

Acute microelectrode array implantation into human cortex: preliminary considerations

J. Sales

Neurosurgeon University Hospital Alicante-Spain

4th edition of the European Summer School on Neuroengineering



Instituto de Bioingeniería Universidad Miguel Hernández





Neurosurgical implants in the Head and Neck zone

- Single-use hydrocephalus shunts and components.
- Self-closing intracranial aneurysm clips.
- Spinal artrodesis
- Implantable neural stimulators.

Neural interfaces

Visual prostheses- stimulate retina/cortex

Deep brain stimulation

Cochlear implants – stimulate auditory nerve

> Stimulate skin nerves for pain relief

Stimulate back muscle to stop abnormal spine curvature

Record sensory

feedback from hand

FES - Activate paralysed hand muscles BCI - Record cortical motor commands/motor intentions

 Pacemaker for heart, diaphragm

 Myoelectric prostheses – Record EMG signal to control artificial arm/hand

Stimulate autonomic nerves to control bladder, correct impotence

> FES - Coordinate activation of paralysed leg muscles for walking

Implantable neural stimulators.

- Auditory-Brainstem-Implant
- DBS for Parkinson
- VNS Therapy for seizures
- Motor cortex stimulation for pain
- (¿Science Fiction?)
- Neurophrosthesis devices for the blind

Indications of Auditory Brainstem Implants in the Treatment of Hearing Loss

• Profound hearing loss resulting from damage to both hearing nerves.

• Frequently encountered in patients with neurofibromatosis type 2.

Material Auditory-Brainstem-Implant





Action Mechanism

• Electrical stimulation to the second neuron of the auditory pathway at the brainstem





• These protheses are capable of partially bridging the gap in the auditory pathway caused by the loss of hearing nerve and inner ear function. The resulting hearing impression is useful to improve lip reading and the distinction of environmental sounds.

• Open word recognition, however, is rarely gained.

Future

- The search for alternatives has centered around improving the electrode-brainstem interface.
- Penetrating electrodes for deep brain stimulation of the cochlear nucleus have been developed and await there first clinical application.



Place of Insertion



Abbildung 2: Topographisch-anatomische Lokalisation und Zuordnung der Nuclei cochlearis in einer axialen Schnittebene in Höhe der Eintrittszone des Nervus vestibulocochlearis (Einsatz rechts unten). tp, Tractus pyramidalis; Ncv, Nucleus cochlearis ventralis; cpb, Corpus pontobulbare; Ncd, Nucleus cochlearis dorsalis; V, Tractus trigeminali; ol, Olive; nvst, Nucleus vestibularis; Im, Lemniscus medialis; ventr. IV, IV. Ventrikel; nVIII, Nervus vestibulocochlearis; SS, 2. Neuron der somatosensorischen Bahnen; pci, Pedunculus cerebelli inferior; fr, Formatio reticularis

Parkinson indications

Disabling, medically unresponsive tremor due to essential tremor or Parkinson's disease

Material



 Four thin insulated, coiled wires bundled within polyurethane insulation. Each wire ends in a 1.5 mm electrode, resulting in four spaced electrodes at the tip of the lead. The DBS Lead delivers stimulation using either one electrode or a combination of electrodes.

Place of Insertion

• Ventralis intermediate nucleus of the thalamus (Vim),

• Globus pallidus pars interna (GPi)

• Subthalamic nucleus (STN).

Subthalamic Stimulation

The electrodes are placed under local anesthetic, using stereotactic or computer-assisted guidance techniques.

Intraoperative microelectrode recording of single neurons is often performed to verify the correct physiological target location, and test stimulation is used to confirm therapeutic benefit and to evaluate side effects.

Several electrode passes may be required to refine the target location.

Once correct physiological targeting has been confirmed, the electrodes are permanently **anchored in place.**







Method

- Electrodes may be placed unilaterally or bilaterally, depending on the disease being treated and the individual patient's symptomatology.
- The electrodes are then connected to a computerized pulse generator that is implanted subcutaneously, in a manner similar to that used for a pacemaker.
- Pulse generator implantation is performed either contemporaneously with electrode placement, or as a staged procedure at a later date.
- Stimulation parameters are adjusted to maximize therapeutic effects.

