MORPHOMETRY AND TOPOGRAPHY OF THE DEEP BRAIN STRUCTURES IN NORMAL CONDITIONS AND IN THE PRESENCE OF SPACE-OCCUPYING LESIONS BASED ON MRI DATA

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ABSTRACT

This study analyzes the morphometric parameters and spatial relationships of the deep brain structures under normal anatomical conditions and in patients with intracranial space-occupying lesions. MRI-based measurements demonstrate significant patterns of displacement, deformation, and volumetric changes in basal ganglia, thalamus, internal capsule, and ventricular structures. The findings emphasize the diagnostic and prognostic value of MRI morphometry in identifying mass effect, planning neurosurgical interventions, and improving differential diagnosis.

Introduction

Deep brain structures—including the thalamus, basal ganglia, internal capsule, and ventricular system—play a key role in motor integration, sensory processing, and regulation of higher neural functions. Space-occupying lesions (SOLs), such as tumors, cysts, abscesses, and hematomas, frequently produce mass effect leading to displacement or deformation of these structures.

MRI offers high soft-tissue contrast and serves as the gold standard for evaluating morphological changes induced by SOLs. However, comprehensive morphometric analysis of deep structures remains underutilized in routine practice. Systematic quantification may significantly enhance diagnostic accuracy and early detection of pathological shifts.

The aim of this study is to assess morphometric and topographic alterations of deep brain structures in normal conditions and in the presence of SOLs using MRI data.

Materials and Methods

–A comparative observational study was conducted on two groups:

–Control group: Individuals with MRI scans showing no intracranial pathology.

–Study group: Patients with confirmed intracranial SOLs producing measurable mass effect.

Examinations were performed on 1.5T scanners using:

– T1-weighted images (pre- and post-contrast)
– T2-weighted images
– FLAIR
– DWI
– SWI (if hemorrhagic components suspected)

Morphometric Measurements

Measured parameters included:

– volumetric indices of thalamus and basal ganglia

– distances from midline structures (septum pellucidum, third ventricle) to reference points

– width of lateral ventricles

– displacement angles relative to the interhemispheric fissure

– deformation indices of internal capsule

Statistical Analysis

Data were evaluated using descriptive statistics and correlation analysis. Significance level: $p < 0.05$.

Results

Normal Morphometry

In the control group, symmetric morphology of deep structures was observed. Ventricular width and the thalamic positions showed minimal variability.

Mass Effect in SOLs

Patients with SOLs demonstrated:

– lateral displacement of thalamus and basal ganglia (average 4–12 mm depending on lesion size)

– compression or expansion of lateral ventricles

– distortion of the internal capsule, particularly in lesions adjacent to deep white matter

– rotational shifts of midline structures in large tumors

– proportional relationship between lesion volume and degree of anatomical displacement

Correlation With Lesion Characteristics

– Larger lesions (>30 cm^3) produced statistically significant displacement ($p < 0.01$).

– In cystic or necrotic tumors, surrounding tissue deformation was more pronounced than volumetric displacement.

– Highly infiltrative lesions (gliomas) showed more diffuse morphometric changes compared to metastases or meningiomas.

Discussion

MRI morphometry provides valuable insight into the biomechanical impact of SOLs on deep brain structures. The displacement magnitude correlates not only with lesion size but also with its biological behavior, location, and growth pattern.

The analysis confirms that morphometric criteria can:

– improve early detection of mass effect

– differentiate infiltrative from expansive processes

– support preoperative planning by mapping critical pathways

– assist in monitoring postoperative or post-radiation changes

Routine incorporation of quantitative MRI metrics into clinical workflows may increase diagnostic precision and enhance neurosurgical outcomes.

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