Quantifying perinatal brain maturation using anatomical MRI

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***Abstract*—Perinatal Magnetic Resonance Imaging has proven to be suitable and efficient for detecting alterations in a growing number of pathologies. Major advances in brain MRI acquisition and processing open the way to quantitative analyses not achievable so far. Recent results highlight the great potential of regional descriptors of the geometry of the cortical surface extracted from anatomical MRI to characterize typical and abnormal maturation trajectories in the perinatal period.**

I. Introduction

Continuous, sustained methodological advances in image acquisitions and processing (fast acquisition, movement correction, super-resolution/reconstruction) allow to address new problems that were not affordable few years ago (e.g. RS-fMRI, tractography) [1], [2]. More specifically, dedicated image processing pipelines allow to extract a 3D mesh representation of the cortical surface from an anatomical MRI acquired either before or after birth [3]. Global shape descriptors such as the gyrification index can then be computed for each individual and compared across groups. Early disturbance in cortical development at birth in preterm babies can be quantified using this approach, and the extracted measures are predictors of infants'outcome at term equivalent age [5]. Global gyrification measures were also used in [4] to compare intra uterine maturation in fetuses and extra uterine maturation in age-matched preterm infants and showed that the folding dynamics is different.

II. Finer Scale Descriptors

In order to get access to more local shape descriptors, we recently adapted a surface registration technique developed initially for adult brain to address the problem of defining spatio-temporal correspondences across cortical surfaces from a group of fetuses [6]. The analysis of local curvature showed that brain folding is a progressive process, and that large folds observed in adults do emerge from smaller indivisible entities. Based on this observation, we developed a technique to decompose the sulci into smaller entities corresponding to putative first sulcal folds, denoted as sulcal pits [7]. Using a closely related approach [8], Im and colleagues have shown that sulcal pits are valid descriptors of brain folding in fetuses, allowing to detect abnormal folding patterns [9]. On the other hand we have shown that sulcal pits are also suitable for characterizing postnatal brain maturation and abnormal folding in a group of children with Autism spectrum disorder between 1.5 and 10 years old [10]. Finally, sulcal pits and corresponding shape descriptors can also be extracted from synthetic folded surfaces resulting from bio-mechanical modeling such as proposed in [12] and compared to real data. In the future, these predictive models will be decisive for enhancing our understanding of neural mechanisms resulting in abnormal cortical maturation in developmental brain disorders.

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III. Conclusion

Quantitative local/regional descriptors of the geometry of the cortical surface have a great potential to highlight abnormalities in cortical folding pattern and to detect departure from typical developmental trajectories in the perinatal period, both before and after birth. They will be instrumental to uncover the biological mechanisms underlying the cortical maturation.

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