11 History of Stereotactic Surgery in China

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Prehistoric and Feudal China

China is unique among the world civilizations in that it has a well-established indigenous medical treatment philosophy dating back thousands of years. This was epitomized by the well known *Huang Ti Nei Jing* (Yellow Emperor's Inner Classic), a seminal medical text of ancient China where a legendary physician Yu Fu was alleged to possess the skill for surgical exposure of the brain. The *Neijing*, *Shennong Ben Cao Jing* (Divine Husbandman's Classic of the Materia Medica), and a few other ancient texts laid the foundation of the so-called Traditional Chinese Medicine (TCM), an alternative treatment being actively practiced even today in mainland China and among overseas Chinese alongside modern Western medical and surgical therapies.

A good depiction appeared in the popular *History of the Three Kingdoms* where "cranial surgery" was proposed by Hua Tuo (Hua Lun), a famous physician, on one of the three reigning kings Cao Cao who suffered persistent headaches, presumably due to battle trauma–related intracranial hematoma (or perhaps even intracranial tumor) during the turbulent warring period of Eastern Han and Three Kingdoms (222–280 A.D.). Hua Tuo (*Figure 11-1*) had also reportedly performed surgeries with anesthesia, 1,600 years ahead of similar endeavors in Western Civilization, using wine and a herbal concoction of cannabis boil powder. Incidentally, Hua Tuo came from the ancient Qiao City of Pei State in the modern day Anhui Province, where China's first stereotactic neurosurgery institute and training center was established in 1983 and the first National Stereotactic and Functional Neurosurgical Conference was held on June 8–14, 1987.

The oldest prehistoric evidence of human trephination in European Civilization was probably the Ensisheim Stone Age skull unearthed from a burial site in France which was dated to 5100 B.C. [1]. Archaeological evidence also surfaced in China in 1995 with the excavation in Shandong Province of an adult male skull, aged 35–45 years, bearing a 31 × 25 mm round parietal calvarial defect with smooth border. The perimeter showed evidence of scrapping and bone regeneration. This belonged to an ancient inhabitant of the Dawen Kou Culture (third to fifth millennium B.C.) and was ^{14}C-dated to about 5000 B.C. (*Figure 11-2*). The opening appeared to have been made with tools resembling a trephine. This lends credence to the conclusion that trephinations were probably performed in Neolithic China. Similar finds were discovered at other archaeological sites in the Qinghai, Heilongjiang, and Henan Provinces of China, variously radiocarbon-dated to between 2000 and 4000 B.C. [2]. The motivation for these skull openings remained varied and speculative, just like in other European archaeological discoveries of the Paleolithic and Neolithic period. Whether for curative or ritual purposes to heal and alter behavior, these could have been early men's attempt to relate structure to functions and behavior, perhaps a primitive version of modern day functional neurosurgery.

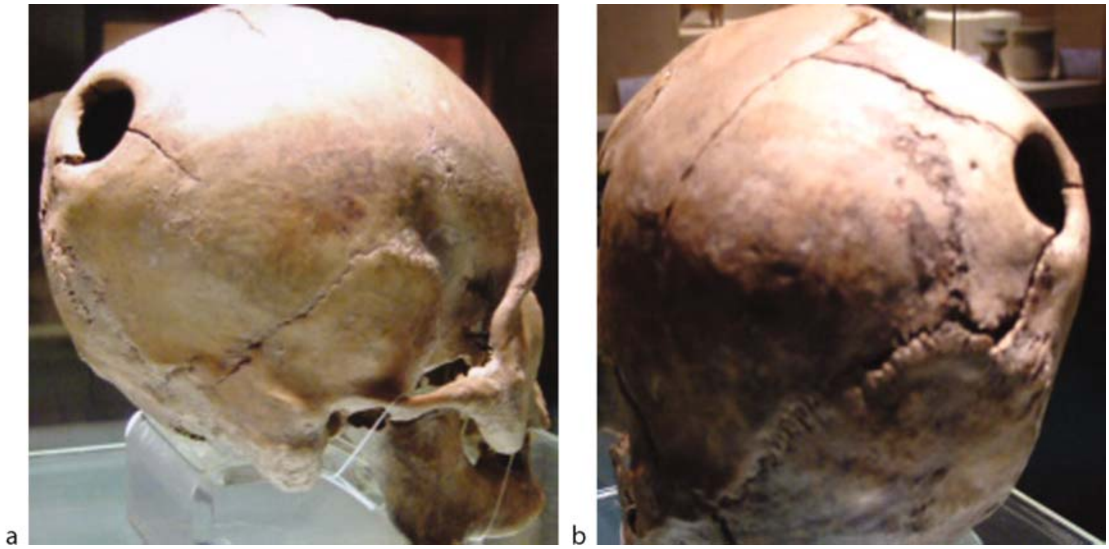
Birth of Neurosurgery in Modern China

An understanding of the development of stereotactic and functional neurosurgery in China will be incomplete without due reference to the history of general neurosurgery, the foundation on which the former has evolved. Modern neurosurgery did not develop much until the last century of Chinese history. Like the rest of the Chinese civilization, it was shrouded in mystery behind the "bamboo curtain" as a result of the cultural and diplomatic isolation of this monolithic, inward-looking nation. The country was plagued by the ineffective, feudalistic Imperial Manchurian rule, subsequently overthrown in 1912 in a popular revolution led by Dr Sun Yat-sen, the father and founder of modern China.

Due credit should be given to Dr Song-Tao Guan (ST Kuan) and Dr Cha-Li Zhang (Charles Chang) from Beijing and Shenyang, respectively, for their pioneering works in neurosurgery in China [3]. Guan completed his residency program at the Peking Union Medical College Hospital (PUMC) in 1926. PUMC was jointly founded in 1906 by the American Board of Commissioner for Foreign Missions, the Presbyterian Church in the USA, the Methodist Episcopal Church, and the London Missionary Society, among others. From 1926 to1930 Guan received neurosurgery training at the University of

Figure 11-1
Hua Tuo (Hua Lun), born 208 B.C. in Qiao (present Anhui Province, China)

Figure 11-2
Archaeological find at Dawen Kou 5000 B.C. (picture courtesy of Cheng-Yuan Wu)



Pennsylvania under Dr Charles H. Frazier, who was among the first group of American neurosurgeons who established neurosurgery as a new discipline from general surgery. In 1938 Yi-Cheng Zhao, another graduate from the same medical college, was sent by the Rockefeller Foundation (established 1913), through its subsidiary, the China Medical Board, for formal neurosurgical training under Dr Wilder Penfield at the Montreal Neurological Institute at McGill University. Upon his return to China in 1940, Zhao practiced neurosurgery at the PUMC Hospital with Guan. In 1952, three years after the Chinese civil war ended with the establishment of the People's Republic of China, Zhao founded the first Brain Department comprising neurology and neurosurgery in the port city of Tianjin, one of the very few cities with early Western influence in the ethnophobic China of the nineteenth century. It was reluctantly opened by the Qing Dynasty of China as a treaty port accessible to France, Britain, and others in 1860. Formal concessions with foreign settlements were ceded to Western powers and Japan in 1903 after the Imperial Qing Dynasty's defeat in the war during the Boxer Rebellion of 1899. These three neurosurgeons, along with Tong-He Zhang of Xian City, performed the first neurosurgical procedures in modern China. Zhang performed prefrontal lobotomy for a psychiatric disorder [4].

From 1932 to 1949, only 16 neurosurgical articles were published in the indigenous *Chinese Medical Journal* (CMJ), which was initially established in 1887 in Shanghai as *China Medical Missionary Journal* for publications mainly by Western medical missionaries serving in China. The name was changed to *China Medical Journal* in 1907, thereafter adopted its current name of CMJ in 1932, when it merged with the English language section of *National Medical Journal of China*. Only about 60 brain tumors were reported in the Chinese literature.

With his training under Dr Frazier who pioneered subtemporal retrogasserian neurotomy in 1910 as a permanent cure for tic douloureux, Guan reported his experience with Frazier's operation for trigeminal neuralgia in 1932 in the CMJ [5]. Charles Chang published on similar procedure and alcohol block three years after Guan. He also drew attention to the occurrence of anesthesia dolorosa and abducens nerve palsy and reported on neurofibroma of the Gasserian ganglion [6]. However, further progress in the development of neurosurgery was repeatedly halted when the country was plunged into two devastating civil wars between the ruling Nationalist Army (Kuomintang) and the Communist People's Liberation Army (PLA) from 1927 to 1936 and 1946 to 1949, with an intervening period of brutal invasion of China by the Japanese Imperial Army that lasted from 1937 to 1945 when World War II finally ended (*Figure 11-3*).

Before the formation of the communist People's Republic of China (PRC) in 1949, international assistance in the development of neurosurgery as in many other fields was predominantly rendered by the United States and European nations mainly through the China Medical Board. After 1949, however, international collaborations were confined to fellow Communist Bloc countries, in particular the USSR. A 6 month neurosurgery training course was conducted in Beijing by Dr A.E. Arutiunov from the Kiev Neurosurgical Institute of the former Soviet Union in October 1954. Participants of this program included Chung-Cheng Wang (Zhong-Cheng Wang), Ya-Du Zhao, and Da-Jie Jiang, while others were sent to the prestigious Moscow Burdenko Neurosurgical Institute. Among them, Tong-Jin Tu set up a neurosurgery service for the People's Liberation Army in the Fourth Military Medical University in Xian City (ancient capital of Qin dynasty 221–206 B.C.) upon his return to China in 1956. The T J Tu Award for excellence in neurosurgery was established in honor of his invaluable contributions to military neurosurgery.

DrYi-Cheng Zhao (*Figure 11-4*) founded the first Brain Department in China, comprising

Figure 11-3
Some early Chinese textbooks, journals, and monographs on stereotactic and functional neurosurgery

Figure 11-4
Dr Yi-Cheng Zhao (1908–1974), Father of Neurosurgery of China

neurology and neurosurgery services at the Tianjin Municipal General Hospital in 1952 aided by his students Chung-Cheng Wang and Qing-Cheng Xu. The Neurosurgery Department at the Beijing Tong-Ren Hospital was established two years later. It was later shifted to the Xuan-Wu Hospital, the predecessor of the Beijing Neurosurgical Institute, the largest neurological center in China. A one-year intensive formal postgraduate neurosurgery training program was started in Tianjin in 1953. The graduates from these programs were to form the core group and foundation of modern neurosurgery in China. Dr Zhao established the Beijing Neurosurgical Institute in March 1960, holding the position of director until his untimely demise in1974, whereupon his student Chung-Cheng Wang took over.