Mechanism of Action

- In PD, loss of dopamine-producing cells leads to excessive and abnormally patterned activity in both the GPi and the STN. "Pacing" of these nuclei with a constant, steady-frequency electrical pulse corrects this excessive and abnormal activity.
- The mechanism by which the constant-frequency stimulation pulse affects nearby brain cells has not been determined.
- Although depolarization block may remain a major mechanism of action, generation of action potentials and release of neurotransmitters may also be involved in the therapeutic effects of DBS in Parkinson's disease.

Results

- Following DBS, there may be a reduction in need for, but not elimination, of antiparkinsonian medications.
- At present, it is believed that DBS only suppresses symptoms and does not alter the underlying progression of PD.









VAGUS NER VE STIMULATION IN EPILEPSY



Indications

 In Europe, VNS Therapy is indicated for use as an adjunctive therapy in reducing the frequency of seizures in patients whose epileptic disorder is dominated by partial seizures (with or without secondary generalisation) or generalised seizures, which are refractory to antiepileptic medication.

VNS Therapy Pulse Generator & Lead Model 102

- Model 102 for use with a single-pin lead (Model 302)
- 6.9 mm thick (33% thinner than Model 101)
- Weighs 25 g (34% lighter than Model 101)
- 6- to 11-year battery life

Cheronics and the second secon		
Gherontes -	e	(VINS) PU
1		Gherontes-
	1	

VNS Therapy Pulse Duo Generator Model 102R

- New Model 102R for use with a *dual-pin* lead (Model 300) for routine generator battery replacement
- Same technology as the Model 102 product line
 - 6.9 mm thick (33% thinner than Model 101)
 - Weighs 27 g (29% lighter than Model 101)
 - 6- to 11-year battery life



Vagus Nerve: Cranial Nerve X

Left cervical vagus nerve

- 80% afferent fibers, mostly unmyelinated
- 20% efferent fibers, mostly unmyelinated parasympathetic fibers to viscera, with myelinated fibers to vocal muscles
- **Right** cervical vagus nerve has more potential for cardiac effects in animal models



Vagus Nerve - NTS - PBN Project to Key Cerebral Regions



Limbic structures

- Amygdala
- Insula

Autonomic structures

- Hypothalamus
- Periaqueductal gray
- Reticular structuresThalamus

NTS=nucleus of the tractus solitarius; PBN=parabrachial nucleus; PAG=periaqueductal gray; CNA=central nucleus amygdala; PVN=periventricular nucleus of hypothalamus; VPM=ventral posterormedial nucleus of thalamus.

Henry TR. Neurology. 2002;59(suppl 4):S3-S14.





• In clinical studies, most patients had a reduction in seizure frequency, although some had no change. Some patients do not start having a noticeable reduction until after many months of therapy.



• Ongoing and future studies will determine how important a role VNS will ultimately play in the overall treatment of epilepsy.

Motor Cortex Stimulation for Pain

• Chronic, persistent pain (which has a variety of causes), in patients that are not responding to medication.

• Devices for chronic pain have been implanted in a variety of regions, most commonly in the spinal cord.



Mechanism of Action

- CBF increases occur in the ipsilateral ventrolateral thalamus in which corticothalamic connections from the motor and premotor areas predominate.
- There is a correlation with the extent of pain relief and the increase in cingulate blood flow.
- Activation of the brainstem periaqueductal gray area is also a possible effect.



• Effective in approximately 50% of the patients with central deafferentation pain in the largest published series.

El trabajo de Jose Manuel Rodriguez Delgado



El gato contrae los músculos de la pierna en respuesta a la estimulación de un electrodo implantado en su cerebro (experimento realizado en 1950)



Experimentos en toros





Experimentos en toros





Cortical Visual Neuroprosthesis for the Blind

OUR PROJECT

 Set-up all the required industrial know-how to realize and safely implant an active cortical device to provide a functional sense of vision to blind persons with dysfunctions located in the periphery of the visual system Currently there is no effective treatment for some patients who are profoundly visually handicapped due to degeneration or damage to the:

- Retina Optic nerve
- Brain.



• While the full restoration of vision seems to be impossible, the discrimination of shape and location of objects could allow blind subjects to 'navigate' in a familiar environment and to read enlarged text, resulting in a substantial improvement in the standard of living of blind and visually impaired persons.
• Several laboratories worldwide are developing microelectronic prosthesis intended to interact with the <u>remaining healthy retina</u> or <u>optic nerve</u>.

