CT-DIRECTED BRW STEREOTACTIC NEUROSURGERY: LOCAL EXPERIENCE WITH 42 CASES

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ABSTRACT
Initial experience with the Brown-Roberts-Wells (BRW) computed tomographic (CT)-guided stereotactic system is reported. Forty-two procedures were performed over a 22-month period on 21 female and 20 male patients (one patient had a repeat procedure). Their ages ranged from 11 years to 89 years. These included 21 stereotactic biopsy procedures, 2 stereotactic implantations of third ventricular catheters through the foramen of Monro for intraventricular opiate insertion in terminal cancer patients, 2 stereotactic aspirations for brain abscess, 10 stereotactic aspirations of intracerebral haematomas, 3 stereotactic aspirations of cystic brain tumours, 1 stereotactic placement of a fourth ventricle-peritoneal shunt and lastly 3 stereotactic craniotomies. Successful targeting was achieved in all cases. There was one operation-related complication which resulted in uncontrollable intracerebral haemorrhage and ultimately led to the patient's demise.

Keywords: Brain biopsy, Brown-Roberts-Wells stereotactic system, computed tomography, haematoma aspiration, stereotactic surgery.

INTRODUCTION

Stereotactic neurosurgery is that field of neurosurgery where a special guiding apparatus is used to insert instruments into exactly localised targets within the brain with minimal injury to adjacent or overlying structures.

Stereotactic surgery began in 1906 when Horsley and Clarke designed an apparatus using a Cartesian tricoordinate system that could guide an electrode to specific targets within the brains of animals[1]. The relationship between targets within the animals' brains and the landmarks of the skull were determined from an atlas made by sectioning the brain. However, variability between the landmarks of the skull and the cerebral structures is too great to employ this technique in humans. It was not until after forty years later in 1947 when Spiegel and Wycis, using the intracerebral landmarks based on ventriculograms taken in the operating room, performed the first stereotactic procedures on human patients[2].

New techniques nowadays employ targets visualised on computerised tomography (CT) scans, magnetic resonance imaging (MRI) and angiography.

CT-guided stereotactic surgery involves the localisation of specific structures within the brain using CT scans, and allows the accurate insertion of a probe into any target visualised on the CT scan.

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Several techniques using slightly differing principles have been employed, resulting in several stereotactic frames. We will discuss here in this article our experience using one particular type of instrument, the Brown-Roberts-Wells (BRW) computerised tomography stereotactic guidance system.

MATERIALS AND METHODS

Forty-one patients underwent 42 stereotactic procedures from July 1989 to May 1991 at the Department of Neurosurgery, Tan Tock Seng Hospital. There were 21 females and 20 males with ages ranging from 11 to 89 years.

The BRW CT-directed stereotactic system was used in all cases and target localisation was performed using the Picker 1200 SX CT scanner to obtain fiducial data. An Epson HX-20 portable microcomputer was used for data processing, assimilating the entry point data and CT fiducial data to generate the three-dimensional frame coordinates for translation into polar frame settings and probe depth (vide infra).

In 21 patients, the procedure was undertaken for purposes of biopsy, in 2 patients for aspiration of an abscess, in 2 patients for localisation of the foramen of Monro for entry into the third ventricle, in 3 patients for aspiration of a cystic brain tumour, in 1 patient for posterior-fossa insertion of a 4th-ventricle-peritoneal shunt and lastly in 3 patients for stereotactic craniotomies. Representative CT scans are presented (Fig. 1,2,3).

Fig 1 – A deep-seated hypodense lesion in the right basal ganglia eminently suitable for stereotactic biopsy.

