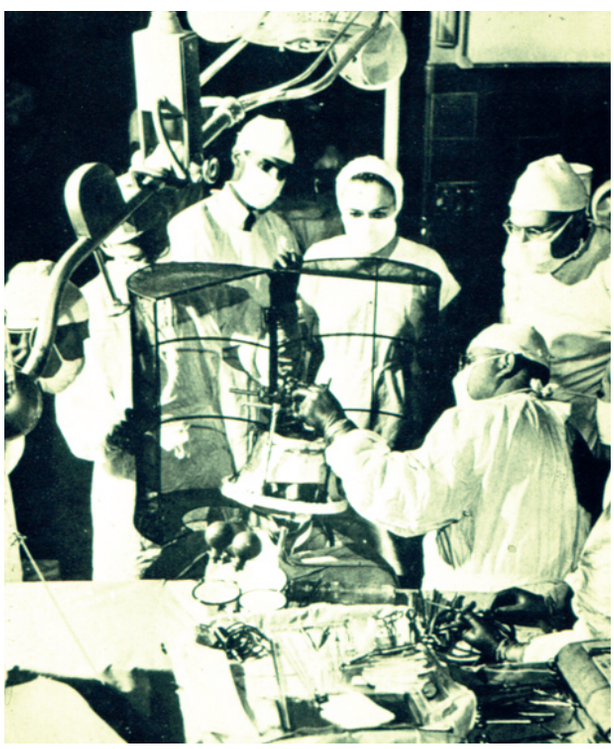
A SURGICAL HISTORICAL EXHIBITION

A short history of movement disorders surgery



Spiegel and Wycis performing one of the first stereotactic operations

Joachim K. Krauss, Marwan I. Hariz, Patric Blomstedt and Christian Riederer

Supported by the WSSFN and an unrestricted educational grant from Medtronic

Foreword

This booklet will provide the reader with a short history of movement disorders surgery. We start with early attempts of surgery on the pyramidal system and we conclude when we reach the "goldrush" times of contemporary deep brain stimulation introduced for tremor, Parkinson´s disease and dystonia.

The posters which are summarized in this booklet were shown for the first time during the 17th Quadrennial Meeting of the World Society for Stereotactic and Functional Neurosurgery in Berlin, Germany, in June 2017. Since we received such a nice echo from the visitors we thought it would be worthwhile to make the history as told in these posters available to a wider audience.

History is never linear. But history is also not circular and repeating itself as some people tend to be believe. Furthermore, obviously history is not a process of dialectical change as has been supposed by some prominent philosophers. Rather, history often is a parallel process of different lines of development. Certainly, the exegesis of the history of movement disorders surgery depends on the eye of the beholder introducing some inevitable subjectivity. The latter we tried to minimize by retrieving as much original documents as possible.

We hope the booklet will be of interest to all colleagues involved in the field. May you enjoy browsing through the decades with us!

Joachim K. Krauss, M.D.

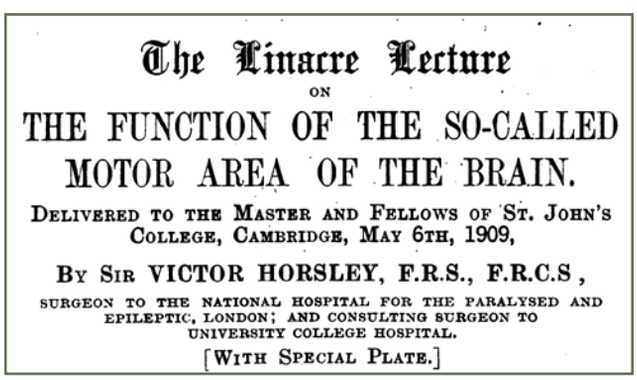
Professor of Neurosurgery; Past President, World Society for Stereotactic and Functional Neurosurgery; Past and Honorary President, European Society for Stereotactic and Functional Neurosurgery

Index

Surgery on the pyramidal system

Victor Horsley, one of the pioneers of modern neurosurgery, introduced removal of cortical areas for athetosis in 1890. Later, in collaboration with Robert Henry Clarke, he introduced the first stereotactic frame for animal research. Thereafter, Putnam and Walker and others carried out open surgery on the pyramidal system including tractotomies.

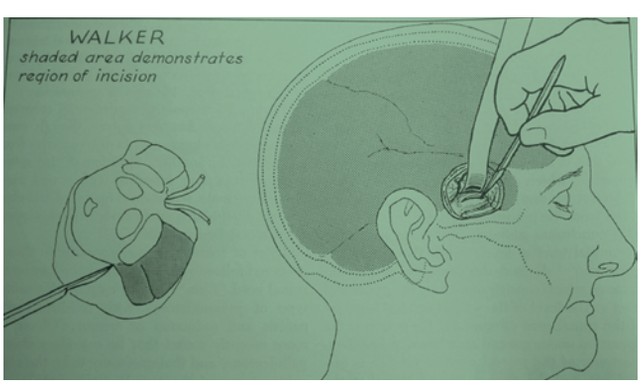
"In 1949, Walker described mesencephalic pedunculotomy for the treatment of hemiballismus. This procedure was extended to the treatment of Parkinson´s disease by Walker and others. Incisions were made at various depths in the peduncle. The tremor relief was proportional to the severity of the hemiparesis, whereas rigidity always remained unaffected. According to Walker, a compromise between paralysis and freedom of tremor was what best could be expected from pedunculotomy" (Laitinen and Hariz, 1996).



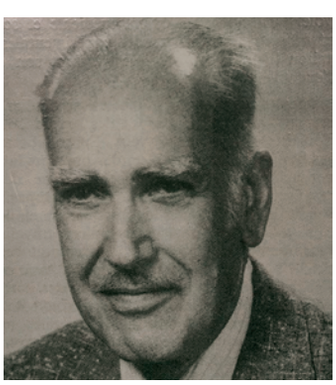
The Linacre Lecture
ON
THE FUNCTION OF THE SO-CALLED MOTOR AREA OF THE BRAIN.
DELIVERED TO THE MASTER AND FELLOWS OF ST. JOHN'S COLLEGE, CAMBRIDGE, MAY 6TH, 1909,
BY SIR VICTOR HORSLEY, F.R.S., F.R.C.S,
SURGEON TO THE NATIONAL HOSPITAL FOR THE PARALYSED AND EPILEPTIC, LONDON; AND CONSULTING SURGEON TO UNIVERSITY COLLEGE HOSPITAL.
[WITH SPECIAL PLATE.]

Horsley published a paper in 1909 on successfully excising the precentral gyrus of the cortex in a young man with involuntary movements of the right arm.