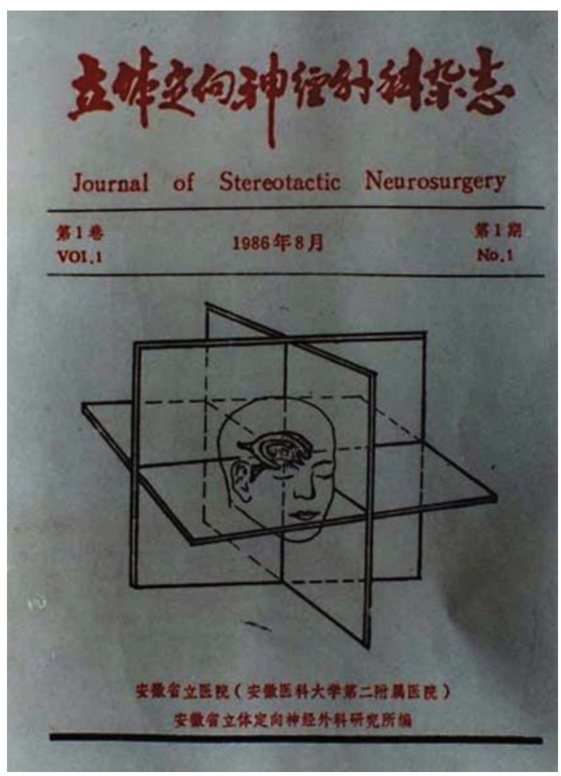
The Beijing Neurosurgical Institute, which is now housed within the Beijing Tiantan Hospital, is currently the national clinical, research, and training center with over 300 neurosurgical beds divided into craniocerebral injury, cerebrovascular disease, spinal injury, skull base surgery, intracranial tumors, pediatric neurosurgery, stereotactic and functional neurosurgery, and neurointensive care units in addition to ten research departments. Its basic neuroscience research departments cover neuroanatomy, neurotransmitter, neuropathology, neuropharmacology, neuroepidemiology, cytobiology, neurophysiology, immunology, neurochemistry, and electron microscopy. The faculty is led by prominent neurosurgeons like Chung-Cheng Wang, Ya-Do Zhao, Shi-Qi Luo, and Ji-Zong Zhao. More than 1000 neurosurgeons have benefited from its training programs till date.

Further south in Shanghai, yet another city subjected to early Western influence after the Opium War with Britain in 1840–1843, neurosurgery service was established in 1953 in the Shanghai Red Cross Society Hospital, the predecessor of the Shanghai Huashan Hospital, by Yu-Quan Shi and Zhen-Qin Zhu. This prestigious institution has been credited with the first Chinese-made stereotactic frame and the first indigenously designed operating microscope and pioneered hemispherectomy for infantile hemiplegia in 1959. Postgraduate neurosurgery training programs have been offered since 1958. Shi retired from the Chair of the Department of Neurosurgery in 1989. The Shanghai Huashan Hospital was incorporated into the Shanghai Huashan Institute of Neurological Surgery (SHIN) in March 2000, with a total annual operative statistics exceeding 4,000.

After the inception of the PRC in 1949, there were periodic sociopolitical upheavals, in particular the notorious Chinese Cultural Revolution from 1966 to 1976, causing widespread social, political, and economic chaos throughout the country. Scholastic aptitude was considered bourgeois and decadent and could constitute the basis for severe persecution. Not surprisingly, there was a striking absence of neurosurgical publications during this "Dark Age" of modern Chinese history.

Until the beginning of the long anticipated economic reform in 1978 by leader Deng Xiao-Ping, the country endured diplomatic and cultural isolation, compounded further by economic embargo from Western nations due to ideological difference, a legacy of the Cold War. Language barrier and paucity in resources meant that innovative Chinese neurosurgeons had to develop skills de novo and design diagnostic and surgical equipment, often under conditions harsh by Western standards. Their works have been documented in monographs and native Chinese journals such as the *Chinese Medical Journal*, *Chinese Journal of Neurosurgery*, *Chinese Clinical Neurosurgery*, and subspecialty journals, e.g., *Chinese Journal of Stereotactic and Functional Neurosurgery*, and *Chinese Journal of Minimally Invasive Neurosurgery*. It is only perhaps in the last decade or so that more and more Chinese neurosurgeons armed with better command of foreign languages have made their works known to the rest of the world through international journals such as *Journal of Neurosurgery*, *Neurosurgery*, *British Journal of Neurosurgery*, *Stereotactic and Functional Neurosurgery*, etc. (*Figure 11-5*).

Figure 11-5
The first issue of the *Chinese Journal of Stereotactic and Functional Neurosurgery* (published in Anhui Province, China, 1986)



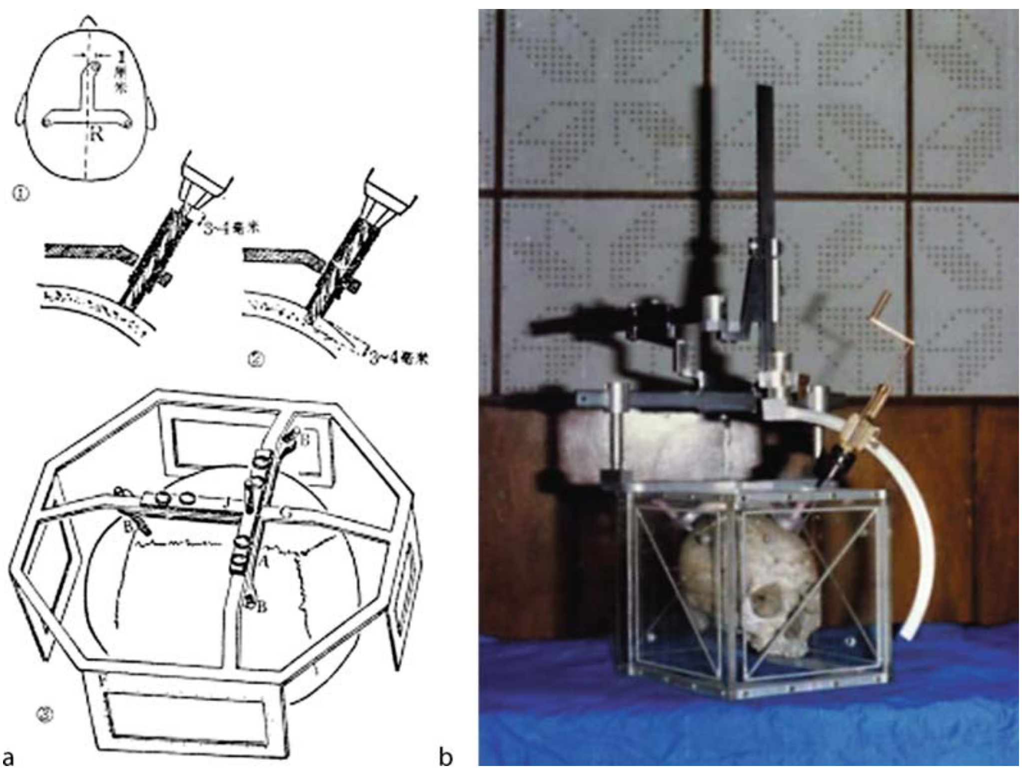
Stereotactic and Functioning Neurosurgery

Historical Developments in China

In the 1940s, psychosurgery was reportedly being carried out by Dr T.H. Zhang. Stereotactic neurosurgery has advanced with strides in North America and Europe since 1946 when Spiegel-Wycis performed the first human stereotactic pallidotomy [7,8] and Prof. Lars Leksell invented of the Leksell stereotactic frame using polar coordinates in 1949 [9]. Nevertheless, the first surgical treatment for Parkinson's disease in China was a freehand transorbital pallidotomy using Novocain and Iodipamide by Chung-Cheng Wang in 1959 [10]. Chung-Cheng Wang and fellow contemporaries Jian-Pin Xu, Mao-Shan Wang, and Da-Jie Jiang were the forerunners of stereotactic and functional neurosurgery in China.

In 1963, Dr Jian-Ping Xu, currently in the Guangdong Hospital of Traditional Chinese Medicine, completed a two-year training at the Moscow Neurosurgical Institute under the tutelage of Dr Edvard I. Kandel, who was the first Soviet neurosurgeon trained in stereotactic surgery. In the same year, Xu embarked on stereotactic surgery on patients with Parkinson's disease using his self-designed Cartesian coordinates–based stereotactic frame in Anhui [11]. Sheer necessity and lack of recourse to expensive Western products motivated many Chinese surgeons, notably Mao-Shan Wang and Da-Jie Jiang of the Shanghai Medical University, in the early 1960s to design stereotactic devices to be used in, e.g., pallidotomy and thalamotomy for extrapyramidal disease [12–14]. Da-Jie Jiang's frame (*Figure 11-6* left) was an attempt to incorporate features of the two main groups of stereotactic devices available in the West then. Devices in the first category were

Figure 11-6
Stereotactic head frame designed by Da-Jie Jiang, Shanghai, 1964 (*left*) and with Li Pan 1989 (*right*) (with permission)



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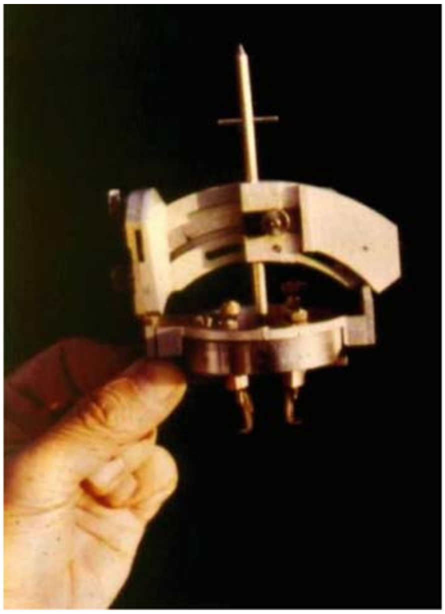
structurally and mathematically complex, bulky, and difficult to operate. Specialized X-rays were needed. However, they offered a high degree of accuracy. These were exemplified by the Spiegel-Wycis, Leksell, Riechert, and Talairach equipment [7,9,15,16]. The second was represented by the Cooper and Austin devices [17,18]. These were structurally simple and easy to use but were compromised by a lower degree of accuracy even with repeated intraoperative adjustments with X-rays. Complications were also more prevalent. Limitations in target precision, control of lesion size, and higher degree of complications resulted in the waning of enthusiasm for these early stereotactic procedures (➲ *Figure 11-7*).

