Early experience of stereotactic biopsy of brain lesion in tertiary centre of Nepal

Binit Kumar Jha MS¹, Prabhat Jha MS¹, Rajiv Jha MCh², Prakash Bista MCh⁴
¹,²,³,⁴ National Neurosurgical Referral Center, National Academy of Medical Sciences, Kathmandu, Nepal

Date of submission: 5th October 2020   Date of acceptance: 14th February 2021        Date of publication: 1st March 2021

Abstract

Background: Stereotactic surgery or stereotaxy is a minimally invasive form of surgical intervention which makes use of a three-dimensional coordinate system to locate small targets inside the body and to perform on them some procedures such as ablation, biopsy, lesion, injection, stimulation, implantation, radiosurgery (SRS), etc. Though it was developed a long time ago as a useful adjunct to brain lesions evaluation, it’s use at our centre is quite recent.

Methodology: The study included eight patients who underwent frame based stereotactic biopsy and pathological evaluation of specimen at National Academy of Medical Sciences (NAMS).

Results: Out of eight patients the results were positive in seven patient and negative in one patient.

Conclusions: The basic advantages of stereotaxy were realized in our cases with minimal morbidity and no mortality. Craniotomy for biopsy could be avoided.

Key words: Brain biopsy, Stereotaxy

Introduction

Stereotactic surgery or stereotaxy is a minimally invasive form of surgical intervention.¹⁻² It makes use of a three-dimensional coordinate system to locate interventions such as injection, stimulation, implantation, radiosurgery (SRS).³⁻⁶ It uses either with a “frame” or “frameless” system, depending on the surgeon’s preference and the location and size of the lesion. It was first used in 1908 by Sir Victor Horsley and Robert Clarke who specified the use of a Cartesian coordinate system.⁵,⁶ First application of “modern” frame-based stereotaxy to humans was used by Spiegel and Wycis in 1947.⁷

For a frame based stereotaxy, a frame is attached to the patient’s head. Then an imaging, a CT or MRI, is done to find out the exact position of the lesion with respect to the different points in the frame.⁸ Then the data is entered into a software and the exact location of the lesion in three different coordinates is calculated, using which, biopsy is later performed.⁸⁻⁹

For a frameless biopsy MRI or CT image is imported into a computer system that provides a 3-dimensional image of brain and biopsy target in the operating room. This image is used along with a biopsy guidance arm to guide needle safely into the target.¹⁰⁻¹¹

Both approaches have the same safety and success record. The main advantage of frame based stereotaxy is that the rigid metal frame serves to maintain a fixed three-dimensional coordinate system.⁸⁻¹¹ But the bulky assembly of the frame limits head positioning and physically interferes with performing a craniotomy. The arc assembly for aiming is non-intuitive, non-interactive, and limited to a single trajectory at a time. Consequently, framed based systems are reserved for procedures such as needle biopsy or placement of depth electrodes. The success rate for obtaining a definitive diagnosis is >95%, but depends on the type of pathology.⁸⁻¹¹

In general, the diagnostic success rate is high. It is either performed to confirm a suspected brain lesion when
resection is not considered appropriate or when a high-
grade tumor is suspected on imaging or when a wide-range
of differential diagnosis is present for a suspected tumor. It is contraindicated in very small lesions and in patients
who have coagulation disorder. The risk of procedure
is bleeding which can present with mild headache to a
stroke, coma, or even death. The risk of bleeding following
biopsy is around 5% and mortality is around 1%. Besides
bleeding, infection and seizure may occur.9-12

This study shares the early experience of frame based
stereotactic biopsy at National Neurological Referral
Center, Bir Hospital.

Methodology

This is a prospective observational study conducted
in the Department of Neurosurgery, National Neurological
Referral Center, National Academy of Medical Sciences,
Bir hospital. Data were collected from the patients’
hospital records. The first frame based stereotactic biopsy
was performed on 2075/04/01 and up to 2077/08/10 eight
cases have been performed. The cases were selected for
the biopsy primarily based upon the location of lesion
(either deeper location or eloquent areas). No cases were
excluded.