Victor Horsley (1857-1916) U.S. National Library of Medicine



Source: Irving S Cooper: Parkinsonism, its medical and surgical treatment, 1961



Arthur Earl Walker (1907-1995)

Horsley V. and Clarke RH. 1908. The structure and functions of the cerebellum examined by a new method. Brain 31, 1:45–124
Horsley V. 1909. The functions of the so-called motor area of the brain: Linacre lecture. BMJ 2:125-132
Laitinen L, Hariz MI. 1996. Movement disorders. In: Youmans J (ed): Neurological Surgery, Philadelphia, Saunders. 3575–3609
Walker AE. 1952. Cerebral pedunculotomy for the relief of involuntary movements. J Nerv and Ment Dis 116:766-775

Surgery on the “extrapyramidal” system

Once the importance of the basal ganglia in motor control was recognized, Russell Meyers was the first to perform direct transventricular surgery to alleviate motor symptoms of Parkinson’s disease by lesioning the caudate nucleus, the anterior limb of the internal capsule and the pallidofugal fibres.

Mortality rates were high (15.7%), but his work inspired Fénélon and Guiot to coagulate the ansa lenticularis. They reported a 72% benefit on tremor and rigidity.

Russell Meyers (1904-1999) in 1953, State University of Iowa, Iowa City, U.S. National Library of Medicine

ELECTRICAL ACTIVITY OF THE NEOSTRIATUM, PALEOSTRIATUM, AND NEIGHBOURING STRUCTURES IN PARKINSONISM AND HEMIBALLISMUS*

BY

RUSSELL MEYERS, ROBERT HAYNE, and JOHN KNOTT

Russell Meyers et al., J Neurol Neurosurg Psychiatry, 1949

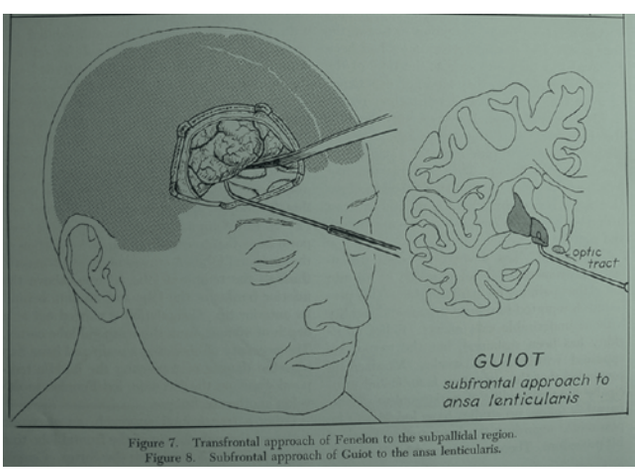
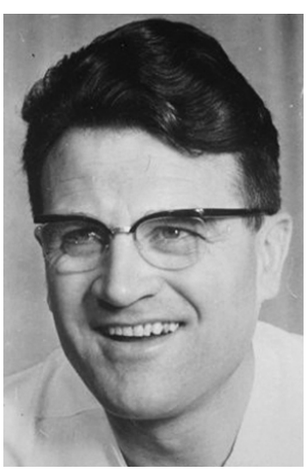


Figure 7. Transfrontal approach of Fenelon to the subpallidal region.
Figure 8. Subfrontal approach of Guiot to the ansa lenticularis.

Source: Irving S Cooper: Parkinsonism, its medical and surgical treatment, 1961



Gérard Guiot (1912–1998) as a young man

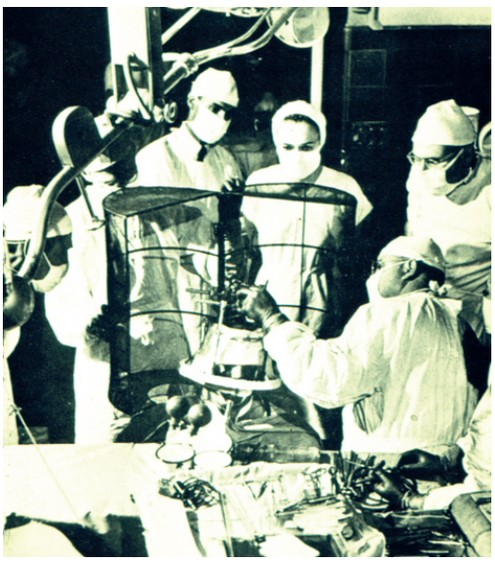
Fenelon F. 1950. Essais de traitement neurochirurgical du syndrome parkinsonien par intervention direct sur les voies extrapyramidales immediatement sous-striopallidales. Rev Neurol 83:437-440
Guiot G. 1953. Traitement des mouvements anormaux par la coagulation pallidale. Rev Neurol 89:578-580
Meyers R. 1942. The modification of alternating tremors, rigidity and festination by surgery of the basal ganglia. Res Publ Assoc Res Nerv Ment Dis 21:602-665

Birth of the stereotactic era

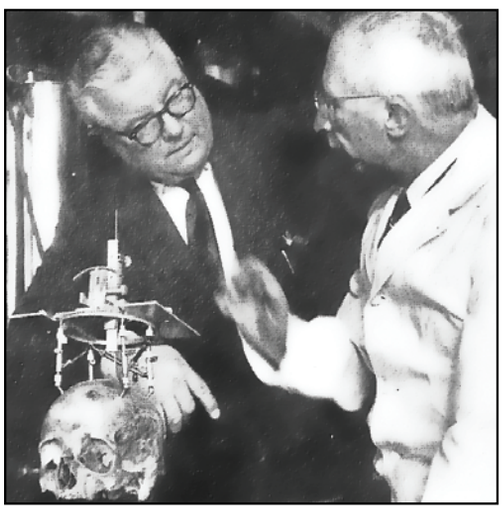
Complications of open surgery and the difficulties in accessing the control structures of the brain prompted Spiegel and Wycis to develop the first stereotactic frame used in humans in 1947.

The most important development with that frame was that the targeting was not based, as in the Horsley-Clarke system, on external bony landmarks, but on internal landmarks, as seen on pneumoencephalography, providing a higher degree of accuracy.

This method revolutionized surgery for Parkinson's disease and other disorders. Within a short period of time, new frames, atlases, targets, and lesion techniques were introduced worldwide.



