

FUNCTIONAL CONFIRMATION OF ELECTRODE PLACEMENT IN THE  
PERIVENTRICULAR/PERIAQUEDUCTAL GRAY REGION FOR DEEP BRAIN STIMULATION OF  
NEUROPATHIC PAIN BY RECORDING THE SACCADE-RELATED LOCAL FIELD POTENTIALS OF THE  
SUPERIOR COLLICULUS

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Deep brain stimulation of the periventricular/periaqueductal gray (PVG/PAG) is an effective therapy for suppression of medically intractable pain of central origin. Functional localisation of the target and confirmation of the electrode placement presents a challenge. Monopolar or bipolar test stimulation has been commonly used. In this case, although the clinical outcome of pain suppression can be largely predicted with test stimulation by either inducing paraesthesia in the area of pain or pain suppression, the precise localisation of the stimulation electrode is still unclear in most of the cases. Neuronal recordings are also restricted as: (1) multi-microelectrode approach may be too risky because the PVG/PAG region is deep down in the midbrain, and (2) no spontaneous local field potentials (LFPs) can be detected as a functional marker via the implanted macroelectrode in the PVG/PAG. We attempted to identify intrinsic activity from the structures neighbouring the PVG/PAG so that LFPs could be recorded via the implanted macroelectrode and be used as a functional marker for localisation.

Based on focal anatomy of the PVG/PAG region and clinical observation of test stimulation inducing abnormal eye movements, with approval of the local ethical committee, the saccade-related LFPs were recorded via six implanted stimulating electrodes (Medtronic 3387) in four patients to identify potential functional markers for functionally localising the PVG/PAG. 2 to 4 days after implantation, LFPs were recorded bipolarly via the three adjacent pairs of electrode contacts under various oculomotor and visual conditions, and the saccadic eye movements were monitored using either surface electrooculogram or video eye-tracker. The compound LFPs were analysed using time-frequency analysis. We found that an intrinsic activity in the frequency range of 2 - 12Hz appeared in the compound LFPs during visually guided saccades. The primarily oculomotor component was in the range of 4 - 12Hz and the visual component appeared mainly below 3Hz. Furthermore the amplitude of the oculomotor component of the LFPs gradually declined with the distance from the superior colliculus. The volume conduction of the saccade-related LFPs was then modelled using non-linear regression of the amplitude and distance correlation. Results suggested that the LFPs were generated by the superior colliculus, and the amplitude of the saccade-related LFPs recorded sequentially via the paired electrode contacts significantly correlated with the distance between the electrode contacts and the superior colliculus. The LFPs disappeared once the electrode contacts were more than 5 - 6mm away from the superior colliculus. The amplitude/distance correlation of the saccade-related LFPs can be used as functional index for functionally localising the superior colliculus and in turn the PVG/PAG region can then be localised. We conclude that recording the saccade-related LFPs is a safe procedure and can be done intraoperatively. Although recordings from a single track only provide a two- rather than three-dimensional mapping along the electrode trajectory, it may still improve the accuracy of electrode implantation for therapeutic pain

suppression. It also provides an invaluable opportunity to directly study physiology of the superior colliculus in human.