Basic principles that are applied when planning a
trajectory to target include

• The instrument’s trajectory should avoid eloquent
brain and breach only one pial surface to minimize
the chance of haemorrhage. This is particularly true
for lesions near the sylvian fissure or pineal region.

• When possible, the instrument should penetrate the
brain parallel to white matter tracts, especially when
interested in brainstem lesions.

• Generally, the majority of the cerebrum, basal ganglia,
thalamus, and brainstem can be approached with
entry points anterior to the coronal suture. For lesions
in the occipital, parietal, temporal lobe or the pineal
region, a superior parieto-occipital approach is better.
Temporal lesions may, additionally, be approached
laterally and cerebellar lesions approached posteriorly.

Our hospital has a Cosman-Roberts-Wells (CRW) frame based system. This system uses a Cartesian
coordinate system, the x- and y-axes refer to a medial-
lateral and anterior-posterior location, respectively,
whereas the z-axis refers to a base-vertex location. Many
methods have been outlined to determine the z-axis, but
the most popular method uses posts with an “N” shape
configuration where the position of the oblique rod relative
to the vertical rods defines the z plane of the slice [3]. Once
the target is localized, the arc method is used to direct a
probe to the selected target and carry out the remainder
of the procedure. The basic steps of the procedure at our
center are as follows:

1. Frame Application

Frame application is performed in the operating room
with the patient in the sitting position. [Figure 1] Our
preference is to sterilize the scalp with an alcohol or
betadine 5 % prep without shaving hair. The assistant
stands either behind or on the side of the patient and
stabilizes the ring. The ring should be applied parallel
to the cranial floor through the use of ear bars, but
some frame parallax is acceptable. We anesthetize
the scalp and periosteum with 2% xylocaine and
adrenaline. We prefer to place the two posterior pins
first and then we place the anterior pins and hand
tighten all four pins, before using the wrench, with
a two-fingers method. Then the patient is taken for
imaging.

2. Target Localization for Stereotactic Biopsy

CT brain is the imaging modality of choice at our
center. With the patient still in the scanner, it is
important to ensure that all fiducial markers are
visible on all images. We obtain fiducial and target
coordinates in all three orthogonal planes and
average the three paired coordinates with the greatest
spatial accuracy, eliminating the coordinate in each
orthogonal plane which is, by definition, less accurate
because of volume averaging.

3. Stereotactic frame attachment

The CRW Stereotactic system is then attached over
the frame [Figure 2].

4. Identifying the lesion on the stereotactic system

The arc system directs a stereotactic probe
isocentrically around the designated target, thus
obviating a fixed entry point. The Cosman-Roberts-
Wells (CRW) system included some of the same
design elements as the BRW system, including
a phantom frame, the same CT localizer, and the
same probe depth fixed at 16 cm.7,8 New innovations
include the introduction of MRI-compatible frames
and localizers, and versatility in arc-to-frame
applications that enabled inferior trajectories into the
posterior fossa or lateral routes into the temporal lobe.
Additionally, this system included a phantom base
onto which the stereotactic frame including the arc
could be placed to test the accuracy of the settings.

The localizer unit is secured to the ring with three ball-
and-socket interlocks and consists of six vertical posts and three diagonal posts, creating an “N” shaped appearance. It is this latter “N” construct that establishes the axial CT plane relative to the skull base by calculating the relative distance of the oblique to the vertical rods. Target coordinates are established by first identifying the axial slice that best features the lesion. The x and y coordinates for each of the nine fiducial rods are identified on the CT or MRI monitor, as are the x and y coordinates for the target. All coordinates are entered into a laptop computer (the SCSI), which computes the target co-ordinates. For institutions with the Radionics OTS frameless image guidance system, target and trajectory calculations can now be performed with the OTS intraoperative workstation, which provides more flexibility than the SCSI laptop.

