Methodological aspects of deep brain stimulation

Summary

In this thesis, the methodological aspects of DBS (Deep Brain Stimulation) surgery technique were reported, investigated and questioned by 5 studies. **In Chapter 2**, we documented technical events encountered during DBS surgeries from 1999 onwards with a retrospective qualitative analysis. The technical complications were mostly originated from stereotactic frames and stereotactic planning stations. Stereotactic frame related complications included movement-related fixation problems, head anatomy related problems, and lack of maintenance related issues. Moreover, we detected some localizer related complications which were compatibility issues of the stereotactic localizer and planning station, field of view effect on fiducials, air bubbles in localizers using liquid solutions, and disengaged localizer effect. Lastly, planning station related complications included image fusion failures and CSF signal effect on image fusion.

Frame mounting is considered one of the most critical steps in stereotactic DBS surgeries. In this sense, we addressed the question whether an asymmetrically mounted frame influences the accuracy of stereotactic electrode implantation **(Chapter 3)**. After magnetic resonance imaging (MRI) scan of a citrullus lanatus, symmetric and asymmetric mounting of the frame, which could occur in clinical scenarios, was performed with computed tomography (CT). We analyzed these images with tree different stereotactic planning stations. Our results showed that an asymmetrically mounted frame did not affect the accuracy in the mediolateral axis (X-coordinate) or the anteroposterior axis (Y-coordinate). However, we found a clinically relevant error in the superoinferior axis (Z-coordinate). These results suggested that asymmetrical frame mounting can lead to stereotactic inaccuracy in the superoinferior axis (Z-coordinate).

The slice thickness of a stereotactic CT is a matter of discussion but often thin slices are used and recommended because of the high reported accuracy. **In Chapter 4** we investigated if the stereotactic CT slice thickness has an effect on stereotactic calculations and its accuracy. We used a phantom, a citrullus lanatus, implanted with a DBS electrode. The deepest contact point of the electrode was the defined fixed target. Stereotactic coordinates, ring and arc angles from all stereotactic CT scans with different slice thicknesses were recorded and compared after fusion with a thin sliced non-stereotactic MRI. We found no significant effect of increasing slice thickness of CT on the stereotactic calculation when fused with a thin-sliced MRI in a simulated stereotactic DBS setting.

Another focus area within the study was the microelectrode recording (MER) method. Firstly **(Chapter 5),** we reviewed the literature and focused on how MER methodology started to be used in clinical applications historically. Then, the necessity of MER methodology after the technological developments in MR imaging in the literature was discussed with current controversies. Finally, we emphasized that intraoperative electrophysiology is not indispensable for DBS surgeries; however, it is important that the MER methodology and technology provides the chance to correct systemic errors that may arise during the application of stereotactic surgical approach.

In Chapter 6, we focused on operational time of MER method. We investigated the average time spent for MER during Parkinson's Disease (PD) DBS surgeries with a prospective study. MER usage durations for the first operated side of the brain, for the second operated side of the brain and the complete operation were recorded and calculated respectively. In addition, we calculated the percentage of central trajectory choice for the permanent electrode implantation for the first side and for the second side for a bilateral PD STN DBS surgery within the same series. The results showed that MER procedure has an incremental impact on the operational time of the surgery. However, we concluded that MER method provides an important maneuverability for DBS surgeries in order to compensate possible error sources intraoperatively.