During the first decade of Western stereotactic neurosurgery, surgeons designed and custom-made their own stereotactic apparatus, as commercially produced frames were not available. The Spiegel-Wycis stereotactic frame was in fact built by Davis, an English machinist, in the workshop of the Temple University Medical Center in Philadelphia. There was also a whole array of Chinese-designed stereotactic equipment, the most prominent among these being the XZ-I to XZ-V brain stereotactic apparatus by Jian-Pin Xu of the Anhui Provincial Hospital (1964–1977). This was not unlike the Guiot–Gillingham frame, small and simple in design, being anchored to the calvarium, and not requiring sophisticated supportive equipment [11,19,20]. However, only procedures within the small confines of one cerebral hemisphere were possible and a lower degree of precision was afforded. The FY85II, designed by the Xian Fourth Military Hospital in 1985, was quite similar in principle to the Todd-Wells and Leksell frames. The patient's head was secured within the base ring. It was based on the arc principle and had a wider range of maneuverability, permitting bilateral hemispheric procedures with a higher degree of accuracy of within 2 mm. Other stereotactic equipment invented included the DZY-A from Nanjing and a frame by Wu SL from the Guangdong Minimally Invasive Neurosurgery Medical Center, Guangzhou, during the same period (➲ *Figure 11-8*). In 1989, Da-Jie Jiang and Li Pan designed a stereotactic instrument incorporating computerized tomography (CT) and magnetic resonance imaging (MRI) guidance (➲ *Figure 11-6* right). The HB-set

Figure 11-7
Dr Jian-Ping Xu with his stereotactic device in 1986 (*left*) and operating with his computer-assisted CT-guided equipment (*right*)

Figure 11-8
Stereotactic device used by Jiang (*left*) and Wu SL in 1983 (*right*)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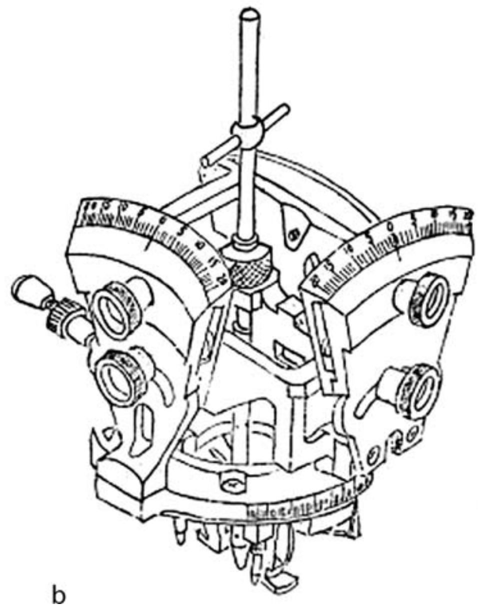
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stereotactic equipment, the fruit of a collaboration between the Beijing Science and Engineering University and the Beijing Naval General Hospital, was launched in 1995 [21]. This later phase of intense activity in research and development of instruments was made possible by the modern economic and sociopolitical reform of the late Chinese leader Deng Xiao-Ping in 1978.

Rapid acquisition of wealth, prosperity, and affluence in China after 1978 resulted in enhanced purchasing power, allowing practically unhindered access to Western technology. Accelerated growth in a very technology-dependent field such as neurosurgery inevitably ensued. Many hospitals have since acquired CT and high-resolution MRI instruments. Positron emission tomography (PET), single photon emission computerized tomography (SPECT) and magnetoencephalography (MEG) machines were also installed in some of the leading centers. Computer-assisted frame-based and frameless neuronavigational surgical procedures were performed. Some hospitals employed home-made systems. In the West, computer-assisted stereotactic neurosurgery was available as early as 1969. Digital CT- and MRI-image-guided stereotactic surgery was introduced in China in 1973 and 1980, respectively.

Following Schaltenbrand-Wahren's publication of the *Atlas for Stereotaxy of Human Brain* in 1977 [22] and Ronald Tasker's release of the *Physiological Atlas of the Thalamus and Midbrain Using Electrical Stimulation* [23], Jia-Qing Yao et al. produced the *Stereotactic Anatomy of Brain Gray Matter* (in Chinese) for use by Chinese neurosurgeons in 1983. In 1992, the same author published the *Applied Stereotactic Anatomy of the Human Brain* with specific reference to the Chinese population [24,25].

Training Programs, Professional Organizations, and National Conferences

The earliest generation of Chinese neurosurgeons received their stereotactic neurosurgery training abroad. Jiang-Ping Xu was trained in Moscow under the distinguished Russian pioneer stereotactic surgeon Dr Edvard I. Kandel from 1960 to1963. Cheng-Yuan Wu was a visiting scholar in stereotactic surgery for one year at the University of Utah, USA, with Dr M. Peter Heilbrun. Others like LZ Cheng, XM Fu, and ZP Ling were subsequently trained at Karolinska Hospital, Sweden, and Henri Mondor Hospital, Paris. Many of the leading stereotactic and functional neurosurgeons currently holding senior positions in major Chinese neurosurgical centers have received training in well-known international centers including UCLA, John Hopkins Hospital, Karolinska Hospital, and Hannover Hospital, among many others.

After the first Chinese Stereotactic Neurosurgery Institute was established in Anhui Province in 1983 (*Figure 11-9*) by Jian-Ping Xu and Ye-Han Wang, indigenous stereotactic neurosurgery training program became available to native Chinese neurosurgeons with Dr Xu as the program director. A Computer-assisted Stereotactic Training Course was organized the next year. The Annual National Workshop on Stereotactic and Functional Neurosurgery was hosted by the Anhui Provincial Stereotaxic Neurosurgical Institute in 1987. By 1986, the total number of Chinese-made stereotactic devices in use had reached 300, and total number of stereotactic surgeries exceeded 1,000. It is estimated that as many as 80% of the current practicing stereotactic and functional neurosurgeons have benefited from the Anhui workshops. At various intervals, other leading medical centers, e.g., Beijing Neurosurgical Institute, Beijing General Hospital of Armed Police Force, Tianjin General Hospital, Shanghai Huashan Hospital, and hospitals in Guangzhou and Harbin, offer training in stereotactic neurosurgical techniques. The Anhui Provincial Stereotaxic Neurosurgical Institute, in particular, has trained more than 400 neurosurgeons in stereotactic and functional neurosurgery to date.

The Neurosurgery Specialty Society of the Chinese Medical Association (CMA) was established in March 1986 with Chung-Cheng Wang as the Chairman. Wang, born 1925, played a very pivotal role in modern neurosurgery in the PRC, having mentored more than one-third of the

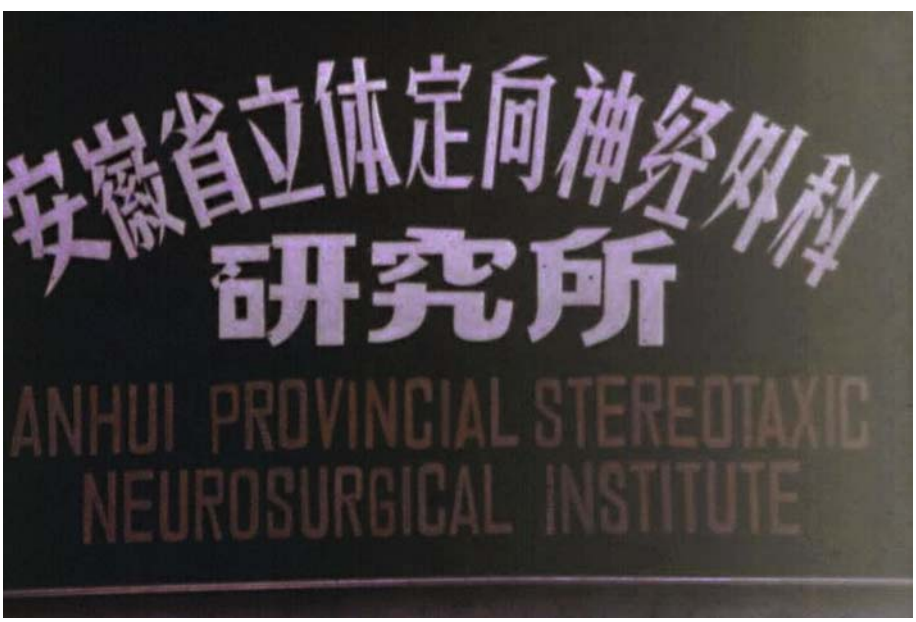


Figure 11-9
The first Stereotactic Neurosurgery Institute in Anhui Province, China

current generation of Chinese neurosurgeons. Apart from a very illustrious neurosurgical career, being the pioneer in brain stem microneurosurgery and the first to perform cerebral angiography in China during the impoverished postliberation and Korean War era of 1950s, he served in the Medical Corps in the Korean War against the US-led Allied Forces in 1952 and has been elected as representative to the People's Congress of China (the Chinese equivalent of the Parliament). The Medal of Honor was bestowed upon him during the XII World Congress of Neurosurgery held in September 15–20, 2001 in Sydney, Australia.

The Chinese Society of Stereotactic and Functional Neurosurgery was formed in July 1987 under the umbrella of the CMA. The first National Stereotactic and Functional Neurosurgery Conference in June 6–8, 1987 at Hefei, Anhui Province, was organized by the Neurosurgery Specialty Society of the CMA and attracted 155 participants with 85 papers presented (*Figure 11-10*). It has since been held seven times: May 16–20, 1990, in Chendu; May 9–13, 1993, in Dalian; May 12–16, 1997, in Beijing; August 1–4, 2001, in Harbin; June 6–10, 2004, in Yinchuan; June 26–30, 2006, in Huangshan.