Fig 2 – Right periventricular hyperdense lesion in a 48 year-old female presenting with giddiness and headache. Stereotactic biopsy showed this to be an astrocytoma grade II.
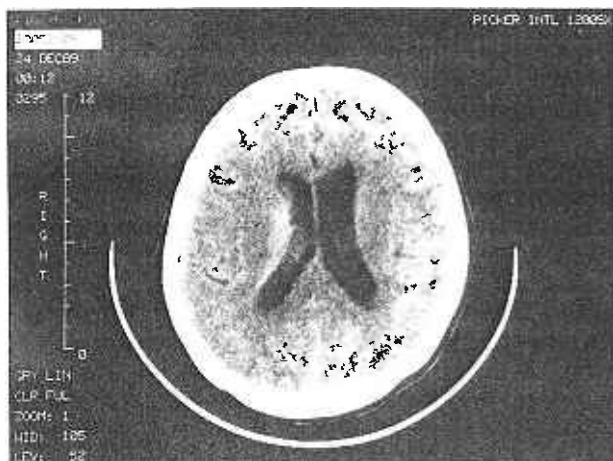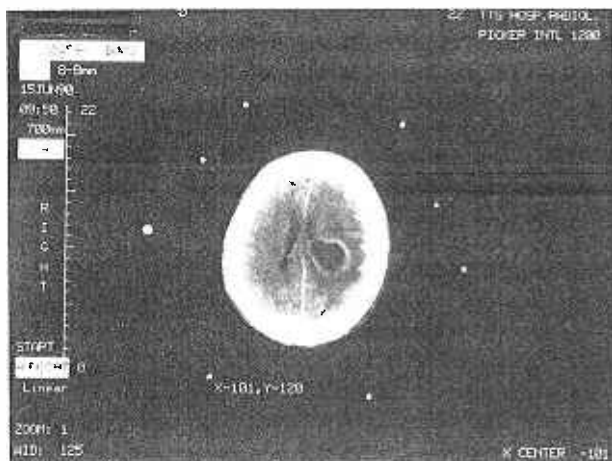

Fig 3 – Fairly deep-seated metastatic cystic tumour from a patient with cancer of the oesophagus. The patient and relatives refused an open craniotomy but were agreeable to lesser procedure of a stereotactic burr-hole aspiration done under local anaesthesia. This was successfully achieved with improvement of his symptoms.

The indications for CT stereotaxy in these cases are summarised in Table I. The targets are presented in Table II.

Thirty-six cases were done under local anaesthesia (usually supplemented with some neuroleptic anaesthesia) and 6 under general anaesthesia. All 3 cases of stereotactic craniotomy were done under general anaesthesia. Burr holes were used in 26 cases and twist-drill holes in 13 cases. A small craniotomy flap was used in the 3 cases of stereotactic craniotomies. We will describe briefly the procedure for stereotactic localisation using the BRW frame together with illustrative photographs. (We will not, however, describe stereotactic craniotomy in this present article).

BRW System Design
The BRW system was developed for a CT image-directed stereotaxy and consists of a series of interlocking arcs to generate a polar-coordinate system transforming two-dimensional CT data into three-dimensional data related to a reference plane surgically fixed to the skull. The mathematical transformation of CT data into three-dimensional target coordinates and polar frame settings after assimilation of entry point data is complex and requires a computer to be used.

Table I
Indications for CT stereotaxy

Brain Biopsy		No.
Deeply sited lesion		7
Diffuse lesion		11
Multiple lesions		3
Aspiration		
Brain abscess		2
Cystic brain tumour		3
Intracerebral haematoma		10
Pain		
Entry into third ventricle through	)	
foramen of Monro for intraventricular	)	2
morphine instillation	)	
Shunt		
Insertion into 4th ventricle in the	)	
posterior fossa for a ventriculo-peritoneal	)	1
shunt in a case of encysted 4th ventricle	)	
Stereotactic Craniotomy		
Deep seated lesion		2
Lesion near eloquent cortex		1
	Total :	42

Table II
Localisation of targets

Supratentorial	
Frontal/fronto-temporal	10
Temporal/temporo-parietal	5
Parietal	5
Occipital	1
Corpus Callosum	1
Thalamus and basal ganglia	15
Periventricular	1
Foramen of Monro	2
Suprasellar Craniophryrangioma cyst	1
Infratentorial/Posterior Fossa	
Encysted 4th ventricle	1
Total :	42

The instrumentation comprises 5 major components: a head ring, a localising "picket fence" ring, an arc system, a phantom base simulator and a programmed laptop computer. The head ring is first fixed to the skull under local anaesthesia in the majority of our cases. This provides a constant reference plane (Fig 4).

