Introduction

Stereotactic surgery, a term first adopted in 1973 by the world society for stereotactic and functional neurosurgery in Tokyo; The word "stereotactic" is derived from the Greek word *stereo,* or three-dimensional, and the Latin word *tangere* , to touch ***(Tasker,1991).***

Stereotactic surgery can be defined as a type of surgery that is performed using a geometric guidance fixed to the head, that is capable of directing a probe or energy beam to an unseen target ***(Gildenberg, 1988).***

The primary goal of surgery is to amend faulty area of the brain whilst curtailing damage to surrounding normal tissue. To attain this objective, surgeon must be capable of navigating through the central nervous system with extreme precision. The word "navigate" is derived from two Latin words *navis* (ship) and *igare* (drive) **(*Zonenshayn and Rezai*, 2005).**

Stereotactic surgery as a technique of neuronavigation may utilize an external frame attached to the head (frame-based) or imaging marker attached to the scalp (frameless or interactive image-guided surgery) ***(Zonenshayn and Rezai, 2005).***

The first "stereotactic instrument" was developed in 1889 by a Russian surgeon, ***D. N. Zernov***, but the details of its use are limited. His "encephalometer" was a frame that was apparently fixated to a person's skull with navigation based on a polar coordinate system referenced to a patient's external anatomy ***(Henn et al., 2001).***

The marriage of the medical profession (***Horsley***, neurosurgeon) with the engineering disciplines (***Clarke***, engineer and mathematician), resulting in revolutionary medical technology. ***Horsley*** and ***Clarke*** in 1908 published a report of a new technique for producing lesions at specific locations within the cerebellum of animals. The animal Stereotactic device that they invented was based on Cartesian coordinate system***(Henn et al., 2001).***

In 1637 ***Descartes*** "the father of modern philosophy" observed that the location of an individual point in space can be defined by relating it to three planes intersecting at right angles to each others.

Any point in space can then be specified by three coordinates, each corresponding to the distance between the point and one of the planes (i.e. coordinates X, y and Z) ***(Zonenshayn and Rezai, 2005).***

Horsley and ***Clarke*** device used a mechanism that would move a probe in three perpendicular dimensions, so that any intracranial target could be specified by x, y and z coordinates (Fig.1-1) ***(kelly, 1990).***

With animal's head placed in external fixator, ***Horsley*** and ***Clarke*** used cranial surface landmarks as reference point because radiology was not available (Fig.1-2) ***(Chin et al., 1996).***

Mussen, a neuroanatomist and neurophysiologist designed and built a human Stereotactic frame in 1918 but he was unable to convince neurosurgeon to use it (Fig.1-3) ***(Chin et al., 1996).***

However, true human Stereotactic surgery had to wait the solutions of the problem presented by the variability of skull dimensions, which prevented the safe use of stereotactic surgery based on surface landmarks; ***Spiegel*** and ***Wycis*** resolved this dilemma in 1948 by visualizing landmarks in the ventricular system, outlined by contrast medium and then using an atlas, relating their target structures depicted in atlas to these ventricular landmarks; this concept of localization led to the development of two types of devices : probe guides fixed to a burr hole and adjusted by hand and eye , and true Stereotactic frame (Fig.1- 4) ***(Tasker, 1996).***

The first Stereotactic applications were envisioned for functional surgery, and most of the potential targets were anatomic structures surrounding the third ventricle. Consequently, the reference points selected by ***Spiegel*** and ***Wycis*** were periventricular structures depicted by pneumoencephalography ***(Chin et al., 1996).***

At that time, the most common indication for stereotactic surgery was relief from movement disorders. The initial work in this field was done by ***Meyers***, a non-stereotactic functional neurosurgeon. In 1942, ***Meyers*** devised transventricular approach for treatment of Parkinsonism, but this technique carried a mortality rate of 15.7%. Stereotactic procedures were soon found to be safer than open surgery and the reported mortality rate by ***Spiegel*** and ***Wycis*** was only 2% ***(Chin et al., 1996).***