In November 16–19, 2007, the First National Congress of Functional Neurosurgery was held in Xiamen. This was organized by the Stereotactic and Functional Neurosurgery Specialty Committee, Neurosurgery Association of the Chinese Medical Doctors Association (CMDA), a parallel organization to CMA. It was attended by more than 400 participants. The first National Congress for Brain Tissue and Neural Cell Transplantation was held in Kunming in January 1990. The Chinese Association of Epilepsy Surgery was established in 1990 and organized its first National Epilepsy Surgery Work-shop in the following year. In December 1998, the Guangdong Minimally Invasive Neurosurgery Medical Center organized the first National Minimally Invasive Neurosurgery Conference in Guangzhou.

The biannual Shanghai International Symposium on Functional Neurosurgery is hosted by the Center for Functional Neurosurgery of the Shanghai Medical University. The Shanghai Medical University, founded in 1927 as the National Fourth Zhongshan University Medical College, was incorporated into the Shanghai Huashan Institute of Neurological Surgery (SHIN) in March 2000.

Invited, distinguished international speakers to these national conferences and other meetings

Figure 11-10
The historic First National Stereotactic and Functional Neurosurgery Conference. Hefei City, Anhui Province

have included Bjorn Meyerson, Bengt Linderoth (Sweden); Andres Lozano (Canada); Philip L. Gildenberg, Weiser, Philip Starr, Antonio.A.F.De Salles (USA); and J.P. Nguyen, Pr Pierre Cesaro (France).

In recent years, Chinese neurosurgeons have increasingly made their presence felt in regional and international conferences such as the Congress of the Asian Society for Stereotactic, Functional and Computer-assisted Neurosurgery (ASSFCN), Congress of European Society for Stereotactic and Functional Neurosurgery (ESSFN), World Congress of the World Society for Stereotactic and Functional Neurosurgery (WSSFN), WFN World congress on Parkinson's Disease and Related Disorders, Congress of Neurological Surgeons (CNS), and the American Association of Neurological Surgeons (AANS) meetings. Frequent scholastic exchange with overseas counterparts has further enhanced international collaboration.

Modern Chapter of Chinese Stereotactic and Functional Neurosurgery

Within the half a century since stereotactic and functional neurosurgery began in China, remarkable progress has been made. However, there is relatively less emphasis on research, be it laboratory or clinical, no doubt due to the immense workload and the difficulty of gathering follow-up information from patients spread over such a vast countryside. Leading neurosurgery centers can now offer stereotactic and functional neurosurgical treatments with cutting edge technology comparable to the West, by neurosurgeons with impeccable credentials. The Beijing Tiantan Hospital with its Beijing Neurosurgical Institute is one of the world's top three neurosurgical institutes and Asia's largest center for neurosurgical treatment, training, and research. It was designated by the World Health Organization (WHO) in 1982, together with the Shanghai Huashan Hospital, as the WHO Collaborating Centers for Research and Training in Neurosciences in China. The Shanghai Huashan Hospital was incorporated into the Shanghai Huashan Institute of Neurological Surgery (SHIN) with the Gamma Knife Hospital and two other affiliated hospitals in March 2000. The large number of practicing stereotactic and functional neurosurgeons became self-evident when close to 500 registered participants attended the First National Congress of Functional Neurosurgery in November 2007 in the southern city of Xiamen which overlooks the Taiwan Strait.

Sophisticated modern neurosurgical treatments however remain largely the exclusive and privileged domain of the elite urban rich, as health insurance has yet to gain a foothold in this part of the world. Huge disparity still exists in wealth, education, and social welfare between the affluent cities of the eastern coastal provinces, and the relatively more deprived rural areas in the interior. The paradox exists that while urban China can boast of world-class hospitals and treatment, the rural poor do not have easy access to sometimes even basic medical facilities. It is commendable that the problem is being aggressively addressed by the Chinese central government through its emphasis on preferential developmental programs for the western regions. Providing adequate healthcare to one-fifth of the world's population spread over such a vast country is a daunting task for any government indeed.

Nevertheless, the huge population with seemingly unstoppable economic progress offers a golden opportunity and a rich substrate for a quantum leap of development of this technology-driven division of medical science. Acquisition of abundant clinical data permits derivation of useful observations and conclusions on treatment modalitiesfrom huge pools of patients. J.N. Zhang published 580 case reports on stereotactic intracranial procedures for Parkinson's disease in 2000 [26], and S.B.Yuan reported on 1,431 cases of intracranial lesions treated with the Chinese-designed rotating gamma system (OUR-XGD) in the *Chinese Journal of Stereotactic and Functional Neurosurgery* in 2001 [27], while 3,094 patients were treated with the Leksell Gamma Knife by Liang JC in Guangzhou up to 1999 [28]. The extreme degree of subspecialization within many of the large metropolitan or university units, the envy of many foreign neurosurgical centers, permits rapid development of subspecialty neurosurgery in China.

Unencumbered by legislative regulatory constraint and working within a much less litigious environment compared to the West, Chinese neurosurgeons are quick to embrace new modalities of treatments, admittedly some still controversial, ahead of their European or American counterparts. The Beijing-based General Hospital of Armed Police Force, for example, established its Department of Neural Stem Cells Transplantation in March 2004 and has since treated close to 200 patients with strokes, traumatic brain injury, spinal cord injury, motor neuron disease, and cerebral palsy [29]. The Xishan Hospital in Beijing has an ongoing program on the implantation of olfactory ensheathing cells (OEC) from the olfactory bulb of aborted fetuses on patients with diagnoses ranging from amyotrophic lateral sclerosis and spinal cord injury to Parkinson's disease. It has reportedly treated over 600 cases since 2001 [30,31], while in Europe, for example, the laboratory research by Geoffrey Raisman at the Institute of Neurology, Queen Square, London, on adult autotransplanted OEC on rats is currently still awaiting human clinical trials [32]. These nascent therapies have not yielded the same consistent and reproducible results of, for example, deep brain stimulation (DBS) in Parkinson's disease.

Psychiatric neurosurgery has largely fallen into disrepute under public and political scrutiny and clouded by controversy in the West for the past two decades. This was due partly to the risk of litigation, ironically sometimes from patients rendered well enough by psychosurgery to initiate legal proceedings, and refusal of reimbursement by insurance companies. The 1986, the U.S. Office of Health Technology Assessment report which stated that "*psychosurgery should be considered experimental as it has never been studied in a scientific manner*" further discouraged its more widespread acceptance. However, we have witnessed its unabated development in China in the same period. For example, psychosurgery for the alleviation of drug dependence gained popularity in China from 2000 to 2004.

Frame-Based Surgery, Neuronavigation, and Robotics

This has seen perhaps the most impressive growth since digital imaging, and the advent of stereotactic instrumentation has brought stereotactic surgery into the realms of many Chinese neurosurgeons, who like their Western counterpart have hitherto confined their works to general neurosurgery [33,34]. Whereas previously stereotactic imaging had to rely on angiography and ventriculography, identification of intracranial landmarks can now be made by noninvasive CT or MRI. Diagnostic tissue biopsies, evacuations of hematomas and abscesses, intracavitatory instillations of radioisotopes for tumors [35,36], e.g., combined ^{32}P and Methotrexate chemotherapy for deep-seated gliomas, interstitial ^{192}Ir brachytherapy for glioblastomas [37,38], and transplantations of neural tissues with minimally invasive techniques have been widely carried out in China. CT-guided neuroendoscopies have also been performed. In 1998, Tian ZM from the Beijing Navy General Hospital of People's Liberation Army reported on 1,300 cases of CT-guided operations under local anesthesia using both the Leksell stereotactic frame and the indigenous HB-III instrument [39]. Intratumoral instillation of radionuclide and chemotherapeutic agent (BCNU) accounted for 780 and 24 cases, respectively. Lesioning of functional targets (101 cases), brain tissue biopsy (171 cases) and evacuation of intracerebral hematomas (155 cases) constituted the remainder. The Chinese-made NDY stereotactic frame has also been employed by some neurosurgeons.

Frameless stereotaxy or neuronavigation permits neurosurgeons to perform stereotactic-assisted volumetric excision of intracranial space occupying lesions accurately, greatly minimizing procedure-related risks [40–42]. It is now being used with intraoperative MRI at the Beijing Tiantan Hospital and Shanghai Huashan Hospital. Neuronavigation with functional MRI (fMRI) has been used in surgery near eloquent areas [43]. Neuronavigation-assisted neuroendoscopies have also been carried out with a high degree of success [44]. It is has become a standard inventory in neurosurgery operating suites in major neurosurgical units in Beijing, Shanghai, Guangzhou, Tianjin, Xian, and other cities. Neuronavigational systems available in China include the SurgiScope (Elekta), StealthStation (Medtronics), VectorVision (BrainLab), and the China-made ASA-610V and ASA-630V (Shenzhen Anke High Tech Co.) [45]. Image-guided, robot-assisted stereotactic system (CRAS HB1) developed by the Beijing Aeronautical and Astronautical Institute was used by Tian ZM of the Beijing Naval General Hospital in 1997 on 32 patients comprising 23 cases of intratumoral brachytherapy, 3 cases of tissue biopsy, and 2 cases each of evacuation of abscess and hematoma, achieving an instrument efficacy of 86% [46].