Fig 4 – The head ring being attached to the skull under local anaesthesia.
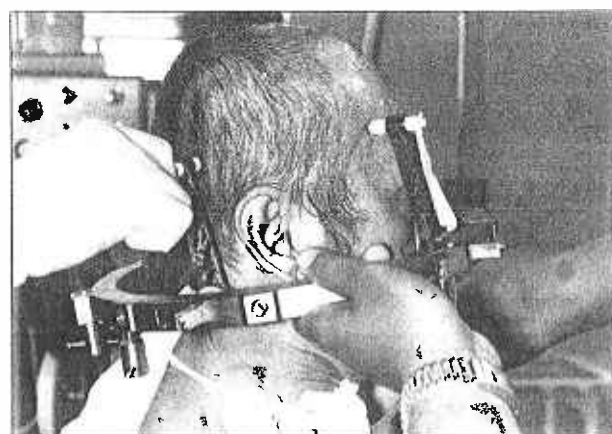
The localising system is then attached to the head ring (Fig 5) and the patient is taken to the CT scan room for scanning. The X and Y coordinates of the 9 localising fiducial points and the target(s) are then obtained from the CT scanner console using software available in the scanner (Fig 6). Back in the operating theatre, a Mayfield headrest adaptor is used for positioning the patient and the localising ring is removed (Fig 7). The data is keyed into the computer which assimilates the CT fiducial data to produce the target coordinates (AP, Lateral and Vertical). The arc system is then placed on the head ring and a pointed probe directed to the chosen entry point. The arc system is then removed and placed on the phantom simulator to obtain the X, Y and Z coordinates of the entry point. These are then keyed into the computer which then calculates the arc settings and the target depth (distance from a reference point on the arc sleeve to the target). The frame settings on the arc system are then checked on the phantom base simulator to confirm target accuracy (Fig 8) before performing the procedure on the patient proper. Any errors in the calculation or setting can therefore be corrected before the actual procedure is undertaken. After target accuracy is confirmed on the phantom, the arc system is placed on the head ring over the patient. The appropriate stereotactic procedure using the special Gildenberg instruments is then undertaken, be it a brain biopsy using the special biopsy forceps, or hematoma evacuation using the Nashold hematoma evacuator incorporating an Archimedes screw, etc. (Figs 9 & 10). The accuracy of the BRW system allows point access to within 1mm of the target.

Fig 5 – 'Picket fence' localising ring attached on to the head ring prior to CT scanning.
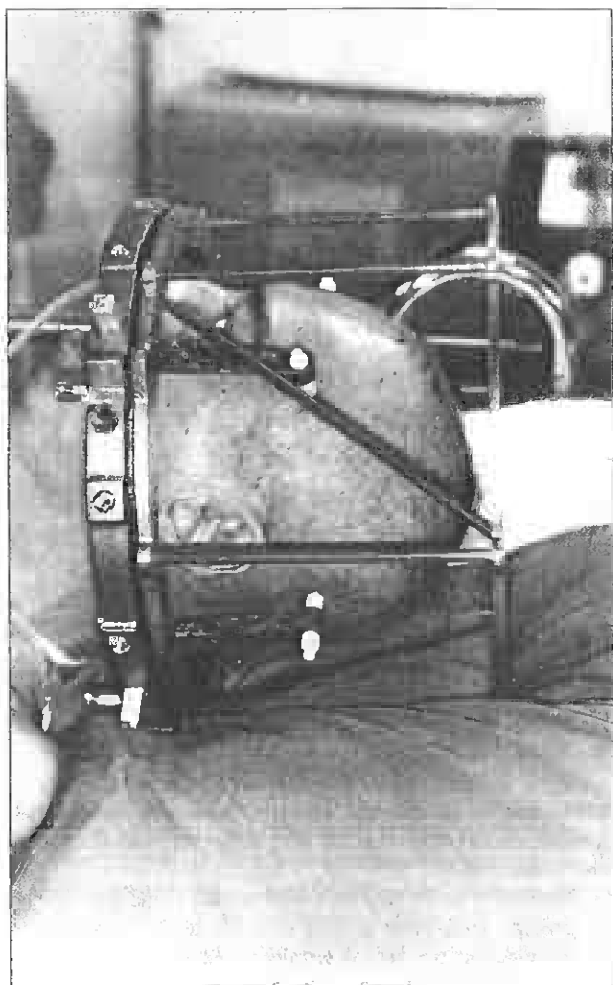

Fig 6 – CT scan of a patient who proved to have a diffuse right frontal glioma showing the X and Y coordinates of the 9 surrounding fiducial points (produced by the 'bars' of the picket fence on the localising ring) as well as the target coordinates.