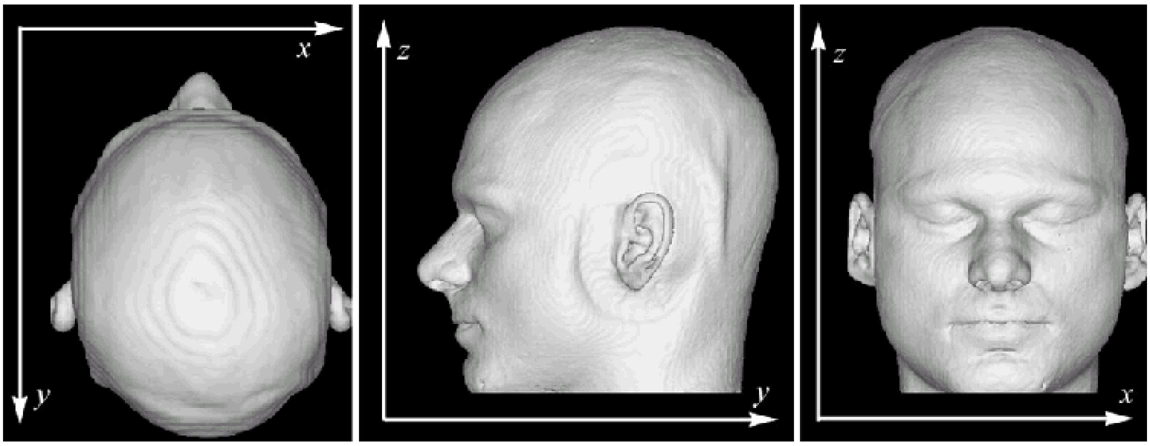

Fig.1-1 : Orientation of the image coordinate system relative to the patient. Axial planes are spanned by the x and y axes, sagittal slices are spanned by y and z, and coronal slices are spanned by x and z ***(Jannin et al., 2002).***

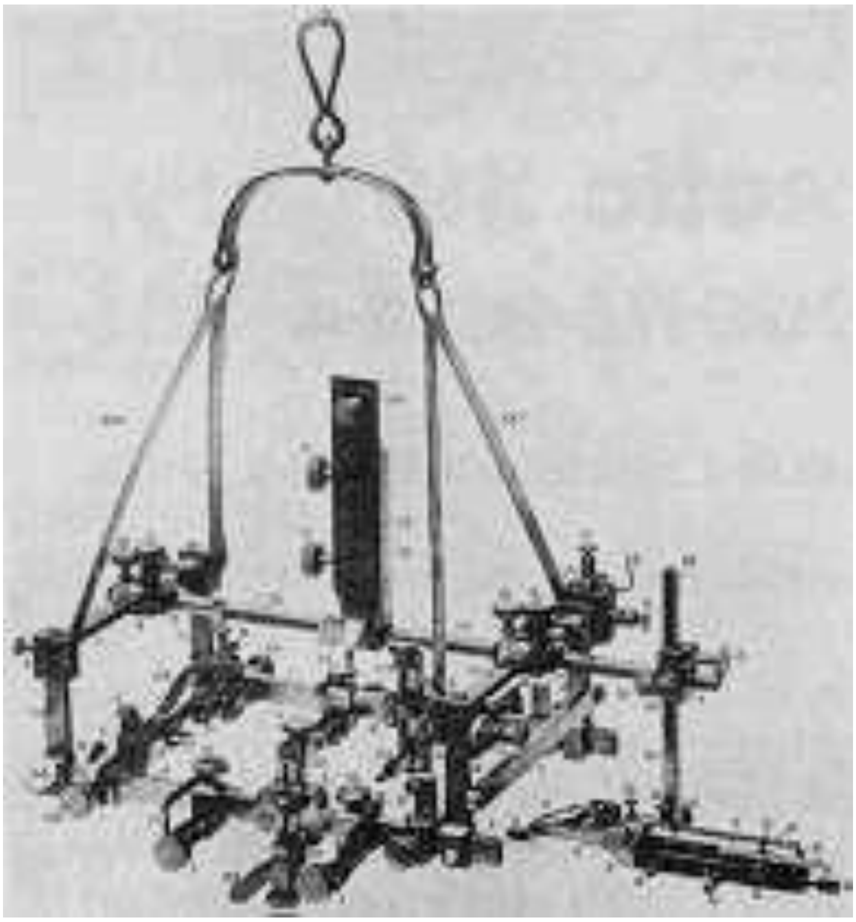

Fig.1- 2: Horsley and Clarke's original animal stereotactic apparatus ***(Henn et al., 2001).***