Surgery for Movement Disorders

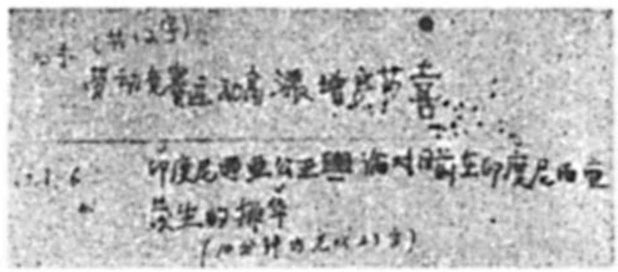
The first pallidotomy for Parkinson's disease was done freehand in1959 by Zhong-Cheng Wang, who is the president of the Chinese Neurosurgical Society and the Beijing Neurological Institute. Wang designed the transorbital approach using trocar puncture of orbital roof, contralateral to the side of tremor or rigidity, 4 cm from mid-sagittal plane aiming 10° superiorly and medially. An FG 20–22 needle was then advanced to the frontal horn, replacing 30–40 ml of cerebrospinal fluid (CSF) with filtered air. The same needle after being withdrawn, was then reinserted a few degrees vertically inclined from Reid's base line (inferior orbital to superior external auditory meatus) and 10° deviated towards contralateral side to a depth of 9 cm. The pneumoventriculogram thus created confirmed placement of needle tip 2 cm posterior and 1 cm inferior to foramen of Munro, 2 cm lateral to mid-sagittal plane. After 0.5 ml of 1% Novocain confirmed favorable response, 0.5 ml of 40% Iodipamide was introduced. This simplified procedure was intended to bring pallidotomy into the hands of many doctors who may have to practice under relatively Spartan circumstances [10] (*Figure 11-11*).

Two years later, Mao-Shan Wang's stereotactic device was put to fruition and he carried out stereotactic alcohol ablation of globus pallidus, quite akin to the original chemopallidectomy that I.S. Cooper published in *Science* in 1955. (Cooper subsequently switched the target to the thalamus and reportedly performed over 3,000 cases of chemo-thalamectomies.) [47,48]. MS Wang published his stereotactic procedure "Surgical Treatment for Parkinsonian Syndrome" in the *Chinese Journal of Surgery* in 1961 [12]. Similar endeavors using self-designed stereotactic apparatus were undertaken by the pioneer surgeon Da-Jie Jiang, who published his two-year preliminary reports on 20 cases of extrapyramidal system disease in the *Chinese Journal of Neurology and Psychiatry* in 1964. Jiang's targets included globus pallidus, ventro-lateral nucleus, centro-median nucleus, nucleus reticularis, and internal capsule depending on the predominance of tremors, rigidity, and upper or lower limb involvement [14]. Localization was based on the Spiegel–Wycis atlas and coordinates [49]. Intraoperative confirmation of electrode placement was

Figure 11-11

Dr Wang's patient feeding with previously tremulous left hand. Handwriting in dots before (*above*) and after procedure of another patient, 1959 (with permission from CC Wang)


a


b

carried out in three stages: using 0.5 ml 1% Novocain instilled into target through electrode needle, electrical stimulation, and depth electrode recording. Parkinson's disease constituted the largest category of conditions treated, and the early procedures were predominantly ablative in nature. A large series of papers was published by Guo-Dong Gao from the Xian Fourth Military University (1,478 cases) and by Zhang JN (580 cases) [26,50].

Following Backlund's first clinical trials in 1982 and Madrazo's 1987 report on open microsurgical adrenal medullary tissue transplantation to the striatum for parkinsonism demonstrating therapeutic benefit [51,52], Wa-Cheng Zhang et al. of the Beijing Xuanwu Hospital embarked on transplantation of adrenal medulla to the head of caudate nucleus for six patients with Parkinsonian tremors using a XZ-III stereotactic device in 1987, using postoperative CT scan to confirm placement of transplant tissue carriage in the head of caudate nucleus. CSF dopamine and normetanephrine levels were elevated to 1–2 times of presurgical assay, and clinical symptomatic improvements of tremors were documented [53]. In 1994, Wu CY et al. published their results of combined fetal substantia nigra tissue transplantation and stereotactic thalamotomy in the *British Journal of Neurosurgery* [54].

Gamma knife thalamotomy (Vim, VO) using a 4-mm collimator delivering 130 Gy for the treatment of 58 cases Parkinson's disease and other movement disorders was reported by Zhang Jie et al., claiming 80% good response over a follow-up period of up to nine years [55].

The first human microelectrode recording (MER) during functional brain surgery was reported by Albe-Fessard in 1961. MER was introduced in China in 1998 by Yong-Jie Li of the Beijing Institute of Functional Neurosurgery, Xuanwu Hospital. More than 2,000 cases of pallidotomies with CT or MR guidance have been carried out annually in China [50,56,57]. A significant proportion of those employed intraoperative MER for physiologic confirmation of electrode placement. Li published a review of 1,135 cases of surgical treatment of movement disorders in 2001 [58].

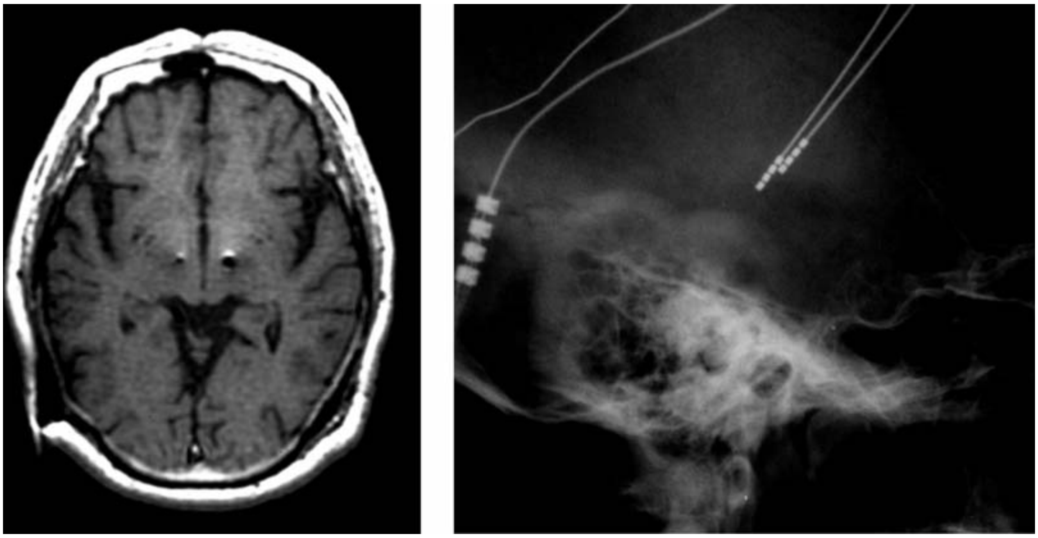
In 1972, Bechtereva N.P. of the former Soviet Union carried out therapeutic stimulation of the deep brain structures using intermittent external stimulation [59]. Siegfried and Benebid started DBS surgery for Parkinson's disease in 1985 after the former unexpectedly noticed amelioration of Parkinsonian tremors from the implanted thalamic deep brain stimulator meant for chronic pain [60,61]. The U.S. FDA has approved DBS as a treatment for essential tremors, Parkinson's disease, and dystonia in1997, 2002, and 2003, respectively.

Led by Chung-Cheng Wang, the Beijing Tiantan Hospital performed the first DBS surgery for Parkinson's disease in China in September 1998. Visits by Dr Philip A. Starr, University of California San Francisco (UCSF), and Dr Andres Lozano, Toronto Western Hospital, to China in 1999 helped DBS surgery, which gained further popularity. By 2003, more than 300 personal cases of DBS of subthalamic nucleus of Luys were performed by leading functional neurosurgeons like Jian-Guo Zhang, Yong-Jie Li (Beijing), and Bomin Sun (Shanghai). Other functional neurosurgeons like Kang-Yong Liu, Xiao-Wu Hu (Shanghai), Zhi-Pei Ling (Anhui), Shi-Zhong Zhang (Guangzhou), and Guo-Dong Gao (Xian) have also accumulated considerable personal experience in DBS surgery. Their works have been variously published in *Chinese Journal of Neurosurgery* in 2002 [50,58,62,63].

There are more than 30 hospitals in China where DBS for Parkinson's disease are regularly performed (*Figures 11-12* and *11-13*). The total number of cases done since 1998 has exceeded 1,000. In the Beijing Tiantan Hospital, Xuanwu Hospital, and Shanghai Ruijin Hospital, DBS treatment has also been extended to dystonia, Tourette syndrome, Hallervorden–Spatz disease, Meige's syndrome, and chorea using subthalamic nucleus as target [26,64]. In 2002, Bo-min Sun used subthalamic nucleus of Luys for primary and tardive dystonia and achieved 90% 3 months to 3 years postoperative improvement based on Unified Parkinson Disease Rating Scale (UPDRS) and the Burke–Fahn–Marsden Scale [65]. Microelectrode recording were generally used in DBS surgery for intraoperative neurophysiologic targeting like in other overseas centers [66,67].

Figure 11-12
Deep brain stimulation surgery at the Shanghai Medical University (Fudan University) Huashan Hospital

Figure 11-13
DBS electrodes in subthalamic nucleus. (Shanghai Huashan Hospital)



Stereotactic Radiosurgery

Stereotactic radiosurgery was first introduced into China in 1993 when the Leksell gamma knife was installed in Wanjie Hospital in the northeastern port city of Qingtao. This was soon followed by the Beijing Tiantan and Shanghai Huashan Hospitals. There are more than 50 stereotactic radiosurgery centers in China. The Chinese-designed rotating gamma system OUR-XGD was launched in 1994 and relied on only 30 cobalt-60 sources instead of 201 in the Leksell system. The SGS-I stereospecific gamma ray whole body treatment system (*Figure 11-14*) has since been launched. It is estimated that more than 8,000 cases of stereotactic radiosurgery and radiotherapy are treated annually, with Beijing Tiantan Hospital alone accounting for more than 10,000 cases till December 2007. Currently, there are 17 Leksell gamma knife radiosurgery installations (compared to 35 in the USA), almost an equal number of LINAC X-Knife units, over 20 rotating gamma system (OUR-XGD) units, 1 Novalis (Brain Lab) ststem, and 4 CyberKnife (Accuray Inc.) systems in mainland China. The OUR-XGD rotating gamma system and the SGS-I have been exported to countries such as Egypt, India, and Hungary.

