to a position that is lower that the real one.

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