Fig 7 – In the operating theatre, the localising ring is removed from the head ring and the latter is attached to the operating table using a special Mayfield headrest adaptor.
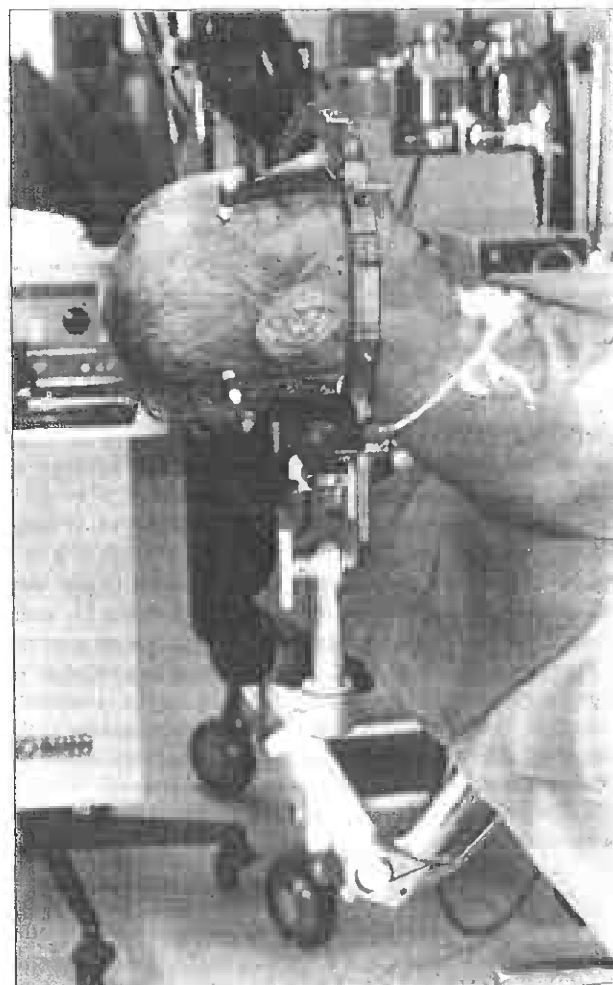
Fig 8 – The arc system mounted on the phantom base. Target accuracy is being confirmed prior to performing the procedure on the live patient.
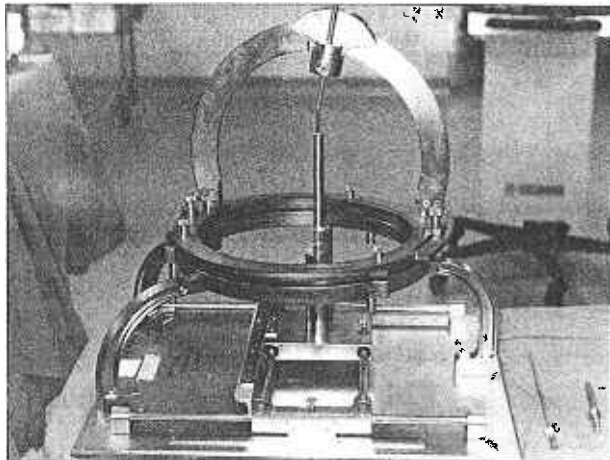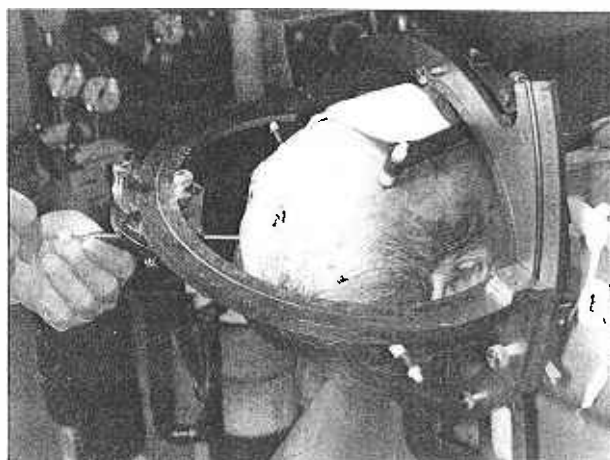

Fig 9 – With the arc system in place on the head ring, a stereotactic procedure is being performed through a twist drill hole in the skull, in this case, aspiration of an intracerebral abscess.