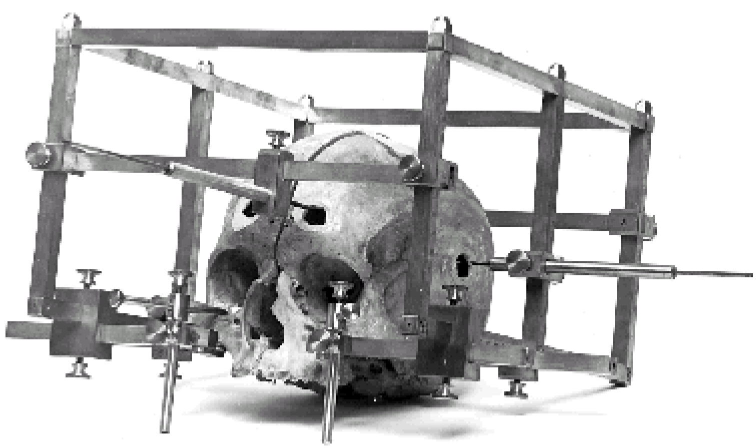

Fig.1-3 : Mussen’s stereotactic instrument ***(Chin et al., 1996).***

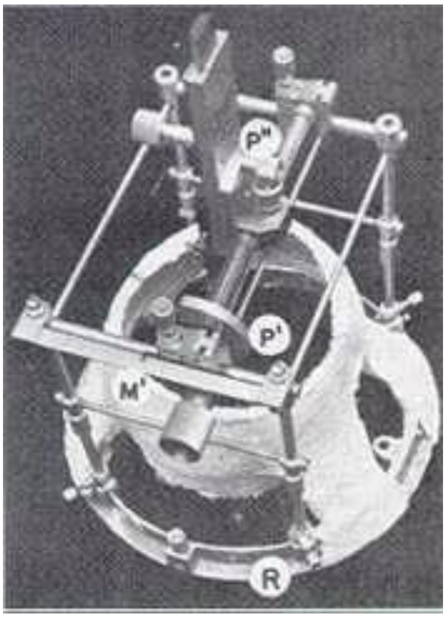

Fig.1- 4 : The original Spiegel and Wycis instrument ***(Chin et al., 1996).***

Similar work was being done by : ***Talairach*** who in 1949 developed teleradiograph, which used X-ray tubes mounted 4 to 6 meters away from the target to minimize errors due to parallax and magnification, ***Leksell*** in 1949 was responsible for the concept of focused beam radiation therapy and the use of radioisotope, and ***Riechert*** who reported a mortality rate of less than 1% for stereotactic treatment of Parkinsonism in 1962 ***(Chin et al., 1996).***

The use of L-dopa in the 1960s resulted in a drastic curtailment of stereotactic surgery and after 1968 stereotactic procedures became relegated to use only in patients refractory to medication ***(Tasker, 1996).***

Modern imaging with computer technology has ushered in a new era, computed tomography (CT) and magnetic resonance imaging (MRI) not only offer more sophisticated visualization of brain structures than ventriculography has done, but they do so noninvasively, more quickly, with less risk and more simply, using their incorporated soft ware, they made it possible to visualize and target normal anatomic structures and pathologic lesions in the brain which can be manipulated stereotactically, the further application of angiography and other specialized imaging techniques completed the evolution of present-day stereotactic surgery ***(Tasker, 1996).***

Calculation of antero-posterior and lateral coordinates was easily performed on the axial images, but determination of the vertical or Z-coordinate proved more cumbersome. Attempts to use wire markers, computed tomography scanner table movement, or calculation of computed tomography scan scout image proved cumbersome and inaccurate ***(Chin et al., 1996).***

In 1979 an elegant system using three sets of N-shaped rods, attached to the stereotactic base ring was described, this was originally devised for the Brown-Roberts-Well (B.R.W) device and has been modified for several other systems ***(Brown, 1979).***

Hand in hand with the development of stereotactic surgery came the elaboration of devices for manipulating targets. These included a variety of aspiration and biopsy instruments, devices for introducing chemicals, radioactive seeds and living cells, equipments for open craniotomies as well as equipments necessary for physiologic localization ***(Tasker, 1996).***

The union of modern imaging and stereotaxis has ushered in a new era of treatment using focused beams of radiation, such as cobalt-60 (Gamma knife) or linear accelerator (Linac), to destroy metastases and primary brain tumors or to thrombose arterio-venous malformations ***(Lunsford et al., 1993).***

Indications for Stereotactic Surgery :

Indications for stereotactic surgery can be divided roughly into two groups, functional and morphological. Functional procedures are designed to change the function of the nervous system and include treatment of movement disorders, psychiatric disorders, pain syndromes, and epilepsy ***(Tasker and Bernstein, 1995).***

Another potential use of stereotactic surgery for restoration of neurological function is in the field of stem cell transplantation **(*Hauser et al., 2002).***

In morphological procedures, the target is a lesion seen by CT or similar imaging techniques ***(Heilburn et al., 1993).***

Such procedures can include biopsy, cyst aspiration, stereotactic open craniotomy, localization for microsurgical removal of a tumor or vascular malformation, aneurysmal clipping, brachytherapy, stereotactic endoscopy for removal of cysts, tumors, or hematomas, and volumetric stereotactic laser surgery. However, biopsy is the most common indication for the use of this technique ***(Apuzzo et al., 1987).***

Although the vast majority of stereotactic procedures have been developed and used for cranial applications, there has been a recent extension of basic navigational principles to other areas of the body, including the spine ***(Zonenshayn and Rezai, 2005).***