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The Inferior Colliculus: Structural, Immunohistochemical, Physiological and Behavioral Properties Following Neural Grafting

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The inferior colliculus (IC) occupies a central position in the auditory pathways and integrates ascending and descending information. Neurons of the central nucleus of IC possess laminated dendritic fields which provide a substrate for selective responsiveness to auditory stimuli. The present investigation examines anatomical, immunohistochemical, functional and behavioral indices of recovery following development of graft implants into the IC.

Adult and infant (PND 0-9) IC of Long Evans rats were lesioned under nembutal anesthetic (50 mg/kg b.w.) and whole tissue from the E16-19 caudal tectum implanted. After 60-270 days animals were processed for one or more procedures. The first experiment involved the study of graft and normal tissues using rapid Golgi stains and Nissl methods to examine the morphology of grafted and normal IC. General connectional information was evaluated using HRP-WGA and diI transport methods. Antibodies to the calcium-binding proteins calbindin and parvalbumin (courtesy of Dr. Kenneth Baimbridge) were applied to normal and unilaterally grafted tissues for reactions using ABC methods. Functional efficacy was studied using tritiated 2-deoxyglucose methodology under quiet and white noise stimulus conditions. Behavioral testing involved spatial detection of noise stimuli in grafted, lesioned and control rats.

In Golgi material many grafted neurons have dendritic arrays which are relatively flattened along one dimension. Such neurons resemble the discoid class of cells which characterize the normal central nucleus of IC. Other stellate cell populations appear in both graft and control animals. HRP-WGA injections into the target of the IC, the medial geniculate body, result in retrograde labelling of both IC and graft neurons. Neurons with oval or elongate soma and polarized initial dendrites suggest discoid-type cells. Labelled multipolar cells also appear in grafted and normal tissues. Fibers of the lateral lemniscus and brachium of IC, as well as dorsal nuclei of the lateral lemniscus and other neurons, are labelled after diI injections into graft cores.

The central nucleus of the control IC stains heavily for parvalbumin including different populations of neurons. However, the central core of IC is almost devoid of labelling for calbindin, in contrast to dorsal and lateral nuclei of IC. Grafted material shows similar staining patterns with the core labelling intensely for parvalbumin, but not for calbindin. Graft margins show more neuronal labelling for calbindin. Metabolic maps show that both quiet control and graft tissues have substantial spontaneous activity at a similar level. Acoustic stimulation significantly enhances metabolic activity in both the graft side and intact host side of experimental animals. The activity of host and graft tissues to sound stimulation is not significantly different. Coupled with anatomical and immunohistochemical findings, these results suggest that tectal grafts not only possess certain normal structural and biochemical properties, but also contain cellular elements responsive to sensory stimulation. These results imply that graft tissue is functionally integrated into the auditory system, but the specificity of this connection is not yet determined.

The final determinant for graft effects on a neural system involves indices of behavioral recovery. Animals with bilateral lesions of IC show deficits on spatial detection tasks (testing began 7 days after recovery). Grafted animals show significant improvement on spatial detection

tasks compared to the group of animals with equivalent size lesions. Performance of grafted animals on spatial tasks approaches performance of unoperated animals. These results suggest that the inferior colliculus plays a role in spatial behavior and that neural grafting can help remedy deficits produced by damage to this region of the auditory system.