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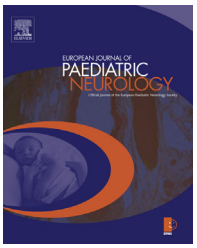

Original Article

Relationship between somatosensory deficit and brain somatosensory system after early brain lesion: A morphometric study

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ABSTRACT

Cerebral Palsy (CP) is a group of permanent motor disorders due to non-progressive damage to the developing brain. Poor tactile discrimination is common in children with unilateral CP. Previous findings suggest the crucial role of structural integrity of the primary (S1) and secondary (S2) somatosensory areas located in the ipsilesional hemisphere for somatosensory function processing. However, no focus on the relationship between structural characteristics of ipsilesional S1 and S2 and tactile discrimination function in paretic hands has been proposed. Using structural MRI and a two-point discrimination assessment (2 PD), we explore this potential link in a group of 21 children (mean age 13 years and 7 months) with unilateral CP secondary to a **periventricular white matter injury (PWMI)** or middle cerebral artery infarct (MCA). For our whole sample there was a significant negative correlation between the 2 PD and the gray matter volume in the ipsilesional S2 (rho = −0.50 95% confidence interval [−0.76, −0.08], one-tailed p-value = 0.0109) and in the ipsilesional S1 (rho = −0.57, 95% confidence interval [−0.81, −0.19], one-tailed p-value = 0.0032). When studying these relationships with regard to the lesion types, we found these correlations were non-significant in the patients with **PWMI** but stronger in patients with MCA. According to our results, the degree of sensory impairment is related to the spared gray matter volume in ipsilesional S1 and S2 and is marked after an MCA stroke.

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Our work contributes to a better understanding of why some patients with CP have variable somatosensory deficit following an early brain lesion.

1. Introduction

Cerebral Palsy (CP) is a group of permanent motor disorders due to non-progressive damage to the developing brain. CP is a major cause of motor disability in children. Among these CP children, approximately one third have unilateral CP (UCP) resulting in abnormal motor function of one upper limb, and normal motor function of the other. Poor tactile discrimination is common in children with UCP.[1] Perception and tactile discrimination deficit is believed to contribute to reduced dexterity, impaired motor learning[2,3] and motor planning.[4–6] Conflicting results have been reported for a correlate with the global motor function.[7] It has been suggested that a somatosensory deficit could behind the prominent motor impairment in certain cases of subjects with UCP[8] (for a commentary see[9]).

Conventional structural Magnetic Resonance Imaging (MRI) is increasingly performed in children with CP. This allows structural and volumetric analysis and could provide critical insights into the relationship between function and underlying cortical changes or damage.

Regarding the anatomical and topographical study, primary (S1) and secondary (S2) sensory areas and the inferior parietal cortex directly neighboring S1 and S2 located in the ipsilesional postcentral gyrus (i.e., contralateral to the paretic hand) were shown to be determinant for the somatosensory function following a middle cerebral artery (MCA) infarct: typically damaged in children with UCP with a somatosensory deficit but typically spared in those without a somatosensory deficit.[10] Using structural analysis of the somatosensory system, we have also suggested[11] that a more pronounced affection of ipsilesional S2, located on the parietal operculum,[12] may underlie the stronger tactile discrimination deficit.

These findings suggest a crucial role for structural integrity of ipsilesional S1 and S2 for somatosensory function processing. Functional outcomes have already been shown to be linked to gray matter volume[13] in healthy subjects but also in pathology.[14] For example, Kühn et al.[15] found a positive correlation between manual dexterity and GM volume notably in the supplementary motor area and the cerebellum. To date, no focus on the relationship between volumetric characteristic of ipsilesional S1 and S2 and somatosensory function has been proposed in children with UCP.

The purpose of our study was to define how the sensory deficit is related to structural brain modifications defined by gray matter volume in children with UCP secondary to white matter (WM) lesion (**PWMI**) or MCA infarct.

Since the structural integrity of S1 and S2 in the ipsilesional hemisphere seems crucial in preserving the somatosensory function of the paretic hand, as demonstrated by previous research,[10] it should be possible to find a negative correlate between the remaining GM volume of S1 and/or S2 and the somatosensory function as assessed by the two point discrimination task (2-PD). Therefore, we tested the hypothesis that the more severe the somatosensory deficit (i.e. the higher the value of 2 PD) the more a reduced volume (i.e. the lower the value of GM volume) would be found for S1 and S2 located in the ipsilesional hemisphere (see the method part for a detailed explanation).

2. Materials and methods

2.1. *Participants*

Twenty-one children ((seventeen males, mean age 13 years and 7 months, aged 6 years 10 months–20 years 10 months) with clinical apparent UCP were included as part of an ongoing study[16–18]) (Table 1). The population analyzed here is made up of from 12 subjects suffering from right UCP (left brain lesions) and 9 from left UCP (right brain lesions). 10 subjects suffered from MCA and 11 from **PWMI**. Subjects 20 and 21 presented pure left UCP despite some MRI signal abnormalities in the left hemisphere which are not clinically relevant. **All participants were born after 35 weeks of gestation**. The Bimanual Fine motor function was used to categorize children into five levels according to their ability to perform fine motor function.[19] Approval was given by the local Ethics' Committee. All subjects and parents gave written, informed consent. Exclusion criteria were as follows: severe mental retardation, severe vision impairment, severe attention disorders.

2.2. *Sensory assessment*

Neurological examination was performed in all participants by the last author (MD). Discriminative somatosensory function was characterized by the minimal distance between two points of tactile stimulation on the thumb that render them distinguishable. (2-Point Discrimination, 2-PD). The 2-point aesthesiometer (Aesthesiometer Lafayette®) was used to determine this distance on the paretic hand (affected hand) and the non paretic hand (unaffected hand) using the thumb pad on the palm. Each subject was instructed to close their eyes while the examiner (MD) applied the two contact points. The subject was asked to report whether they felt one or two points. Two trials were performed for each hand. The trial was performed by increasing the aesthesiometer distance from 0 cm in 1 mm steps until the subject was able to successfully resolve two points. The average of these two discrimination trials was recorded. Higher values reflect stronger

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