Spiegel and Wycis performing one of the first stereotactic operations



Henry Wycis (1911–1972) and Ernest A. Spiegel (1895–1985)

Ernest A. Spiegel in 1951
U.S. National Library of Medicine

Stereotaxic Apparatus for Operations on the Human Brain[1]

E. A. Spiegel, H. T. Wycis, M. Marks, and A. J. Lee

Department of Experimental Neurology, Temple University School of Medicine, Philadelphia

EA Spiegel et al., Science, 1947

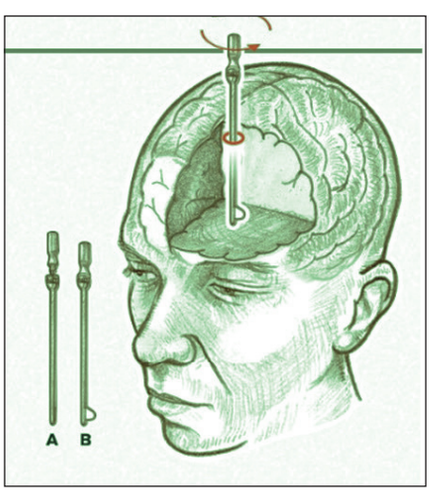
Spiegel EA, Wycis HT, Marks M, Lee AJ. 1947. Stereotaxic apparatus for operation on human brain. Science 106:349-350
Spiegel EA, Wycis HT. 1953. Ansotomy in paralysis agitans; demonstration of results by motion pictures and electromyograms. Trans Am Neurol Assoc 3:178-80; discussion, 180-183
Spiegel EA. 1966. Development of stereoencephalotomy for extrapyramidal diseases. J Neurosurg 24:433-439

Stereotactic lesioning techniques

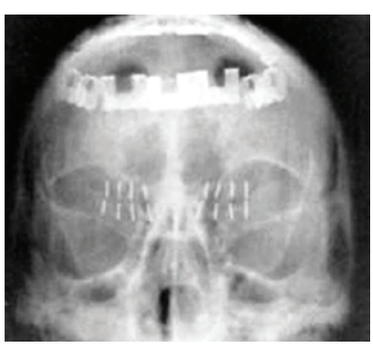
Different lesioning methods were developed: direct current (anodal electrolysis), alcohol injection, oil-procaine-wax injection, balloon, leucotome, cryoprobe, ultrasound, interstitial radiation, focused radiation (Linac, protonbeam, Gammaknife) and thermo-controlled radiofrequency. Radiofrequency lesioning became the dominant method for decades and until now.

Liquid nitrogen is poured into the cryosurgical device by Edward Kandel in the USSR

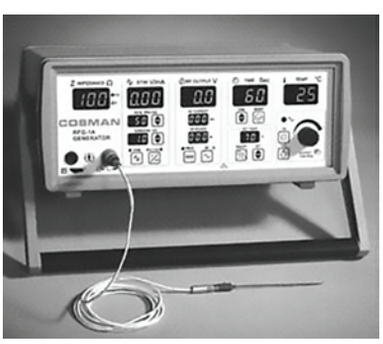
Gamma knife (picture from 1975, courtesy Dr Christer Lindqvist)



Claude Bertrand´s leucotome



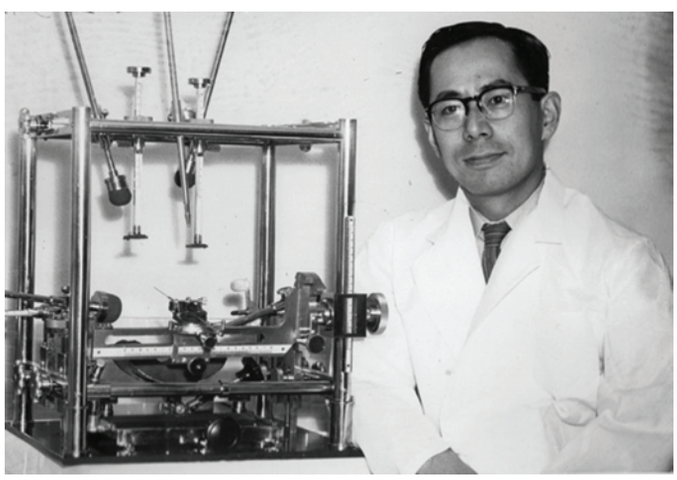
X-ray with radioactive Yttrium in situ by Geoffrey Knight in London

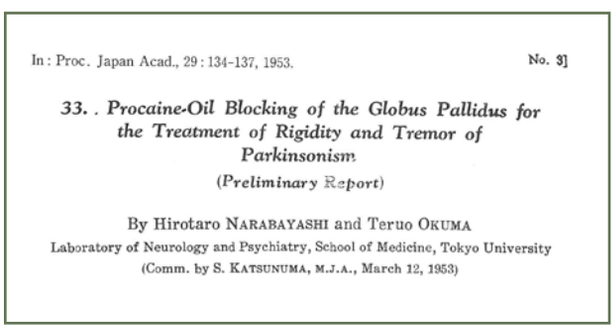


Radiofrequency lesioning generator

Ablative surgery on the pallidum

Surgical procedures involving the globus pallidus flourished in the early 1950s. Born in Kobe, Japan, Hirotaro Narabayashi (1922-2001) performed his first pallidotomy for athetosis using procaine oilwax in 1951, and performed his first surgery for Parkinson's disease one year later. He reported 26 cases of pallidotomy in Parkinson's disease in 1956. He also contributed to the neurophysiological analysis of rigidity and spasticity. Many other neurosurgeons worldwide developed their own pallidal targets for treatment of a variety of movement disorders.





In : Proc. Japan Acad., 29 : 134-137, 1953. No. 3]

33. . Procaine-Oil Blocking of the Globus Pallidus for the Treatment of Rigidity and Tremor of Parkinsonism

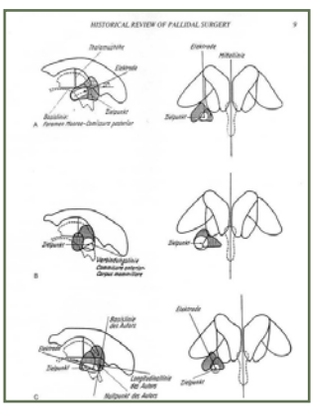
(Preliminary Report)

By Hirotaro NARABAYASHI and Teruo OKUMA

Laboratory of Neurology and Psychiatry, School of Medicine, Tokyo University

(Comm. by S. KATSUNUMA, M.J.A., March 12, 1953)

Hirotaro Narabayashi in his young days and the third version of his stereotactic instrument. © QOL laboratory Corp., Tokyo, Japan

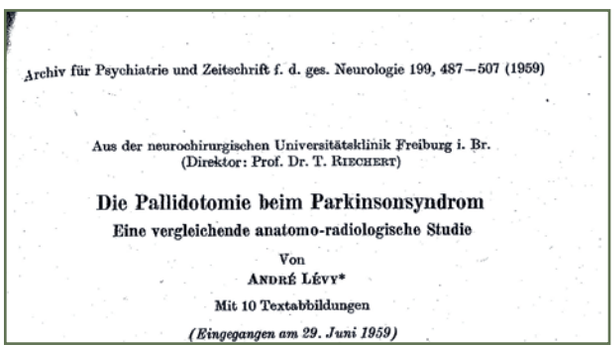


Examples from Levy´s analysis of the location of the pallidal targets used by various neurosurgeons during the 1950s.

A: Riechert and Hassler
B: Guiot and Brion
C. Remond

The medical pallidum is depicted by longitudinal bars, the lateral pallidum by horizontal bars against the outlines of the ventricles. The target area corresponds to the white dots, respectively. Sagittal sections are on the left and coronal sections on the right.