In 1999, Liang JC and Wu HX of the Guangzhou General Hospital of PLA reported on the gamma knife treatment of 3,094 cases of intracranial lesions including brain tumors (with or without cytoreductive surgery), arteriovenous malformations, and even functional targets [28,68]. From July 1995 to May 1998, they had treated 280 cases of arterio-venous malformations, of which 42 were Spetzler–Martin grade I, 68 grade II, 95 grade III, and 7 grade IV and grade V 4, with a high obliteration rate for grade I and II. Another large clinical series of 1,431 cases was published by Yuan SB of the Sichuan Gamma Knife Center, Chengdu Army Hospital, using the OUR-XGD rotating gamma system over a four-year period from January 1997 to January 2001 [27]. The results of the LINAC X-Knife treatment on 510 cases were documented by Wang LG in 2000 [69]. Gamma knife radiosurgery have been utilized for thalamotomy in Parkinson's disease and other functional disorders [55]. It is worth noting that Lars Leksell actually conceived stereotactic radiosurgery in 1951 for the treatment of the functional disorder

Figure 11-14
SGS-I: Chinese-made whole-body rotating gamma ray treatment system

of obsessive compulsive neurosis apart from tic douloreaux [9]. X-Knife radiosurgery for intractable epilepsy had been carried out by Qi ST on focal functional areas after preoperative electroencephalography (EEG), MRI, and PET evaluations [70].

Epilepsy Surgery

Treatment of epilepsy in China can be traced to ancient times. Apart from *Neijing* (Yellow Emperor's Inner Classic) 2000 years ago, there have been many medical classics dating back to Tang Dynasty (Qian Jin Yao Fang – *The Invaluable Medical Script* 652 A.D.), Sung Dynasty (*Ji Sheng Fang Medical Script* 1253 A.D.), Yuan Dynasty (*Danxi Miscellaneous Comprehensive Medical Text* 1481 A.D.) and Ming Dynasty (*Treatment Yardstick* 1600 A.D.), where traditional (TCM) treatments of epilepsy were described.

Victor Horsley introduced surgery for medically intractable epilepsy in 1886. It is estimated that about one-quarter of epilepsy patients become medically intractable, rendering them candidates for surgical intervention. Epilepsy surgery was accepted as an alternative treatment by the U.S. National Institute of Health Consensus Development Conference on Surgery for Epilepsy, March 19–21, 1990. In China, with a population of 1.3 billion, the total number of surgeries performed for medically refractory epilepsy had quadrupled from 600 before the year 2000 to 2500 in the year 2005 with a quarter from Beijing alone [71].

Review of the medical literature and hospital records indicate that the earliest documented works on epilepsy in China were in the 1950s, when Guo-Sheng Duan reported on lesionectomy for post-traumatic epilepsy with the aid of electrocorticography [72]. Krynauw RA first reported the removal of one cerebral hemisphere as the treatment for infantile hemiplegia [73]. Yu-Quan Shi of Shanghai First Medical College performed hemispherectomy under general anesthesia on four cases of severe infantile hemiplegia aged 3 years 5 months to 9 years in 1956. Pneumoencephalography demonstrated ipsilateral ventricular and cisternal enlargement, ventricular shift to contralateral side, as well as porencephaly. A normal contralateral ventricle was a prerequisite. EEG was used in cooperative patients. Hemispherectomy was done *en bloc* as opposed to Krynauw's cruciate excision of the hemisphere in four blocks, sparing the caudate nucleus and thalamus (*Figure 11-15*). Shi observed improved seizure control, alleviation in aggressive behavior, and slight improvement in developmental IQ, but persistence of hemiplegia. Spasticity and hypertonia, though reduced, did not translate into improvement in dexterity of hand movements [74].

Ya-Du Zhao of Beijing Xuanwu Hospital also reported his experience on 12 cases of hemispherectomy and anterior temporal lobectomy from 1959 to 1963, employing intraoperative electrocortical recording and bipolar direct electrical cortical stimulation [75] (*Figure 11-16*). Shi and Zhao were considered the pioneers who laid the foundation of modern epilepsy surgery in China. (Ya-Du Zhao was the younger son of Yi-Cheng Zhao, the "founder of neurosurgery in China"). Subsequent works were done by Chen-Ji Liu of the Nanjing Military General Hospital and Zhi-Xun Wu of the Kunming Medical College in 1963. Jian-Ping Xu and Ye-Han Wang of the Anhui Provincial Hospital popularized stereotactic ablative epileptic surgery using home-designed stereotactic equipment in the 1970s. In 1978, surgical treatment for epilepsy was finally made available in the western interior province of Sichuan by Li-Da Gao, Ge Wu, and Chang-Gui Zhou.

After a quiescence of 10 years during the unfortunate Chinese Cultural Revolution (1966–1976), resurgence of epileptic surgery was made possible by the rapid socioeconomic development commencing 1978. Many procedures were undertaken, including temporal lobectomy, corpus callosotomy, neuroaugmentation (vagal nerve and cerebellar stimulation), and multiple vertical subpial transaction (MST) (Frank Morell, Rush-Presbyterian-St Luke's Medical Center) [71,76–78]. Techniques in stereotactic corpus callosotomy and hippocampal resection were published by Jian-Ping Xu and Ye-Han Wang of the Anhui Provincial Stereotaxic Neurosurgical Institute in 1984 [79], while in 1994 Xiao AP et al. from

Figure 11-15

Pneumoencephalography showing left cerebral hemispheric atrophy, compensatory ipsilateral ventriculomegaly (*left picture*), and the medial surface of the excised left cerebral hemisphere (*right picture*). (DrYu-Quan Shi, 1956, Shanghai, with permission)

圖 4　例 2 的气腦造影，示左側腦室扩大及左大腦半球萎縮情況（前后位）。

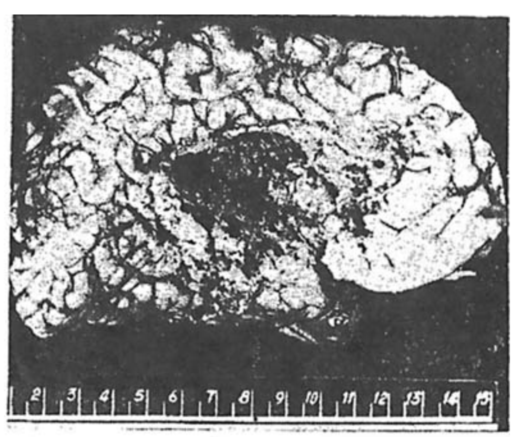
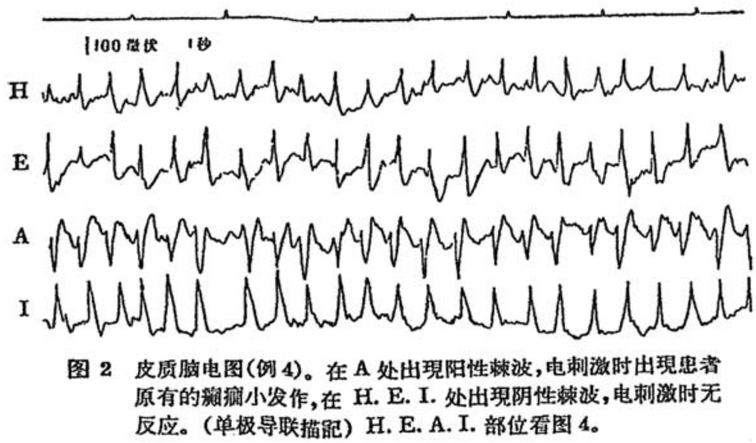


圖 5　例 2，切除的大腦半球，重 308 克（內側面）。

Figure 11-16
Electrocorticography – unipolar lead tracing. Site A showed positive spike waves, electrical stimulation reproduced a subdued form of the original seizure. (Dr YD Zhao, Beijing, 1959, with permission)



the Nanjing Medical University reported 51 cases of stereotactic ablation of Forel H. Field (Mukawa J 1966) [80,81] and unilateral or bilateral amygdalotomy for 51 patients, aged 7–54 years, over a seven-year period since 1987 [82]. Bilateral cingulotomy and anterior capsulotomy were supplemented on 16 patients who had mental disorder. Procedures were done under local anesthesia except for four children. Intraoperative target localization was aided by pulsed electrical stimulation and acoustic impedance.

Through similar works by C.C. Jiang and DJ Jiang of the Shanghai Huashan Hospital (1989) [83], Tang YL, and Zhang ZX, 82 cases (1990) [84] have been published. Gui-Sing Wang in 2004 used depth electrode for hippocampal EEG monitoring and stereotactic guidance in temporal lobe epilepsy surgery [85]. Neuronavigation and electrocorticography have been used in the resection of tumors causing secondary epilepsy [86,87].

Notable contributions were made by Qi-Fu Tan from the Hospital of Nanjing Military Area Command, who proposed guidelines on patient selection, preoperative assessment, operative results, and evaluation protocols, and also improved on the techniques of temporal lobectomy. He performed corpus callosotomy in 1983 and Rasmussen's functional hemispherectomy (Theodore Rasmussen, Montreal Neurological Institute) [88]. His results were published in *Stereotactic and Functional Neurosurgery* [89].

The spectrum of operated cases currently ranges from focal or partial epilepsy due to neoplasm to focal cortical dysplasia, hippocampal hemiatrophy, epileptogenic foci in temporal or frontal lobes, and multifocal epileptic zone located at or near eloquent cortex. Standard presurgical workup includes comprehensive neurosurgical, neurological, and neuropsychiatric assessment, electrophysiological studies including video EEG monitoring, digital imaging with MRI, and fMRI and MR spectroscopy where indicated [90,91]. Alterations in cerebral metabolism in the ictal and interictal period are documented with PET or SPECT [92]. MEG and implanted electrodes have also been employed [85,93].