**Results**

The first case was performed in 2075/04/01. A total of eight cases have been included in this study. The histopathology reports were conclusive in six cases and was inconclusive in one case. Deep lesions in thalamus were biopsied in three cases. Other cases had lesions in frontal or temporal lobes (table 1).
Discussion

Since the introduction of stereotaxy it has been a great help for neurosurgeons.5-7 Our centre uses the CRW system which is the most modern form of frame-based biopsy. As the volume of cases increases and the experience of surgeon increases it can be utilized as a regular tool at our centre as well.

Biopsy was positive in all except for one. This could have been because of deeper location of the lesion and sampling error. The main reason to prefer stereotactic biopsy over an open operative procedure is that stereotactic procedures have a higher rate of diagnostic accuracy and minimal adverse effects.7-9 Stereotactic biopsy is preferred over open biopsy in tumours with characteristics which include (1) lesions that do not exert symptomatic mass effect or are not treatable by surgical excision, such as metastases or malignant intrinsic brain tumours (2) deep-seated lesions or those occupying space in eloquent cortical regions or deep nuclei (e.g., basal ganglia, thalamus), for which open resection would lead to unacceptable morbidity or mortality; and (3) infiltrative lesions (e.g., gliomatosis cerebri) that do not have a clear brain-tumour margin and are unlikely to be excised without significant loss of normal brain parenchyma. Besides if the lesion’s appearance on imaging or the course of the disease suggest an alternative pathology, such as an infectious or demyelinating process, stereotactic biopsy is an appropriate first step rather than a large open procedure.12-15

Relative contraindications are vascular tumours such as metastatic renal cell carcinoma, choriocarcinoma, or metastatic melanoma. If suspected, these should not be
approached stereotactically, because of inherently higher risk for hemorrhage. In cases of metastatic tumours, effort should be made to find the primary neoplasm. Besides, tumours close to major blood vessel, the vessel-rich sylvian fissure, the cavernous sinus, or the brain-pial border should alert the neurosurgeon to the risk for haemorrhage. Stereotactic biopsy should also be avoided, when possible, in patients treated with anti-platelets or anticoagulant drugs.

Sampling error is a concern with stereotactic biopsies, particularly with non-enhancing lesions, such as low-grade gliomas. An inherent limitation of stereotactic biopsy localization is that the surgical coordinates are based on information obtained from preoperative imaging. A number of factors can lead to mis-registration of stereotactic coordinates on imaging with actual physical location. Intraoperative fluid shifts or brain displacement after dural opening is the largest source of anatomic alteration that leads to ambiguity within the navigational system. When such frame shifting occurs, diagnostic yield and accuracy are less probable. In an effort to avoid this problem, we avoid large dural openings and insert biopsy needles through the smallest possible bone and dural opening.

The most common complication of stereotactic biopsy is intracranial haemorrhage, which frequently results from damage to blood vessels in the trajectory of the biopsy needle or at the biopsy site itself. Current navigation systems with the trajectory view allow trajectory planning to avoid crossing sulcal and pial surfaces and to avoid blood vessels. Second, damage to pathologically friable vessels within the targeted neoplastic lesion can also account for hemorrhagic complications. Reported rates of haemorrhage during stereotactic biopsy procedures range from 0% to 11.5%. A second, less frequent complication of stereotactic biopsy is a new neurological deficit caused by trauma to the surrounding brain parenchyma as a result of direct damage by the needle biopsy or the resulting edema. No major complication was reported in our cases. This could be due to the small size of sample.

**Conclusions**

The basic advantages of stereotaxy were realized in our cases with minimal morbidity and no mortality. Craniotomy for biopsy could be avoided.