Figure and legend from Krauss and Grossmann, 1998



Archiv für Psychiatrie und Zeitschrift f. d. ges. Neurologie 199, 487—507 (1959)

Aus der neurochirurgischen Universitätsklinik Freiburg i. Br.
(Direktor: Prof. Dr. T. RIECHERT)

Die Pallidotomie beim Parkinsonsyndrom

Eine vergleichende anatomo-radiologische Studie

Von

ANDRÉ LÉVY*

Mit 10 Textabbildungen

(Eingegangen am 29. Juni 1959)

Levy, 1959

Krauss JK, Grossmann RG. 1998. Historical review of pallidal surgery from treatment of parkinsonism and other movement disorders. In: Krauss JK, Grossmann RG, Jankovic J (eds). Pallidal Surgery for the Treatment of Parkinson's Disease and Movement Disorders. Lippincott-Raven, Philadelphia - New York

Levy A. 1959. Die Pallidotomie beim Parkinsonsyndrom. Eine vergleichende anatomoradiologische Studie. Arch Psychiatr Nervenkr 199:487-507

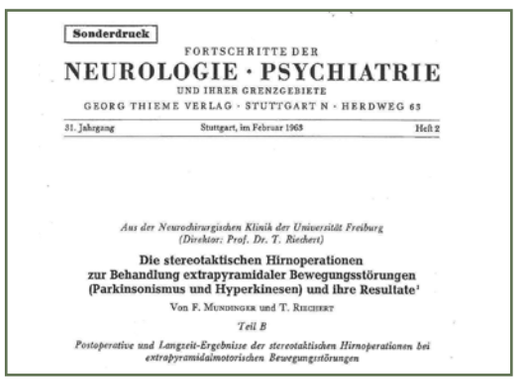
Narabayashi H, Okuma T, Shikiba S. 1956. Procaine oil blocking of the globus pallidus. Arch Neurol Psychiatry 75:36-48

Ablative surgery on the thalamus/subthalamic area

The ventrolateral thalamus was introduced in 1952 as a target for tremor based on the work of Rolf Hassler. The first thalamotomy was performed by Fritz Mundinger in the presence of Traugott Riechert and Rolf Hassler. The methods and results were published in 1954.

Thalamotomy became more popular in the late 1950s after Cooper published his work on a misplaced pallidal lesion that had abolished tremor but which was located in the motor thalamus as discovered at autopsy.

In the 1960s, subthalamic targets became popular aiming at the zona incerta, the fields of Forel and the posterior subthalamic area. Many neurosurgeons subsequently used a combination of thalamic and subthalamic targets, avoiding the STN.


Sonderdruck

FORTSCHRITTE DER
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31. Jahrgang | Stuttgart, im Februar 1963 | Heft 2

Aus der Neurochirurgischen Klinik der Universität Freiburg
(Direktor: Prof. Dr. T. Riechert)

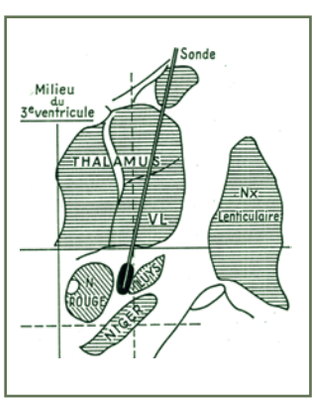
Die stereotaktischen Hirnoperationen zur Behandlung extrapyramidaler Bewegungsstörungen (Parkinsonismus und Hyperkinesen) und ihre Resultate

Von F. Mundinger und T. Riechert

Teil B

Postoperative und Langzeit-Ergebnisse der stereotaktischen Hirnoperationen bei extrapyramidalmotorischen Bewegungsstörungen

Traugott Riechert (1905-1983) and Fritz Mundinger (1924-2010)



Subthalamotomy by Houdart, 1965

Rolf Hassler (1914-1984)

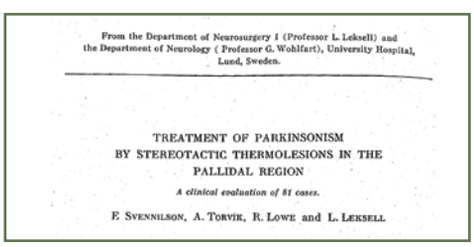
Irving S. Cooper (1922-1985)

Hassler R, Riechert T. 1954. Indications and localization of stereotactic brain operations. Der Nervenarzt 25, 11:441-447
Houdart R, Mamo H, Dondey M, Cophignon J. 1965. Results of subthalamic coagulations in Parkinson's disease (apropos of 50 cases). Rev Neurol 112(6):521-529
Wertheimer P, Bourret J, Lapraz C. 1960. Apropos of a case of volitional postural dyskinesia treated with thalamic subthalamic leucotomy. Rev Prat 102:481-486

Renaissance of surgery for movement disorders

The introduction of L-dopa as a medication for Parkinson's disease in the 1960s led to a decreased demand for stereotactic functional surgery, which in many centers was abandoned.

In January 1985, Lauri Laitinen in Umeå, Sweden, revived Leksell´s old posteroventral pallidotomy (published in 1960) and demonstrated that not only was it effective on parkinsonian symptoms, but also on the side effects of L-dopa (fluctuations and dyskinesias). Laitinen´s paper, published in 1992, heralded the renaissance of stereotactic functional neurosurgery. Laitinen was among the very first to use stereotactic MRI for targeting and pioneered visualisation of the globus pallidus allowing thus an individual targeting without relying on atlas coordinates. Subsequently, pallidotomy was performed on thousands of patients worldwide and endorsed by the Movement Disorders Society as an evidence-based procedure for Parkinson´s disease.

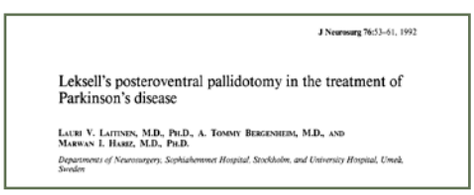


From the Department of Neurosurgery I (Professor L. Leksell) and the Department of Neurology (Professor G. Wohlfart), University Hospital, Lund, Sweden.

TREATMENT OF PARKINSONISM BY STEREOTACTIC THERMOLESIONS IN THE PALLIDAL REGION

A clinical evaluation of 81 cases.

E. Svennilson, A. Torvik, R. Lowe and L. Leksell



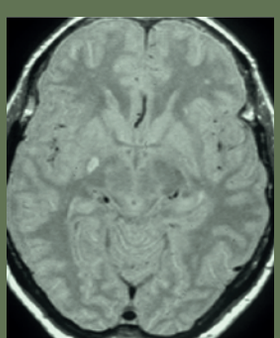
J Neurosurg 76:53–61, 1992

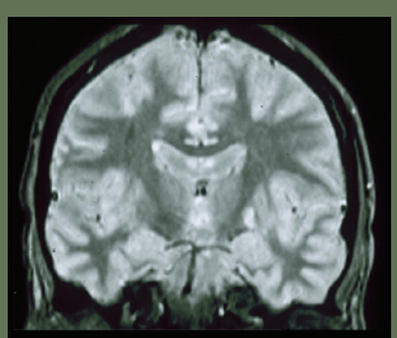
Leksell's posteroventral pallidotomy in the treatment of Parkinson's disease

Lauri V. Laitinen, M.D., Ph.D., A. Tommy Bergenheim, M.D., and Marwan I. Hariz, M.D., Ph.D.