• However the output neurons of the eye (ganglion cell neurons, which in turn give rise to the optic nerve axons) often degenerate in many retinal blindnesses and therefore a retinal or optic nerve prosthesis would not be always helpful.

...However, the brain is usually perfectly functional in spite of these injuries.



... the solution: Communicate directly with the brain

bioinspired encoder intracortical electrodes

3

telemetry system

Physiology and Pathology of the Visual System





Electronics and Materials Engineering

Implementation, Rehabilitation, Regulatory Aspects

University of Utah • R.A. Normann Universidad de Harvard • Alvaro Pascual-Leone **University of Oldenburg** • Josef Ammermüller Universidad de Granada • F. Pelayo • S. Romero **University of Vienna** • Peter Ahnelt **CNRS** (Paris) •Lyle Graham **University of Montpellier** • Pierre Rabischong **INESC-ID** (Portugal) •M. Piedade

Hospital General Universitario de Alicante • Carlos Botella • Juan Sales • Ignacio Aranda **Universidad Miguel** Hernández • Eduardo Fernández • Bernat Soria • Jose Manuel Ferrandez •M. Bongard •R. De Abajo •Ana Jaen •Raquel Climent • Marcelino Aviles • Arantxa Alfaro Paula Bonomini • Cristina Marin •Lola Catala

• Paqui Leyva



CORTEX V1





Design of electrodes for cortical stimulation





Microelectrode Arrays

- Electrode arrays with larger numbers of electrodes could provide greater therapeutic function than arrays with small numbers of electrodes.
- The University of Utah developed silicon based electrode arrays that contain 100 microelectrodes.
- Currently the most sophisticated technology available to provide high-density temporal and spatial resolution of neuronal signals.

• Each of these spikes or electrodes is connected to a very fine wire that provides an electrical connection to the "outside world".

• The array is inserted into the cortex with a special patented device so that the electrode spikes penetrate to exactly the correct depth to interface with a stable population of cortical neurons on a long term basis.

- Diameter of electrode at base is approximately 80 μm.
- Radius of electrode tip is approximately 3-5 μm.
- Active electrode region is platinum, 35-75 μm long.
 E
- lectrode impedance is approximately 100-800 kohm.
- Substrate and needles insulated with parylene insulation.
- Substrate is 4.2 mm x 4.2 mm x 0.25 mm silicon.

Biological problems

- Difficulties in surgery: most surgical interventions are not possible without destroying neighboring parts of neural tissue.
- Biocompatibility:
 - It does not evoke a toxic, allergic or immunologic reaction
 - It does not harm or destroy enzymes, cells or tissues
 - It does not cause thrombosis or tumours
 - It remain for a long term within the organism without encapsulation or rejection
- Reliable fixation
- Others: Materials, Sterilizing agents, ...



The pedestal was designed for long-term implantation. The low-profile design allows for protection from damage during and after experimental recordings





¿How to push?

- Trying to push the array into the tissues only mechanically depresses the surface of the tissue, resulting in incomplete insertion of the array and potential tissue trauma.
- However, the viscoelastic nature of neural tissues makes it possible to insert the array with a high velocity implantation technique.

Pneumatically-actuated Impulse Microelectrode Array Inserter



• Designed to use a momentum impulse technique to insert the 1.5-mm long 100-electrode arrays into feline and primate cerebral cortical tissues in about 0.2 ms.

Implantation: surgery procedure



Human Experiments: First Results











6 patients with epilepsy and cortical resection

House PA, MacDonald JD, Tresco PA, Normann RA.

Acute microelectrode array implantation into human neocortex: preliminary technique and histological considerations. Neurosurg Focus. 2006 May 15;20(5):E4.





Acute Experiments: Early response



Acute Experiments: histology





Human: Control

Human: Microelectrode











Microhemorrhages at the border of the array



The speed of the pneumatic insertion device has also not yet been fully optimized for human tissue

Explantation of the arrays













Cortical depression in the surface of the cortex



Hemorrhage results

 Insertion of the arrays resulted in no clinical complications, and no significant hemorrhage was visualized intraoperatively

Insertion Results

• Higher insertion speeds may be needed to overcome more consistently the physical barriers associated with human cortex

MICROSCOPIC RESULTS

- Some kind of cells initially damaged
- The neurons are unaltered.
- The most important alterations are in the periphery.