Zhang G.J. of Beijing Xuan Wu Hospital [94] reported his experience on the application of long-term intracranial EEG monitoring using rectangular grids, linear strips, and stereotactically implanted flexible depth electrodes in epilepsy surgery in the *Chinese Journal of Neurosurgery* in

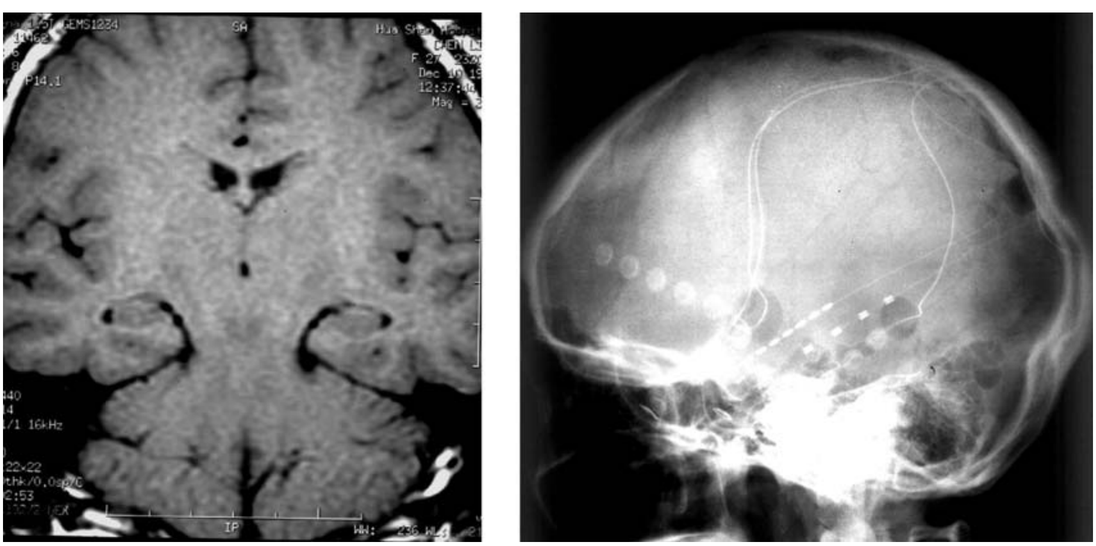
2005 (Figure 11-17). Luan G.M. from the Beijing San-Bo Brain Science Institute pioneered low-power bipolar electrocoagulation on layer III of cerebral cortex for epileptogenic foci on or near eloquent cortex for patients in whom MST was otherwise indicated, and reported good results [95]. This has been increasingly adopted by other epilepsy surgeons. However, its long-term efficacy and delayed sequelae have yet to be fully elucidated. He and his colleague Yunlin Li carried out various combinations of procedures from lobectomy, hemispherectomy, corpus callosotomy, and vagus nerve stimulation to low-power bipolar electrocoagulation on the eloquent cortex on 77 patients with multiple epileptogenic foci. Intraoperative electrocorticography was employed. Fifty-three patients achieved class I and II seizure control, based on Dr Jerome Engel Jr's classification on surgical outcomes [96].

Stereotactic radiosurgery in epilepsy surgery was reported by Qi-Fu Tan in 2001 [97]. S.T. Qi used the X-Knife (BrainLab) with EEG, MRI, and PET for intractable seizures from focal functional areas [70]. Treatment on 38 patients diagnosed with medial temporal lobe epilepsy from January 1998 to December 2004 using the Chinese-made rotating gamma system (OUR-XGD) was reported by Yuan SB, with 73.68% overall efficacy (Engel I–III) [98].

The Beijing Tiantan Hospital took the lead by setting up the first independent epilepsy surgery unit in China, with a current annual surgical census exceeding 200. The number of hospitals with an epilepsy surgery unit in Beijing City alone has tripled from three in 1990 to nine in 2005. There are between 150 and 200 practicing epilepsy surgeons in China responsible for over 2,500 cases per year. Epilepsy surgery is now available in Nanjing, Guangzhou, Harbin, Chongqing, Chendu, Kunming Anhui, Wuhan, Shandong, Xinjiang, and Shijiazhuang, apart from Beijing and Shanghai.

The National Epilepsy Surgery Society was formed in 1990, with the first National Epilepsy Surgery Workshop held in the next year in Qufu (birth place of Confucius). It has since been held four times on annual or biannual basis. The *Chinese Newsletter of Epilepsy Surgery* was published in 1992 with Qi-Fu Tan as the editor. The China Association Against Epilepsy (CAAE) was formed in June 2005. It has become a member

Figure 11-17
Electrocorticography in epilepsy surgery in twenty-first century China



of the International League against Epilepsy (ILAE). Epilepsy surgery has featured prominently during six of the National Stereotactic and Functional Neurosurgery Conferences since 1987. Works by Chinese epilepsy surgeons are published in the *Journal of Epilepsy Surgery*, *Journal of Asian Epilepsy* in addition to the *Chinese Journal of Stereotactic and Functional Neurosurgery*. The second edition of the *Textbook of Epilepsy Surgery* edited by Qi-Fu Tan was released in 2006 [99].

Psychosurgery

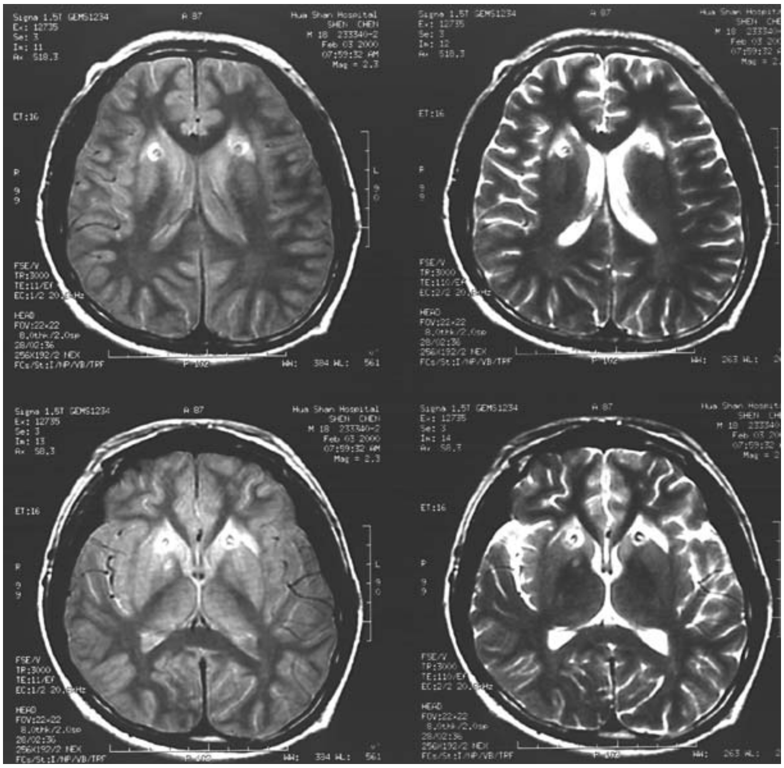
Although psychosurgery was performed in China by Tong-He Zhang of Xi'an in the 1940s, barely five years after the Portuguese Nobel Prize winner neurologist Egas Moniz conceived and performed the first operation for psychiatric disorder with neurosurgeon Almeida Lima on November 12, 1935 [100], this was followed by a lull of almost four decades. This was undoubtedly influenced by the events in neighboring fellow communist Soviet Union. Bekhterev and the father of Russian Neurosurgery Puusepp performed frontal leucotomy for maniac depressive psychosis and psychic equivalents of epileptics in 1906–1910, while classical leucotomies of Moniz and Lima for schizophrenia and severe pain were done from 1930s to late 1940s. Psychosurgery was banned in Soviet Union in1950 for ideological reasons [101].

Interests in psychiatric neurosurgery were rekindled in 1980s in a handful of Chinese hospitals in tandem with developments in the West [102]. Wu SL reported on 23 cases of schizophrenia treated with anterior cingulotomy in 1988 [103]. The first National Psychosurgery Conference was held in Nanjing in 1988, during which 542 cases of neurosurgical treatment for psychiatric disorders were presented. Procedures performed were anterior cingulotomy and amygdalectomies for various intractable mental illnesses including chronic schizophrenia and epileptosis. During the conference, the National Clinical Guidelines for Psychosurgery were formulated, spelling out criteria for patient selection, informed consent, procedure types, and perioperative psychological assessments, among other issues. Since schizophrenia constituted the main bulk of operative cases, surgery expectedly did not result in amelioration of symptoms, just as Ballantine concluded in his retrospective report in 1989 on 198 patients who underwent anterior cingulotomy that schizophrenia and personality disorder responded least well to surgical treatment. A similar conclusion was made by Moniz [104,105]. Surgical option was not warmly received by psychiatrists who were never strong advocates of surgical intervention for their patients. The number of psychosurgeries dwindled progressively, and by the later half of 1990s many hospital had discontinued psychosurgery altogether.

The revival of psychosurgery in China in the twenty-first century coincided with the widespread application of CT- and MRI-guided stereotactic surgery in the field of neurosurgery, allowing components of the limbic system, e.g., cingulate gyrus, amygdale, etc., to be accurately and safely approached [106]. Stereotactic limbic surgery, a more appropriate term than psychosurgery, was applied to the more responsive affective, anxiety, and obsessive compulsive disorders. A better understanding of the pathophysiological substrate of psychiatric diseases resulted in more widespread acceptance of psychosurgery.

The French neurosurgeon Jean Talairach and colleagues first performed anterior capsulotomy for psychiatric disorders in 1949. Radiofrequency (RF) thermocoagulation stereotactic capsulotomy was subsequently developed by Lars Leksell. In 1999, Bomin Sun of Shanghai introduced MRI-guided bilateral capsulotomy (*Figure 11-18*) for refractory obsessive-compulsive disorder, which he reported in the *Chinese Journal of Neuropsychiatric Disorder* in 2003. Capsulotomy-induced localized orbitofrontal subcortical metabolic changes in obsessive compulsive disorder were documented with PET (*Figure 11-19*) [107].