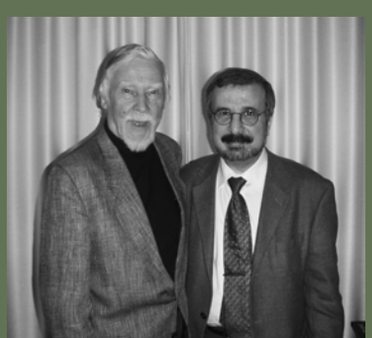
Departments of Neurosurgery, Sophiahemmet Hospital, Stockholm, and University Hospital, Umeå, Sweden

Lars Leksell (1907–1986) and Lauri Laitinen (1928-2005)





Posteroventral pallidotomy



Lauri Laitinen and Marwan Hariz

Laitinen LV, Bergenheim AT, Hariz MI. 1992. Leksell's posteroventral pallidotomy in the treatment of Parkinson's disease. J Neurosurg 76:53-61

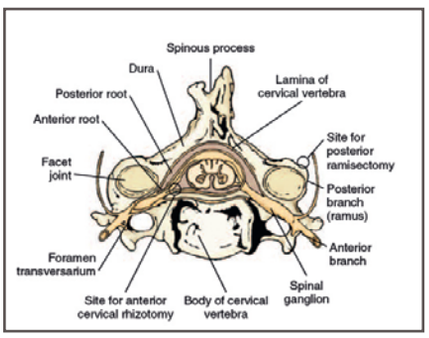
Svennilson E, Torvik A, Lowe R, Leksell L. 1960. Treatment of parkinsonism by stereotatic thermolesions in the pallidal region. A clinical evaluation of 81 cases. Acta Psychiatr Scand 35:358-377

Peripheral surgery for dystonia

Kenneth G. McKenzie (1892-1964) was instrumental to advance the technique of intradural rhizotomy which had been pioneered also by Walter Dandy (1886-1946). The problem was that denervation could not be performed below the C4 root.

Selective peripheral denervation surgery for cervical dystonia was introduced by Claude Bertrand (1917-2014), and it solved many of the problems associated with intradural rhizotomy.

Nowadays, knowledge about how to perform this surgery is becoming lost. We are sure, it will be rediscovered some day.



Anatomy of anterior cervical rhizotomy (intradural approach) and posterior ramisectomy (extradural approach). Redrawn from Krauss JK, Grossmann RG, Jankovic J. Treatment options for surgery of cervical dystonia. In: Krauss JK, Jankovic J, Grossmann RG, eds. Surgery for Parkinson's Disease and Movement Disorders. Philadelphia: Lippincott Williams & Wilkins; 2001:323-334.

Claude Bertrand
Portrait taken at the 4th International Neurological Congress, Paris, 1949
U.S. National Library of Medicine

"In 1950, his interest in pain problems led him to review the spinal and brain pathways of ascending pain fibers, together with Doctor Louis Poirier of the Department of Anatomy of Université de Montréal. This was the beginning of a productive collaboration, when, in 1954, the work on stereotactic surgery of involuntary movements was undertaken. This led to the finding of a safer and more selective method of suppression of involuntary movements. Selective denervation of muscles of the neck evolved from this work, using stimulation under light anaesthesia after recording of muscle activity and nerve blocks, thus enhancing considerably the knowledge of functions of the cervical musculature. A large number of Canadian and foreign patients suffering from spasmodic torticollis have obtained relief from this technique."

Claude Bertrand, Obituary, Montreal Gazette, 2014

Bertrand CM, Molina-Negro P. 1988. Selective peripheral denervation in 111 cases of spasmodic torticollis: rationale and results. Adv Neurol 50:637-643
McKenzie KG. (1954). The surgical treatment of spasmodic torticollis. Clin Neurosurg 2:37-43

Neurotransplantation surgery for Parkinson´s disease

Cellular replacement strategies emerged as a potential curative therapy for Parkinson´s disease. In 1985, Erik-Olof Backlund in Stockholm performed the first transplant of adrenal medullary tissue into the striatum for Parkinson´s disease. Unfortunately, the procedure could not be replicated and was abandoned.

In 1988, Stig Rehncrona from Lund performed the first transplant of fetal mesencephalic tissue in the caudate and putamen of two parkinsonian patients.

Stig Rehncrona, pioneer of PD fetal transplant surgery

1556 THE NEW ENGLAND JOURNAL OF MEDICINE Nov. 26, 1992

BILATERAL FETAL MESENCEPHALIC GRAFTING IN TWO PATIENTS WITH PARKINSONISM INDUCED BY 1-METHYL-4-PHENYL-1,2,3,6-TETRAHYDROPYRIDINE (MPTP)

HÅKAN WIDNER, M.D., PH.D., JAMES TETRUD, M.D., STIG REHNCRONA, M.D., PH.D., BARRY SNOW, M.D., PATRIK BRUNDIN, M.D., PH.D., BJÖRN GUSTAVII, M.D., PH.D., ANDERS BJÖRKLUND, PH.D., OLLE LINDVALL, M.D., PH.D., AND J. WILLIAM LANGSTON, M.D.

"Bilateral implantation of fetal mesencephalic tissue can induce substantial long-term functional improvement in patients with parkinsonism and severe dopamine depletion and is accompanied by increased uptake of fluorodopa by the striatum. The results in these patients resemble those obtained in MPTP-treated primates and suggest that this will be a useful model for the assessment of transplantation therapies in Parkinson's disease."