CONCLUSIONS

- Well tolerated by the CNS
- It can be applied as neuroprosthetic device.
- Developing new diagnostic and therapeutic investigation.
- Physiology of the human cortex and knowledge of his basic properties.



• No differences between healthy brain and brain near a tumor region


The NeuroProbes project

UNIVERSITY OF UNIVERSITY OF



imt

PHILIPS

Cochlean micronit

Objective

Development of arrays of multifunctional microprobes for high temporal and spatial resolution brain studies that include freely moving subjects, with recording **and** stimulation done both electrically and chemically.



Features

- Dense 3-D microelectrode arrays for recording
- Microfluidics for inactivation studies
- Individual depth control for accurate placement
- Attachment and insertion technologies
- Conformation to convoluted surfaces such as *sulci* of highly folded cortices
- Multi-drug delivery
- Integrated biosensor probes
- Telemetry







www.visualprosthesis.org

G • O - 🖹 🖻 🏠 🔎 🛠 🥹 🙆 • 🥃 🕅 • 🗔 🎎 🦓

🛐 Elemento emergente bloqueado. Para ver este elemento emergente o consultar opciones adicionales, haga clic aquí...

CORTIVIS QLK6-CT-2001-00279

Cortical Visual Neuroprosthesis for the Blind

5 ×

	Home	Groups	FAQ	Links	Contact Us
--	------	--------	-----	-------	------------

- Home
- Overview
- Partners
- Publications
- Software
- Links
- Contact Us
- Private

Search this site:







CORTIVIS Home

Welcome to the CORTIVIS Website!!

These pages contain information related with the development of a Cortical Neuroproshesis for the Blind. This project is being carried out with financial support from the Commission of the European Communities, specific RTD programme "Quality of Life and Management of Living Resources", QLK6-CT-2001-00279.

This project aims to develop prototypes in the field of visual rehabilitation and to demonstrate the feasibility of a cortical neuroprosthesis, interfaced with the visual cortex, as a means through which a limited but useful visual sense may be restored to profoundly blind people. While the full restoration of vision seems to be impossible, the discrimination of shape and location of objects could allow blind subjects to 'navigate' in a familiar environment and to read enlarged text, resulting in a substantial improvement in the standard of living of blind and visually impaired persons.

The next pages deal with aspects that are relevant to our approach for restoring a limited but useful sense of vision to profoundly blind. For other alternative approaches, follow the links page.

We hope you will find navigating through our site easy and rewarding.

Please send any questions or comments to: <u>*e.fernandez@nmh.es*</u>

back to top

- 🖹 🖻 🏠 🔎 🜟 🏵 🔗 🦂 🦉 - 📙 鑬 🦓 G

🛐 Elemento emergente bloqueado. Para ver este elemento emergente o consultar opciones adicionales, haga clic aquí...

CORTIVIS QLK6-CT-2001-00279 -

Cortical Visual Neuroprosthesis for the Blind

🥂 – 8 ×

×

Links Contact Us Home FAQ Groups

	back to top	-
 Home Overview 		
 Partners 	Links for scientists	
Publications		
Software	Webvision Home Page	
Links	Information concerning the organization of the vertebrate retina	
 Private 	<u>Retinitis Pigmentosa Page</u> John Wenberg's Retinitis Pigmentosa Page (Information and links related with Retinitis Pigmentosa)	
	Data on Visual Impairment A Global Data Bank on Blindness	
Search this site:	<u>Online Mendelian Inheritance in Man</u> National Center for Biotechnology Information	
Goll	Retinal Information Network RetNet provides tables of genes causing inherited retinal diseases	
R	EyeWorld Online A Print and Electronic News Service for Eye Care Physicians	
	Ocular Genetics Database Ocular Genetics Database	
	Retina International's Scientific Newsletter Retina International's Scientific Newsletter	
	<u>UCSD Retina Information Page</u> This site provides access to information regarding neuroscientific investigation of the retina.	
	A human mitochondrial geneome database A compendium of polymorphisms and mutations of the human mitochondrial DNA	
	<u>The Koch Lab</u> The research in the laboratory of Professor Christof Koch focuses on several areas.	
	The Foundation Fighting Blindness	

G • 💿 · 🗷 🗟 🏠 🔎 🜟 🥹 🙆 • 😓 🛍 • 🗔 🛍 🥸

🛐 Elemento emergente bloqueado. Para ver este elemento emergente o consultar opciones adicionales, haga clic aquí...