Figure 11-18
Postoperative MRI. Capsulotomy in obsessive compulsive disorder. (Shanghai Huashan Hospital 1999)



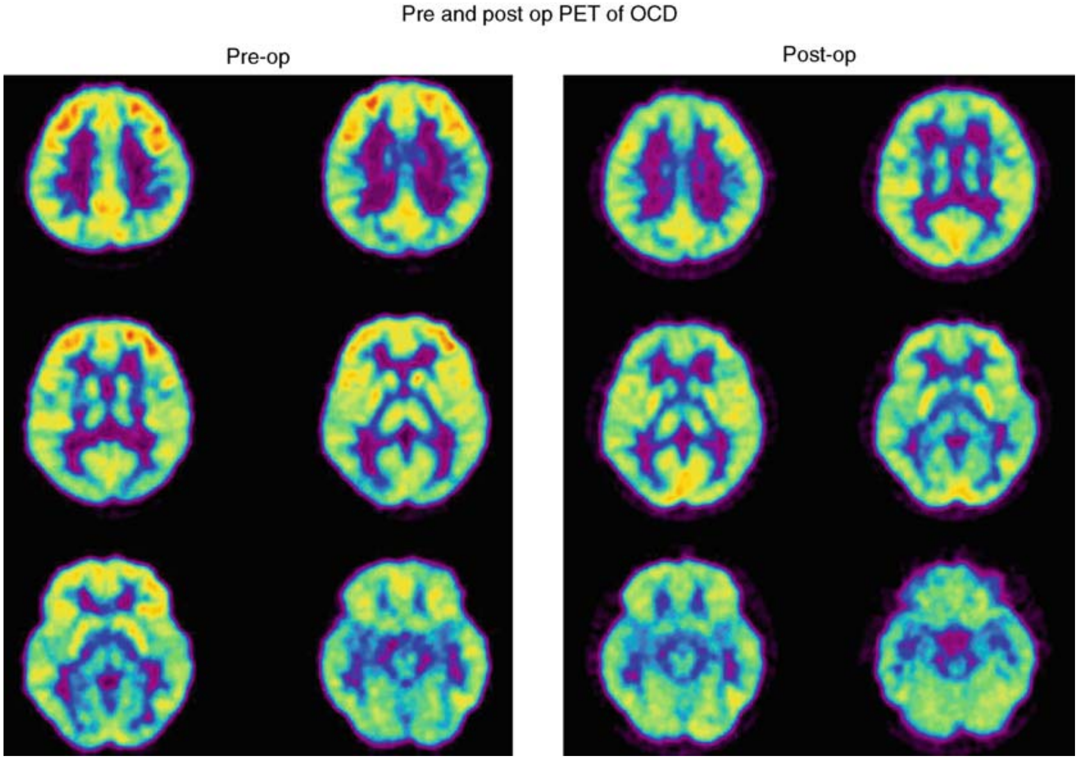
A few cases of DBS for obsessive compulsive disorder have been carried out by Sun, targeting the anterior capsulum. Unilateral (right) lesion combined with DBS of the dominant (left) side appeared to yield better surgical outcomes. Clinical analyses of 138 cases of multitarget stereotactic thermocoagulation of amygdala, anterior cingulum, and anterior internal capsule for intractable psychosis have been reported by Xiao-Feng Wang and Ke-Ming Jiang in the *Chinese Journal of Stereotactic and Functional Neurosurgery* in 2003 [106].

Since 2000, psychosurgery for opiate addiction was carried out in some Chinese hospitals. For the few years till 2004, when it was finally banned for general clinical applications by the Chinese Ministry of Health because of public outcry from its socioethical controversy, more than 500 cases have been performed. From July 2000 to November 2004, 272 cases of stereotactic ablation of nucleus accumbens for opiate addiction were performed at the Tangdu Hospital, Xian Fourth Military Medical University [108]. (Note: The Russians had chosen cingulate gyrus as the target.) Guo-dong Gao published the clinical study on the success and relapse in the initial 28 cases, claiming 65% good to excellent results over a mean follow-up period of 15 months [109]. Other workers have also targeted the medial septal diagonal band complex [110]. One case of successful bilateral DBS on nucleus accumbens was included in Xu Ji-Wen's 27 case reports of neurosurgical treatment for drug addiction in 2005 [111].

Functional Neurosurgery for Pain

Surgical treatment for pain had progressed from interruption of pain pathways to stimulation of

Figure 11-19
From left: Preoperative and post-PET scan of a Chinese patient with obsessive compulsive disorder



pain-inhibiting pathways. Initial reports in the 1960s by Spiegel-Wycis, Ballantine, and, more recently, Wilkinson consisted of thalamotomy and anterior cingulotomy for chronic, intractable pain [8,112,113]. DBS of periaqueductal-periventricular gray and somatosensory thalamus for the relief of cancer pain and deafferentiation pain was reported by Richardson and Akil in 1977 [114]. Meta-analysis of 13 series comprising 1,114 patients by Young RF et al. indicated a modest average long-term success rate of 60% [115]. It is currently performed in the United States as an "off label" (physician discretion) procedure. Neuroaugmentation for pain with the exception of Tsubokawa's motor cortex stimulation (MCS) [116] is rarely performed in China [117]. Instead, the procedures were predominantly ablative in nature.

Jiang-Ping Xu and Chung-Cheng Wang pioneered the percutaneous RF thermocoagulation for trigeminal neuralgia in China. A large series of 1,860 cases was reported by Cheng-Yuan Wu et al. from the Qilu Hospital of Shandong University in 2004 [118]. A stereotactic basal frame for the 3D CT localization of foramen ovale and trigeminal stereoguide was designed. Excellent or good response was noted after selective percutaneous RF thermocoagulation in 96.3% cases, with a two-year recurrence of 24.8%. X-ray guidance, 3D CT, and neuronavigation enhanced the safety and accuracy of the procedure, overcoming the shortcomings of the freehand procedure. Microvascular decompressions for trigeminal neuralgia and hemifacial spasm are regularly carried out. Gamma knife radiosurgery for trigeminal neuralgia was reported by Mian-Shun Pan et al. of the Hefei Gamma Knife Hospital, Anhui Province, on 67 patients from 1997 to 2002, achieving 87.8% relief after an average three weeks [119].

Stereotactic thermocoagulation for central pain has been done since the early 1990s. Yang

FM from Harbin reported on this procedure in 1992 [120].Ventriculogram and, in more recent cases, CT- or MR-guided RF lesion of centromedian nucleus and amygdala for chronic cancer pain on 46 patients have been reported by Jing GJ in 2002 [121,122]. Hu YS and Li YJ concluded in 2005 that a combination of bilateral anterior cingulotomy with mesencephalotomy resulted in more gratifying postoperative results based on the Visual Analog Scale and the McGill Pain Questionnaire assessment of patients [123]. Long-term response is still pending. Gamma knife stereotactic radiosurgery for the treatment of cancer pain has also been reported in a series of 322 patients by Jin Hu and Li-Jie Yi [124]. Frequent psychiatric overlay of chronic pain patients and the exceptional tolerance for pain unique to a race that has endured centuries of tremendous hardship can make objective verification of pain alleviation difficult in China.

Clinical and Laboratory Research

Laboratory research on low-power bipolar coagulation of epileptogenic foci has resulted in its clinical application for intractable epilepsy from eloquent cortex [125]. This was first pioneered by Luan GM of the Beijing Brain Science Institute as an alternative to multiple subpial transaction in 2002 [95]. This has proven effective and is being adopted by many epilepsy surgeons especially in China. Neural transplantation research on the survival, migration, and differentiation, and the effects of Nerve Growth Factor (NGF) or Glial cell line derived neurotrophic factor (GDNF) on transplanted embryonal or bone marrow–derived stem cells and olfactory ensheathing cells in laboratory models of cerebral ischemia, spinal cord injury, and substantia nigra are being carried out [31,126,127], hopefully to be translated to clinical application. Effects of limbic leucotomy on quinpirole-induced obsessive compulsive behavior of rats drew parallel conclusions to human clinical results [128]. Further improvement on the robotic system for stereotactic neurosurgery previously launched in 1998 and 2002 is being carried out by the Robotic Institute of Beijing University of Aeronautics and Astronautics [46], while design and upgradation of software for targeting in stereotactic surgery continues [129]. The effect of controlled-release polymers of BCNU-PLA in experimental glioma in vivo and intratumoral radioimmunotherapy by radio-iodinated monoclonal antibodies form part of the cerebral tumor stereotactic brachytherapy research and experimental treatment by Li AB at the Beijing 304 Military Hospital [130].

Literature and Journals

As the numerous clinical and scientific research papers published in the local journals each year are in the Chinese language mainly for local consumption, they are not accessible to foreigners outside China. However, with a better command of foreign languages, Chinese medical professionals have begun to publish in international journals over the past decade. The *Chinese Journal of Stereotactic and Functional Neurosurgery* was first published by the Anhui Provincial Stereotaxic Neurosurgery Institute in 1986, initially irregularly. It is now released bimonthly (Figure 11-5). The *Chinese Journal of Minimally Invasive Neurosurgery* is a monthly publication of the Guangzhou General Hospital of Guangzhou Military Region. The *Journal of Chinese Neurosurgery*, the official journal of the Chinese Neurosurgical Society, is published quarterly since 1985. Other related journals include the *Journal of Epilepsy Surgery*, *Chinese Journal of Contemporary Neurology and Neurosurgery*, *Chinese Journal of Clinical Neurosurgery*, *Chinese Journal of Neurosurgical Disease Research*, and *Chinese Journal of Neuromedicine*.

Stereotactic and functional neurosurgery books and monographs (in Chinese) published include *Stereotactic Anatomy of Brain Gray*

Matter by Yao JQ and Chen YM in 1980, *Functional and Stereotactic Neurosurgery* by Chen BH [131], *Applied Stereotactic Anatomy of the Human Brain* by Yao JQ and Dai HR in 1992, *Brain Transplantation* by WU CY in 1993, *Stereotactic Radiosurgery* by Chen BH [132], *Textbook of Epilepsy Surgery* edited by Tan QF in 1995 (2nd edition 2006), *Minimally Invasive Neurosurgery* by Ma LT in 1999, *The Temporal Lobe Epilepsy Surgery* by Lin Li in 2003, *Modern Stereotactic Neurosurgery* by Tian ZM in 1997, and the Chinese translation of *Epilepsy Surgery* edited by H.O. Luders and Y.G.Gomair (Lippincott, Williams and Wilkins, Baltimore, 2000).

Conclusion

Napoleon Bonaparte of France (1804) once said: "*Let China sleep. For when China wakes, it will shake the world.*" In the last half century, we have witnessed the spectacular rise of China from obscurity to world prominence. As China integrates herself into the world community, Chinese medical professionals have redefined their roles in the international medical fraternity [133–144].

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