Widner et al., 1992

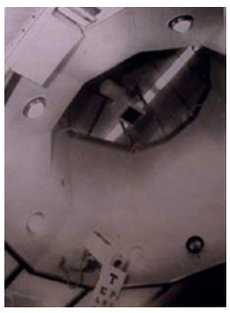
Backlund EO, Granberg PO, Hamberger B, Knutsson E, Mårtensson A, Sedvall G, Seiger A, Olson L. 1985. Transplantation of adrenal medullary tissue to striatum in parkinsonism. First clinical trials. J Neurosurgery 62:169-173
Lindvall O, Rehncrona S, Gustavii B, Brundin P, Astedt B, Widner H, Lindholm T, Björklund A, Leenders KL, Rothwell JC, Frackowiak R, Marsden CD, Johnels B, Steg G, Freedman R, Hoffer BJ, Seiger L, Strömberg I, Bygdeman M, Olson L. 1988. Fetal dopamine-rich mesencephalic grafts in Parkinson's disease. Lancet 31;2:1483-1484
Widner H, Tetrud J, Rehncrona S, Snow B, Brundin P, Gustavii B, Björklund A, Lindvall O, Langston JW. 1992. Bilateral fetal mesencephalic grafting in two patients with parkinsonism induced by 1-methyl-4-phenyl-1,2,3,6-tetrahydropyridine (MPTP). N Engl J Med 26;327(22):1556-63

Evolution of stereotactic frames and imaging modalities

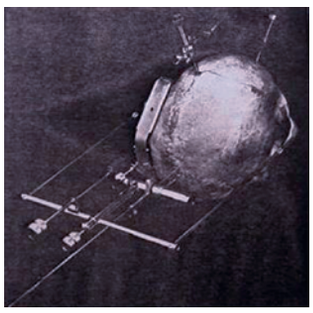
The history of human stereotactic surgery bears witness to the efforts to unite frame and radiological imaging in a geometrically coherent and practical system. “Stereotactic radiography” became a concept to define “classical” imaging methods such as ventriculography, pneumencephalography or angiography.

For these apparatus “teleradiography” was necessary to avoid parallax and distortion and minimize magnification. The X-ray source needed to be far away from the patient.

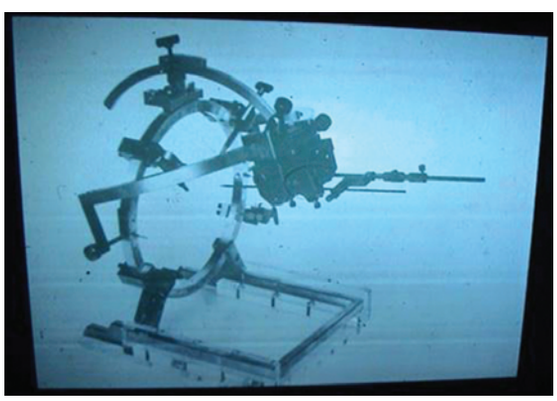
After the introduction of CT and then MRI, the adaptation of stereotaxis to the new imaging methods followed somehow the same pattern known from the pre-CT era: the new radiological technique had to be integrated, and the stereotactic frame had to be re-adapted or re-conceived to conform to the requirements of the new imaging tools.



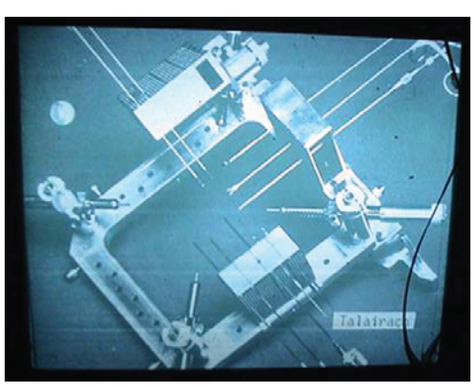
Teleradiography at St Anne Hospital in Paris



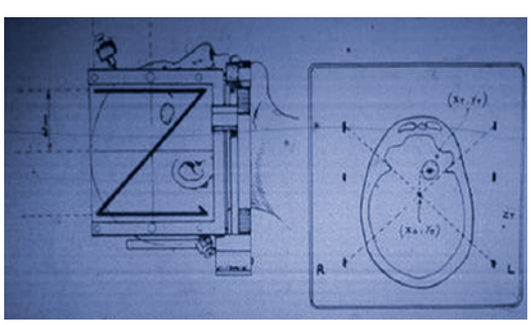
Guiot frame



Riechert-Mundinger frame



Jean Talairach (1911–2007) and his frame



N-shaped fiducial device by engineer student Russel Brown used to calculate target coordinates on axial scans. The N device is used on Leksell, BRW and CRW frames.

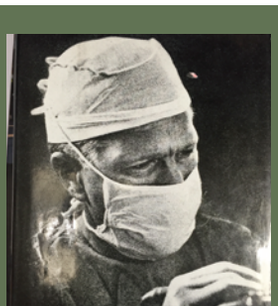
Lozano AM, Gildenberg P, Tasker R. 2009. Textbook of Stereotactic and Functional Neurosurgery. Springer Science & Business Media

Early DBS before 1987

Beginning in the 1950s, depth electrodes were implanted for days or weeks to ensure satisfactory results prior to lesioning via the chronically implanted electrodes. The first detailed account of this technique was provided by Natalia Petrovna Bechtereva and Carl Wilhelm Sem-Jacobsen. Notably, deep brain stimulation for pain was popular before it became adopted for treatment of movement disorders.

One of the first to use deep brain stimulation via externalized electrodes as a therapy was Natalia Petrovna Bechtereva in Leningrad. A large number of patients were implanted for PD and other disorders and treated with intermittent courses of stimulation for periods of up to 18 months.

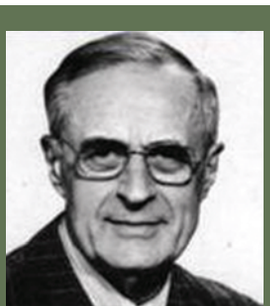
Natalia Petrovna Bechtereva (1924-2008)



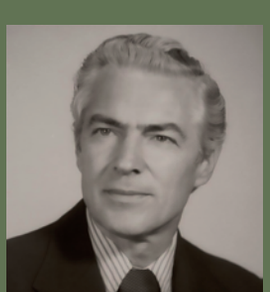
Irving Cooper reported in 1980 on the „effects of electrical stimulation of the thalamus and internal capsule in man".

Jean Siegfried reported beneficial results of chronic stimulation in the sensory nucleus of the thalamus in 1986.

Fritz Mundinger reported the effects of thalamic/ subthalamic chronic stimulation in 7 patients with torticollis in 1977 in an article written in German which almost nobody noted



Gabriel Mazars, 1980 & 1982. Low frequency DBS in the VPL. Good effect in dyskinesias associated with post amputation pain but no effect in tremor or PD.



Orlando Andy, 1983: 9 patients implanted in thalamic targets. "Optimum site for alleviating parkinsonian tremor and other movement disorders are the Vim and other thalamic and subthalamic areas."

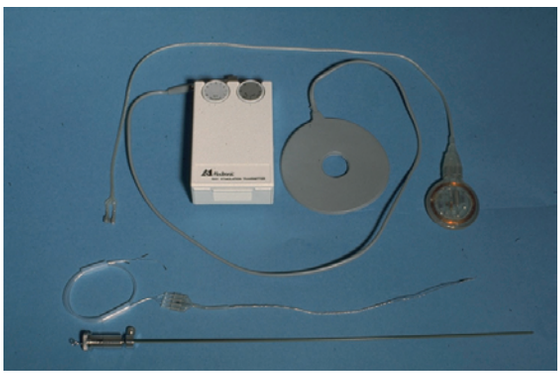
Neurologist Lindsay McLellan (pictured here) and neurosurgeon Jason Brice, 1980: Two MS-patients permanently implanted in the zona incerta. High-frequency stimulation resulted in supression of severe intention tremor.