CORTIVIS QLK6-CT-2001-00279

Cortical Visual Neuroprosthesis for the Blind

Home Groups

Links

FAQ

Contact Us



- Overview
- Partners
- Publications
- Software
- Links
- Contact Us
- Private

Search this site:





Software developed inside the CORTIVIS Consortium

- <u>RETINER: A Retina-like processing and coding platform for Cortical Neuro-Stimulation</u>
- PARBRAILLE: A suite of programs for experiments using Braille characters
- NEV2lkit: Tool for handling multielectrode recordings (plot the data, automatically sort the units...)
- HVBRAIN: Protocol for mapping the human visual cortex using TMS
- DATA_MEAns: Graphical Interface for the management of multielectrode recordings



🌀 • 💿 · 💌 🖻 🏠 🔎 🛠 🥹 🙆 • 😓 🛍 * 🔜 🎎 🖄

🔯 Elemento emergente bloqueado. Para ver este elemento emergente o consultar opciones adicionales, haga clic aquí...

CORTIVIS QLK6-CT-2001-00279

Home
Overview
Partners
Publications
Software
Links

Contact Us
 Private

Search this site:

~

Goll

Cortical Visual Neuroprosthesis for the Blind

🥂 – 🗗 ×

×

Home Groups

FAQ

Links

Contact Us

Eye resources on th	Internet	
Site compiled on be	nalf of the Association of Vision Science Librarians	
Sensory substitution	devices	
Sensory substitution	means replacement of one sensory input (vision, hearing, touch, taste or smell) by another	

Links to other visual prostheses projects

Subretinal Implant
Retina Implant News Bonn & Epi-Ret
Harvard-MIT Collaboration
Intraocular Retinal Prosthesis Group/Wilmer Eye Institute
Optobionics
MIcrosystems based VIsual Prosthesis (MIVIP)
University of Utah (Dr.Richard A. Normann)
The Dobelle Institute
Sensory substitution devices
Hybrid Retinal Implant
The VoiCE auditory display
"Bionic" Eye

back to top

🌀 • 🌍 • 💌 🖻 🏠 🔎 🜟 🏵 🔗 🌭 📼 • 🔜 🎎 🦓



Alicante a 13 de junio de 2006



- Actividades Científicas
- Blog
- Calendario
- Comité de Neurooncologia
- Consulta de Hidrocefalia
- Ficha del Servicio
- Galería de Imágenes
- Información a Pacientes
- Intranet
- Sesiones Docentes
- Weblab
- Webmail
- @ 2006 Neurocirugía Hospital General Universitario de Alicante
 - desarrollo web: neurocirugia.com



CENTRO ACREDITADO POR EL MINISTERIO DE SANIDAD Y **CONSUMO PARA LA** FORMACIÓN DE NEUROCIRUJANOS



CONSELLERIA DE SANITAT



AGÈNCIA **VALENCIANA DE SALUT**



Servicio de Neurocirugía

Jefe de Servicio: Dr. C. Botella Asunción Pintor Baeza, s.n. 03010 Alicante - España Tel. +34965938337 Fax. +34965938197 🖃 ncr@neurocirugia.com

HOSPITAL GENERAL UNIVERSITARIO DE

ALICANTE



Sesión Bibliográfica

Dr.Moreno-Dr.Sales

NOTICIAS

12/06/2006

Entrevista al doctor Antonio Pelegrín responsable de la Unidad del Dolor del Hospital de León en España. Las unidades del dolor nacieron con la idea de ser

multidisciplinarias, pero eso es imposible porque la administración nunca ha hecho caso a las unidades del dolor.