**Conflict of Interest:** None

**Source(s) of support:** None

---

**References**

1. Principles of Stereotaxy. Chapter 2 of Ganz, J. Gamma Knife Neurosurgery, Springer, 2011.
2. Rahman, Maryam; Murad, Gregory J. A.; Mocco, J (September 2009). “Early history of the stereotactic apparatus in neurosurgery”. Neurosurgical Focus. 27 (3): E12. https://doi.org/10.3171/2009.7.FOCUS09118
3. Solberg, Timothy D.; Siddon, Robert L.; Kavanagh, Brian (2012). “Chapter 1: Historical Development of Stereotactic Ablative Radiotherapy”. In Lo, Simon S.; Teh, B.S.; Lu, J.J.; Schechter, T.E. Stereotactic body radiation therapy. Berlin: Springer. pp. 9–35. https://doi.org/10.1007/174_2012_540
4. Kandel EJ, Schavinsky YV. Stereotaxic apparatus and operations in Russia in the 19th century. J Neurosurg. 1972 Oct;37(4):407-11. https://doi.org/10.3171/jns.1972.37.4.0407
5. Willems PW, Taphoorn MJ, Burger H, Berkelbach van der Sprenkel JW, Tulleken CA. Effectiveness of neuronavigation in resecting solitary intracerebral contrast-enhancing tumors: a randomized controlled trial. J Neurosurg. 2006 Mar;104(3):360-8. https://doi.org/10.3171/jns.2006.104.3.360
6. Spiegel EA, Wycis HT, Marks M, Lee AJ. Stereotaxic Apparatus for Operations on the Human Brain. Science. 1947 Oct 10;106(2754):349-50. https://doi.org/10.1126/science.106.2754.349
7. Gildenberg PL. Spiegel and Wycis—the early years. Stereotact Funct Neurosurg. 2001;77:11-16. https://doi.org/10.1159/000064587
8. Dorward NL, Paleologos TS, Alberti O, Thomas DG. The advantages of frameless stereotactic biopsy over frame-based biopsy. Br J Neurosurg. 2002 Apr;16(2):110-8. https://doi.org/10.1080/02688690220131705
9. Woodworth G, McGirt MJ, Samdani A, Garonzik I, Olivi A, Weingart JD. Accuracy of frameless and frame-based image-guided stereotactic brain biopsy in the diagnosis of glioma: comparison of biopsy and open resection specimen. Neurol Res. 2005 Jun;27(4):358-62. https://doi.org/10.1179/016164105X40057
10. Woodworth GF, McGirt MJ, Samdani A, et al. Frameless image guided stereotactic brain biopsy procedure: diagnostic yield, surgical morbidity, and comparison with the frame-based technique. J Neurosurg. 2006;104:233-237. https://doi.org/10.3171/jns.2006.104.2.233
11. Quiñones-Hinojosa A, Ware ML, Sanai N, McDermott MW. Assessment of image guided accuracy in a skull model: comparison of frameless stereotaxy techniques

---

**Stereotactic biopsy of brain lesion**
vs. frame-based localization. J Neurooncol. 2006 Jan;76(1):65-70. https://doi.org/10.1007/s11060-005-2915-z

12. Kongkham PN, Knifed E, Tamber MS, Bernstein M. Complications in 622 cases of frame-based stereotactic biopsy, a decreasing procedure. Can J Neurol Sci. 2008 Mar;35(1):79-84. https://doi.org/10.1017/s0317167100007605

13. Jackson RJ, Fuller GN, Abi-Said D, et al. Limitations of stereotactic biopsy in the initial management of gliomas. Neuro Oncol. 2001;3(3):193-200. https://doi.org/10.1093/neuonc/3.3.193

14. McGirt MJ, Villavicencio AT, Bulsara KR, Friedman AH. MRI-guided stereotactic biopsy in the diagnosis of glioma: comparison of biopsy and surgical resection specimen. Surg Neurol. 2003 Apr;59(4):277-81. https://doi.org/10.1016/s0090-3019(03)00048-x

15. McGirt MJ, Woodworth GF, Coon AL, Frazier JM, Amundson E, Garonzik I, Olivi A, Weingart JD. Independent predictors of morbidity after image-guided stereotactic brain biopsy: a risk assessment of 270 cases. J Neurosurg. 2005 May;102(5):897-901. https://doi.org/10.3171/jns.2005.102.5.0897

16. Coffey RJ, Lunsford LD. Stereotactic surgery for mass lesions of the midbrain and pons. Neurosurgery. 1985;17:12-18. https://doi.org/10.1227/00006123-198507000-00003