Bekhtereva NP, Bondarchuk AN, Smirnov VM, Meliucheva LA. 1972. Therapeutic electric stimulation of deep brain structures.. Vopr Neirokhir 36:7–12 (Russian)
BLomstedt P, Hariz M. 2010. Deep brain stimulation for movement disorders before DBS for movement disorders. Parkinsonism Relat Disord 16(7):429-433 Cooper IS, Upton AR, Amin I. 1980. Reversibility of chronic neurologic deficits. Some effects of electrical stimulation of the thalamus and internal capsule in man. Appl Neurophysiol 43(3-5):244-258
Sem-Jacobsen CW. 1966. Depth-electrographic observations related to Parkinson's disease. Recording and electrical stimulation in the area around the third ventricle. J Neurosurg 24: 388–402

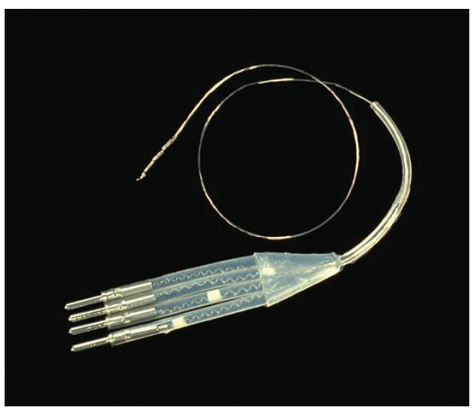
History of DBS hardware

Founded in 1957 by Earl Bakken and Palmer Hermundslie in Minnesota, Medtronic started to design hardware for DBS in the early 1970s. Initially, DBS was developed as a treatment for chronic pain. Within a few years, the first pioneers applied the new technology for the treatment of movement disorders.

In the 1980s, Alim-Louis Benabid and Pierre Pollak collaborated with Medtronic and introduced the first modern fully implantable DBS system. Over the next years, the classical quadripolar DBS electrodes and rechargable pacemakers became available.



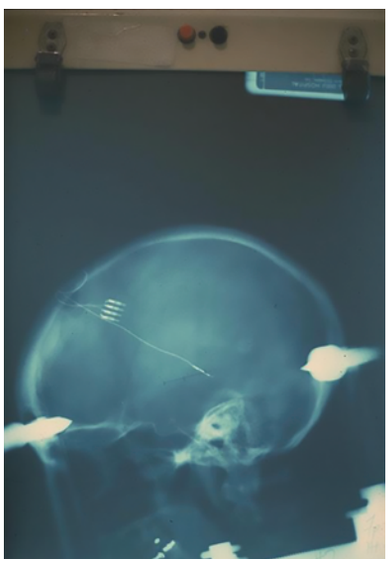
DBS system, 1970s. Implantable components are the DBS lead, the percutaneous (trial) extension, RF receiver and extension. Nonimplantable (external) components are the transmitter (showing voltageamplitude and frequency-Hertz dials) and the antenna.
Courtesy of Medtronic, Frans Gielen



Early-generation Medtronic DBS lead, early 1970s. Two of the four pin connectors (corresponding to electrode contacts located near the tip) could be permanently connected to sockets on the RF receiver extension.

Courtesy of Medtronic, Frans Gielen
Legend taken from Coffey, 2008

Modern Activa PC neurostimulator
Courtesy of Medtronic, Frans Gielen



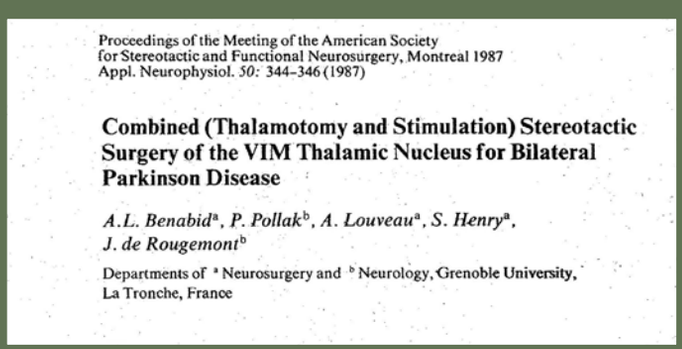
DBS around 1978
Courtesy of Medtronic, Frans Gielen

Coffey RJ. 2008. Deep brain stimulation devices: a brief technical history and review. Artif Organs 33:208-220

DBS for tremor

The modern breakthrough for DBS, in general, and for tremor in particular was heralded by Benabid´s seminal paper from 1987 describing Vim DBS for parkinsonian and essential tremor. Initially, these findings were met with limited interest. Only after the results were convincingly demonstrated using pre- and postoperation videos and confirmas, longterm studies became available, and after multicenter studies were conducted, this method gained wide acceptance.

Only after DBS was applied to the STN did this method reach global popularity. Although most DBS for tremor has targeted the Vim nucleus, the posterior subthalamic area has been revived as a target for PD and essential tremor, either alone or in combination with Vim DBS. Since then, DBS became the main surgical procedure for treatment of tremor and it virtually replaced thalamotomy for some decades.



Proceedings of the Meeting of the American Society
for Stereotactic and Functional Neurosurgery, Montreal 1987
Appl. Neurophysiol. *50:* 344–346 (1987)

Combined (Thalamotomy and Stimulation) Stereotactic Surgery of the VIM Thalamic Nucleus for Bilateral Parkinson Disease

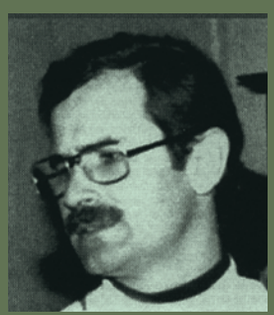
A.L. Benabid[a], *P. Pollak*[b], *A. Louveau*[a], *S. Henry*[a], *J. de Rougemont*[b]

Departments of [a] Neurosurgery and [b] Neurology, Grenoble University, La Tronche, France

Pierre Pollak

"Although still experimental, VIM stimulation appears to be a helpful additional therapy to thalamotomy, which could provide a way to manage patients with bilateral dyskinesias without side effects."