Fig 10 – Stereotactic burr-hole aspiration of a haematoma using the specially designed Nashold haematoma evacuator.
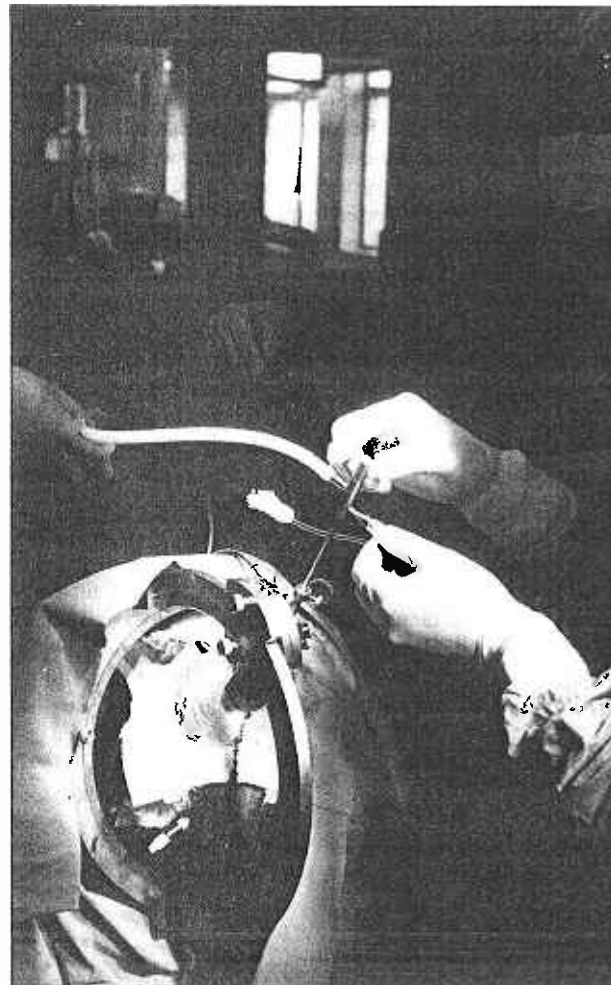
RESULTS

Definitive histological diagnosis was possible in 18 of the 21 cases (86%) who underwent the procedure for purposes of biopsy. (One patient received a repeat procedure to obtain a definitive diagnosis as the initial target chosen was, in retrospect, not representative of the lesion). An average of 3 to 5 specimens were taken from each target. Multiple targets were chosen in 8 cases and single targets in the remaining 13. In the 3 cases with inconclusive results, single targets were selected. Those found to have high grade gliomas, secondaries or lymphoma underwent radiotherapy without further craniotomy except in 5 cases where an open craniotomy was done after the stereotactic biopsy (one for inconclusive histology, and 4 for further surgical decompression prior to radiotherapy).

The foramen of Monro was entered exactly in the 2 cases who underwent the procedure for insertion of a catheter into the third ventricle. This was confirmed on fluoroscopy intraoperatively in both cases. The 2 patients who underwent the procedure for aspiration of a brain abscess had it successfully aspirated as confirmed on post-operative CT scans. Three patients had deep-seated cystic tumours which were successfully aspirated via stereotactic placement of a ventricular catheter into the cyst with resolution of their neurologic symptoms.

One patient had stereotactic placement of a ventricular catheter into an encysted and dilated fourth ventricle via a poste-

rior fossa approach and this was converted into a conventional ventriculo-peritoneal shunt.

Ten patients had stereotactic evacuation of intracerebral haematomas, 9 of which were of hypertensive etiology and 1 traumatic. Nine cases were successfuly evacuated but one developed a new intracerebral arterial bleed as a result of the procedure and required an open craniotomy to evacuate the clot and arrest the bleeding. This patient however, eventually succumbed and died. It is the only operation-related complication and mortality in our series.

Three patients had a stereotactic craniotomy done. In these cases, a probe was used to guide the surgeon directly to the lesion thus avoiding a large craniotomy and preventing undue trauma to surrounding normal brain. The lesions removed were an AVM (arterio-venous malformation), a cavernous angioma and an abscess.

DISCUSSION

Access to deep structures in the brain is difficult, often requiring transaction through normal brain tissue with resultant neurological deficits. The BRW stereotactic system offers a relatively simple, precise and efficient means of reaching any intracranial target seen on CT very accurately and eliminating any guesswork.

Definitive tissue diagnosis is important in the management of patients with intracranial lesions. It not only allows for prognostication but also determines treatment. Pre-operative diagnosis is not always accurate as is seen in Lunsford's series where as many as 26% of the cases in his series had a different histological diagnosis from the pre-operative diagnosis follow-

ing stereotactic biopsy[3]. Stereotactic biopsy of small lesions deep within the brain or in the brainstem makes possible definitive diagnosis of many lesions where only a presumptive diagnosis could have been made previously. This is an important advantage as open biopsies to obtain a histological diagnosis in small deep-seated lesions is like looking for the proverbial needle in the haystack and is more likely to give rise to neurological deficits as more brain tissue is likely to be transected. Another advantage is in low grade gliomas where there is almost no plane between tumour and good tissue and it is impossible to discern at open operation the tumour and its limits. CT-directed stereotactic biopsy is useful in these instances as these tumours are fairly well seen on CT scan. Superficial lesions on the other hand can easily be biopsied or removed by open craniotomy, omitting the need for a stereotactic procedure.

