Minimally Invasive Endoscopic Resection of Intraparenchymal Brain Tumors

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Key words
- Brain tumor
- Endoscopy
- Intraparenchymal
- Minimally invasive

Abbreviations and Acronyms
3D: Three-dimensional
ACA: Anterior cerebral artery
CT: Computed tomography
FLAIR: Fluid attenuated inversion recovery
MRI: Magnetic resonance imaging
WHO: World Health Organization

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■ OBJECTIVE: **To report a minimally invasive, nontubular endoscopic technique to resect intraparenchymal brain tumors and assess the feasibility, safety, and surgical resection margins achievable by this novel technique.**

■ METHODS: **Over a 21-month period, 48 patients underwent 50 consecutive endoscopic intraparenchymal tumor resections. Data on surgical morbidity and mortality and length of stay were collected prospectively. The percentage of surgical resection and residual tumor volumes were calculated using preoperative and postoperative volume computed tomography or magnetic resonance imaging. All tumors were resected through a 2-cm minicraniotomy using a high-definition rigid endoscope with a 30-degree viewing angle. Bimanual resection was performed using standard microsurgical technique.**

■ RESULTS: **Mean patient age was 53 years. There were 42 supratentorial (19 frontal, 17 temporal, 3 occipital, 1 parietal, and 2 parafalcine) tumors and 8 infratentorial tumors. Mean tumor volume was 41 cm^3. There were 12 metastases, 24 glioblastomas, 4 World Health Organization grade III gliomas, 5 World Health Organization grade I–II gliomas, 3 meningiomas, and 2 hemangioblastomas. On volumetric analysis, the overall mean percent resection was 96%. In 70% of cases, >95% resection was achieved; total resection was achieved in 48% of cases. At 30 days postoperatively, there was 1 new postoperative neurologic deficit; there were no deaths during this period.**

■ CONCLUSIONS: **Our experience demonstrates that resection of intraparenchymal tumors using a minimally invasive endoscopic technique is technically feasible and safe, achieves good tumor resection margins, and has some potential advantages over a traditional microscopic technique.**

INTRODUCTION

Resection of intraparenchymal brain tumors has evolved significantly over the last few decades. High-resolution microscopes, intraoperative image guidance, intraoperative magnetic resonance imaging (MRI), diffusion tensor imaging to identify white fiber tracts, and functional MRI have been introduced in the operating room to help the surgeon maximize tumor resection and reduce morbidity and mortality. The endoscope is another tool that has developed in parallel with high-definition cameras and viewing screens and, more recently, three-dimensional (3D) cameras. The endoscope has traditionally been used in neurosurgery to access a lesion within a natural body cavity (i.e., the cerebral ventricular system). The challenge has been to access and resect deep-seated intraparenchymal lesions using a minimally invasive endoscopic technique. Kelly pioneered the development of a stereotactic frame–guided cylinder retractor system in an attempt to create a safe access corridor to perform laser excision of small brain lesions using the operating microscope (9, 10). Other investigators developed variations of this fixed tubular retractor system but were able to achieve total resection in only relatively small-sized lesions because of the fixed conduit and its small diameter (3, 5, 6, 18, 22). More recently, Kassam et al. (7) achieved good resection of tumors using an endoscopic bimanual technique through an 11.5-mm conduit (Neuroendoport, University of Pittsburgh Medical Center, Pittsburgh, Pennsylvania, USA). Access to the tumor was obtained by adjusting the conduit trajectory multiple times throughout tumor surgery to facilitate resection of large lesions.

Over the past 2 years, we have been exploring techniques to perform intraparenchymal tumor resection using the rigid endoscope. We present our prospective single-center study of minimally invasive, transcranial, fully endoscopic, bimanual resection of both superficial and deep intraparenchymal brain tumors. The aim of this study was to assess the feasibility, safety, and surgical outcomes of this endoscopic approach.

