P4.23.

Time-frequency analysis of interictal discharges and ripples recorded with laminar microelectrode arrays in humans

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High frequency oscillations (HFOs) have been implicated in the generation of seizures and localization of seizure activity. Using a system of laminar arrays of microelectrodes, we recorded potential gradient, current source density (CSD) and multi-unit activity in wakefulness from the neocortex and mesial temporal lobe of patients with medically intractable focal epilepsy undergoing clinical study for localization of seizure foci (n = 14). Bursts of high frequency activity consistent with previously described ripple oscillations were recorded in 8 subjects. The vast majority of these events (over 90%) were coincident with epileptiform interictal discharges (IID). Such HFO bursts were maximal after the onset of the IID. Conversely, this high frequency activity was not present in all discharges even for a given subject. When present, HFOs with a central frequency of 80-150 Hz had greatest power in upper cortical layers. CSD analysis showed the presence of an alternating sink-source pair in these upper cortical layers. Faster oscillations and activities (>150 Hz) were more prevalent in lower cortical layers. In general, this faster, deeper activity preceded the slower activity seen in superficial layers (10-30 ms). We often observed a long lasting (100-300 ms) de-activation before the IIDs, that resembled a cortical down-state. These results suggest that different frequencies observed may reflect different aspects of the same fundamental process in different cortical domains.