We present here our initial results of 42 stereotactic procedures done in the department over the last 22 months. Our experience has shown stereotactic surgery to be a relatively safe and accurate procedure. As it can be done under local anaesthesia, it should be tolerated even by patients who are not fit for general anaesthesia. It eliminates the need for an open craniotomy in some cases (depending on the pathology and histological diagnosis) as it only requires a burr-hole or twist-drill hole to be made. In instances where the lesion is deeply located or just under eloquent brain, a stereotactic-guided craniotomy may be performed to accurately localise the lesion at craniotomy to minimise cortical injury.

The smaller biopsy specimen size may present problems in histological diagnosis unless the neuropathologist is very experienced. This is offset, to some extent, by the ease and safety with which multiple tissue samples can be obtained from various areas of interest as seen and selected on the CT scan. Zones with varying CT appearances can be studied histologically and correlated[5]. Accuracy in the grading of heterogenous tumours should therefore improve. There should be fewer false negative biopsies. Series reported by Ostertag et al[4], Apuzzo et al[6], Bonvier et al[7], Bullard et al[8], Heilbrun et al[9], Mundinger et al[10] and Thomas and Nouby[11] showed a diagnostic biopsy rate varying between 91% to 100%. Our positive biopsy rate of 86% is in good standing with these results and familiarity with the procedure should further increase the positive biopsy rate.

With regards to the cases of aspiration of abscess and cystic tumour, the procedure was straightforward and uncomplicated once successful targeting was achieved.

In the 2 cases with terminal cancer pain who had ventricular catheters inserted stereotactically via the foramen of Monro into the third ventricle for instillation of intraventricular morphine (the bulk of opiate receptors are situated there around the periaqueductal gray matter), the accuracy was confirmed by intra-operative ventriculography. Satisfactory pain relief was achieved after instillation of substantially lower doses of intraventricular morphine in these two patients whose pain was refractory to oral or intraparenteral morphine at dosages causing drowsiness.

In stereotactic evacuation of hypertensive intracerebral haematoma using the Nashold haematoma evacuator, an Archimedes screw was used to break up the haematoma and controlled suction was used to aspirate the clot usin, Ringer's solution as a constant irrigating fluid. It is stressed here that it is not the purpose of the stereotactic procedure to remove all of the clot seen on the CT scan but only a sufficient amount to effect decompression and relieve severe brain shift.

In 6 of the patients who underwent stereotactic evacuation of their intracerebral haematomas, the catheter tip of an Ommaya reservoir was placed stereotactically into the centre of the clot via a separate entry point to assist in irrigation and to act as a conduit for urokinase instillation 24 hours after clot evacuation, urokinase was instilled into the cavity left behind. Further reduction in the size of the remnant clots on subsequent CT scans were noted.

Having mentioned the above, it must be borne in mind that surgical evacuation of intracerebral haematomas, stereotactic or otherwise, remains a controversial issue. Factors such as the patient's pre-operative status and the site and volume of the clot all influence the decision as to whether surgery would be beneficial in a particular case. We hope to address some of these questions in a future article (when we have collected more cases than our present 10) and discuss the merits, if any, of a stereotactic approach as opposed to a conventional open craniotomy in the evacuation of intracerebral haematomas.

In summary, we have found the BRW CT-directed stereotactic system to be accurate, safe and useful in allowing access to deep-seated lesions or structures. Whilst our initial experience with this technique has been limited to CT-guided stereotaxy and use of a basic apparatus, the results herald the advent of a new era in local neurosurgical practice. Further development and refinement in stereotactic neurosurgical includes use of MRI scanning to localise targets not seen on CT scanning and the use of stereotactic laser surgery to completely remove certain types of deep-seated tumours[12,13]. Interstitial brachytherapy for malignant gliomas, brain tissue transplantation and neurostimulation/neurodestruction for control of intractable pain also incorporate stereotactic techniques. There has been a resurgence of interest in functional neurosurgery as targets are better visualised. As these technologies become available locally, we will be able to offer the unfortunate neurosurgical patient a better prospect of a cure.

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