Alim-Louis Benabid 1987



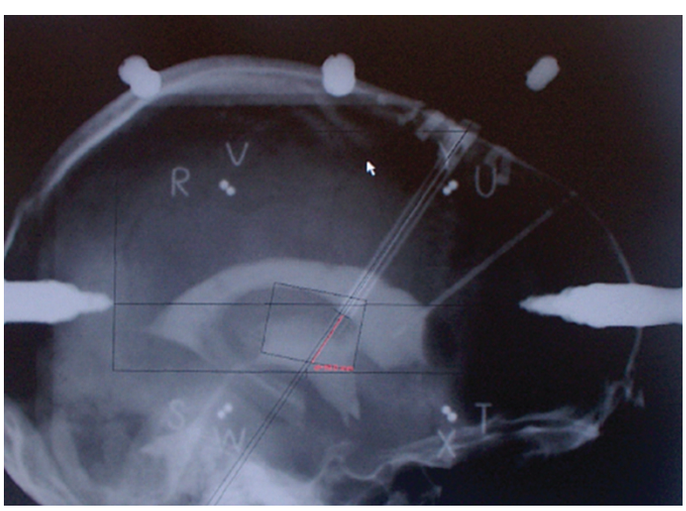
Benabid AL, Pollak P, Gervason C, Hoffmann D, Gao DM, Hommel M, Perret JE, de Rougemont J. 1991. Long-term suppression of tremor by chronic stimulation of the ventral intermediate thalamic nucleus. Lancet 16;337(8738):403-6

DBS for Parkinson´s disease

The subthalamic nucleus (STN) had been avoided as a target in functional neurosurgery during the lesional era for fear of hemiballism. In the early 1990s, Hagai Bergman, then Tipu Aziz, and collaborators performed lesions of the STN and demonstrated improvement of parkinsonian signs in the MPTP model of Parkinson´s disease. Benazzouz used high frequency stimulation of the STN in the MPTP-monkey. These findings set the stage for a new era in the surgical treatment of Parkinson´s disease.

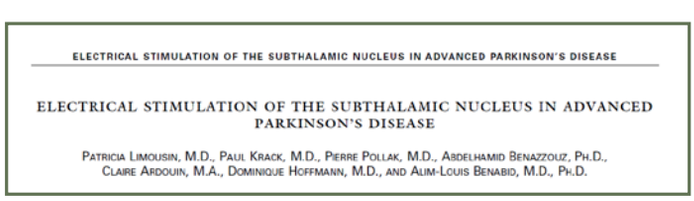
Alim-Louis Benabid and Pierre Pollak were the first to use DBS of the STN in Parkinson´s disease in 1993. This procedure has spread worldwide since then and has proven to be the most efficient surgery for Parkinson´s disease.

In 2014, the Lasker-DeBakey Clinical Medical Research Award was bestowed to Benabid and Mahlon Delong to "honor two scientists who developed deep brain stimulation of the subthalamic nucleus".



Ventriculography for STN DBS by Alim-Louis Benabid

Lasker Award winner
Alim-Louis Benabid



ELECTRICAL STIMULATION OF THE SUBTHALAMIC NUCLEUS IN ADVANCED PARKINSON'S DISEASE

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PATRICIA LIMOUSIN, M.D., PAUL KRACK, M.D., PIERRE POLLAK, M.D., ABDELHAMID BENAZZOUZ, PH.D., CLAIRE ARDOUIN, M.A., DOMINIQUE HOFFMANN, M.D., AND ALIM-LOUIS BENABID, M.D., PH.D.

Limousin et al., 1998

Communication préliminaire

EFFETS DE LA STIMULATION DU NOYAU SOUS-THALAMIQUE DANS LA MALADIE DE PARKINSON

Pollak et al., 1993

Aziz TZ, Peggs D, Sambrook MA, Crossman AR. 1991. Lesion of the subthalamic nucleus for the alleviation of 1-methyl-4-phenyl-1,2,3,6-tetrahydropyridine (MPTP)-induced parkinsonism in the primate. Mov Disord 6(4):288-292
Bergman H, Wichmann T, DeLong MR. 1990. Reversal of experimental parkinsonism by lesions of the subthalamic nucleus. Science 21;249(4975):1436-1438
Limousin P, Krack P, Pollak P, Benazzouz A, Ardouin C, Hoffmann D, Benabid AL. 1998. Electrical stimulation of the subthalamic nucleus in advanced Parkinson's disease. N Engl J Med 15;339(16):1105-1111
Pollak P, Benabid AL, Gross C, Gao DM, Laurent A, Benazzouz A, Hoffmann D, Gentil M, Perret J. 1993. Effects of the stimulation of the subthalamic nucleus in Parkinson disease. Rev Neurol 149(3):175-176

DBS for dystonia

Pallidal DBS was inaugurated by Jean Siegfried in Zürich in the early 1990s as an alternative to pallidotomy for Parkinson´s disease. Pallidal DBS, however, became more important only later in the treatment of dystonia. During the lesional era various other targets had been used.

Pallidal DBS for dystonia was pioneered in the late 1990s by Joachim K. Krauss (cervical dystonia) in Berne, Switzerland, and by Philippe Coubes (generalized dystonia) in Montpellier, France. Initially, these results were met with skepticism. However, subsequent multicenter studies provided evidence-based proof confirming the posteroventral lateral globus pallidus internus as the target of choice for DBS in dystonia. In particular, blinded study designs including a sham-stimulation algorithm were pivotal for the general acceptance of this therapy.

Joachim Krauss in Berne, 1998

Treatment of DYT1-generalised dystonia by stimulation of the internal globus pallidus

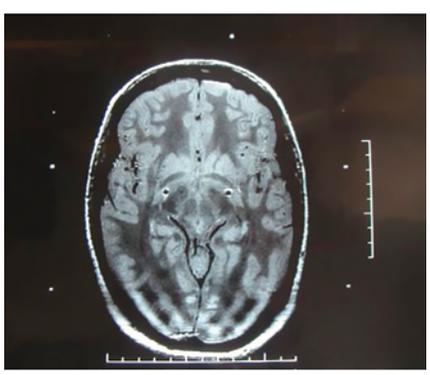
Philippe Coubes, Agathe Roubertie, Nathalie Vayssiere, Simone Hemm, Bernard Echenne

Philippe Coubes and the paper of his group, Lancet, 2000

Bilateral stimulation of globus pallidus internus for treatment of cervical dystonia

Joachim K Krauss, Thomas Pohle, Sabine Weber, Christoph Ozdoba, Jean-Marc Burgunder

Krauss et al., Lancet, 1999



DBS pallidal electrodes for dystonia

Pallidal deep brain stimulation in patients with primary generalised or segmental dystonia: 5-year follow-up of a randomised trial

Volkmann et al., Lancet Neurology, 2012

Bilateral Deep-Brain Stimulation of the Globus Pallidus in Primary Generalized Dystonia

Vidhailet et al., The New England Journal of Medicine, 2005

Coubes P, Echenne B, Roubertie A, Vayssière N, Tuffery S, Humbertclaude V, Cambonie G, Claustres M, Frerebeau P. 1999. Treatment of early-onset generalized dystonia by chronic bilateral stimulation of the internal globus pallidus. Apropos of a case. Neurochirurgie 45(2):139-144

Krauss JK, Pohle T, Weber S, Ozdoba C, Burgunder JM. 1999. Bilateral stimulation of globus pallidus internus for treatment of cervical dystonia. Lancet 4;354(9181):837-838