O Buscar en Google 💿 Buscar en nuestra WEB



Otros Recursos -

- → Sociedad Española de Neurocirugía → Sociedad Española de Base de Cráneo → Sociedad Española de Ciruqía de la Epilepsia →Sociedad Española de Neurocirugía Pediátrica →Sociedad Española de Neurorraguis
- →Sociedad Española de Radiocirugía →Sociedad de Neurocirugia de Levante de las
- Comunidades Autónomas de Valencia y de Murcia









🥂 – ð ×

Comité de Neurooncología del Hospital General Universitario de Alicante

Reuniones: Miércoles 08:15 (6ª Planta-Sala de Reuniones del Servicio de Neurocirugía)

Próxima Reunión: 14/06/2006

	Casos 14/06/2006
<u>Protocolo gliomas malignos</u>	Tumor parietal
Directorio de Acceso Restringido	Tumor occipital
Usuario:	07/06/2006
Enviar	Tumor cuerpo calloso
	Lesión cerebelosa
	Lesion parietooccipital izquierda
	Tumor quístico parietal
	Tumor frontoparietal izquierdo
	31/05/2006
	▶ <u>Tumor selar</u>
	Tumor espinal dorsal
	24/05/2006
	<u>Tumor de glomus</u>
	Tumor frontal

LOES cerebrales cuerpo calloso y hemisférico

Paciente de 24 años, que ingresa por LOES cerebrales

Antecedentes personales: colitis ulcerosa diagnosticada en 2002. Ha presentado 2 ingresos por reagudización. Anemia ferropénica secundaria.Ingresa por un cuadro de 1 mes de evolución consistente en cefalea occipital y frontal intensa de predominiodiurno.Episodios esporádicos de fiebre, sobre todo de carácter vespertino, de hasta 39 °C con sensación distérmica que aparecen cada 3-4 días aprox., con empeoramiento durante su igreso en medicina interna.Su familia comenta que lo notan desde hace 1 mes distinto con mayor torpeza.

Exploración neurológica:Disminución de fuerza 4/5 en MSI con torpeza dislal. Alteración de la memoria para hechos recientes.

TAC TORACOABDOMINOPÉLVICO: Ligera esplenomegalia.TAC y RM CRANEAL: Masa central de 5 cms del cuerpo calloso con crecimiento inferior de densidad heterogénea, y realce tras contraste. Otra masa de 4 cms. en zona cortical frontal superior derecha. (linfoma cerebral, glioma multifocal. y menos probable metástasis.)Pendientes. Serología VIH y toxoplasma.



đΧ

🌀 · 🕥 · 📓 🛃 🌈 📌 🌝 🔗 🎍 🗷 · 🗔 🛍 🖏



Resultado Histológico:

Glioblastoma Multiforme Decisión del Comité:

Biopsia estereotactica de la lesion hipercaptante.Radioterapia y Temozolamida <u>Envía tu comentario para su publicación</u>

Literatura

Β×

0



..............................





....................................

Guest_Sales

de May de 2006 a las 09:21 AM]

iajo anestesia local y sedación se realiza TAC en condiciones estereotácticas, y se realiza drill coronal zq. eligiendo las coordenadas X 110 Y 100 Z 74. Se obtienen 2 muestras en punto cardinal y una más :n Z + 0,5 cm.

Guest_Eva [26 de May de 2006 a las 06:48 PM] Yo creo que será un glioma de alto grado [27 de May de 2006 a las 09:01 AM] Santos [27 de May de 2006 a las 09:01 AM] Creo que la segunda lesión que se aprecia es una continuidad de lo que en conjunto sería un glioma en ala de mariposa [27 de May de 2006 a las 09:03 AM] Abadia [27 de May de 2006 a las 09:03 AM] [27 de May de 2006 a las 09:03 AM] No se puede descartar una leucencefalopatía diseminada aguda [27 de May de 2006 a las 02:31 PM] Es muy importante el resultado de serología, pues estas lesiones pueden ser producidas por SIDA. En la RMN cerebral se pueden evidenciar varios focos de lesión. La presencia de fiebre y las lesiones hepáticas me hacen sospechar mucho de esta patología. javier [27 de May de 2006 a las 02:52 PM] La serología será fundamental por epidemiología deberá descartarse en primer término lesiones marcadoras de SIDA Juan [29 de May de 2006 a las 09:03 AM] El resultado HIV es negativo

Añadir u	n comentario		
Nombre	Anónimo	Comentario	40

Powered by Coppermine Photo Gallery