MATERIALS AND METHODS

Patients

In a 21-month period between December 2011 and August 2013, 50 consecutive endoscopic resections of intraparenchymal brain tumors were performed on 48 patients. All patients were discussed at a neuro-oncology multidisciplinary team meeting before surgery as per United

Kingdom national guidelines (1) with a management plan of surgical resection agreed on and patient consent given for the operations.

All surgical procedures were performed by the senior author (P.P.). The mean age of patients was 53 years (range, 23–75 years). There 24 women and 24 men in the study. Of tumors, 42 (84%) were supratentorial. Based on the closest cortical surface used for access, tumors were classified as predominantly frontal (n = 19), temporal (n = 17), occipital (n = 3), parietal (n = 1), and parafalcine (n = 2). There were 8 (16%) infratentorial tumors (all cerebellum). World Health Organization (WHO) performance grade was 0 in 66% of patients, grade I in 26%, grade II in 6%, and grade III in 2%. The most common preoperative neurologic symptom was headache (22% of cases). At the time of presentation, preoperative mild limb or facial weakness was seen in 20% of cases, cerebellar symptoms were seen in 12%, seizures were seen in 10%, short-term memory problems or confusion was seen in 10%, and speech deficits were seen in 8%.

Volumetric assessment of preoperative imaging demonstrated a mean tumor volume of 41 cm^3 (range, 2.4–131 cm^3). The mean distance to the cortical surface for subcortical tumors was 8 mm (range, 1–32 mm). In 9 cases, the tumor came to the pial surface. First-time operations accounted for 40 cases, and 10 cases were repeat resections for recurrent tumors.

Surgical Planning

Planning neuronavigation imaging was acquired in patients using a 1.5-T MRI scanner. T1-weighted contrast-enhanced contiguous 1.25-mm axial slices were used to acquire a volume data set that was compatible with both neuronavigation software packages used (Brainlab; Brainlab AG, Munich, Germany, and StealthStation; Medtronic, Inc., Minneapolis, Minnesota, USA). Patients with tumor in an eloquent location underwent preoperative functional MRI and diffusion tensor imaging to plan a safe trajectory and determine extent of surgical resection.

Patients underwent routine neuroanesthesia and endotracheal intubation. Patients with supratentorial tumors were placed in a supine (frontal and temporal tumors), lateral (parietal tumors), or prone (occipital tumors) position. Patients with cerebellar tumors were placed in the park bench or semiprone position. In all cases, the patient's head was immobilized with a Mayfield pin-fixation device (Mayfield Clinic, Cincinnati, Ohio, USA). Frameless image guidance was used in all cases, and registration was performed using facial recognition or scalp fiducial markers for supratentorial or cerebellar tumors, respectively. Brainlab was used in 44 cases, and StealthStation was used in 6 cases.

The endoscope stack, comprising a camera unit with light source and screen (Karl Storz GmbH & Co., Tuttlingen, Germany), was positioned behind the surgeon to allow maximum length on the camera and light source leads. A high-definition screen was positioned directly opposite the surgeon and the assistant so as to be in the direct line of sight of the operating surgeon (Figure 1A). In all cases, a 30-degree, 4-mm-diameter, rigid endoscope was used (Karl Storz GmbH & Co.).

Cortical entry site and trajectory were planned using the navigation guidance system. We generally chose the shortest distance to the tumor avoiding eloquent areas of cortex where possible and limiting the extent of white matter tract resection as visualized on diffusion tensor imaging and functional MRI scans. A 3-cm "lazy S" or linear incision was made in the scalp over the planned area, and a 2- to 2.5-cm craniotomy (Figure 1B) was performed followed by a cruciate durotomy. For temporal tumors, the incision typically was in front of the tragus of the ear, and for frontal tumors, it was typically behind the hairline (Figure 1C and D).

Endoscopic Resection

Using the image guidance probe, a 1- to 1.5-cm corticotomy was performed over a noneloquent gyrus for a transcortical approach and in some cases an intrasulcal approach. The 30-degree rigid endoscope was introduced by the assistant surgeon. Using the image guidance trajectory, a 1- to 1.5-cm access corridor was created by

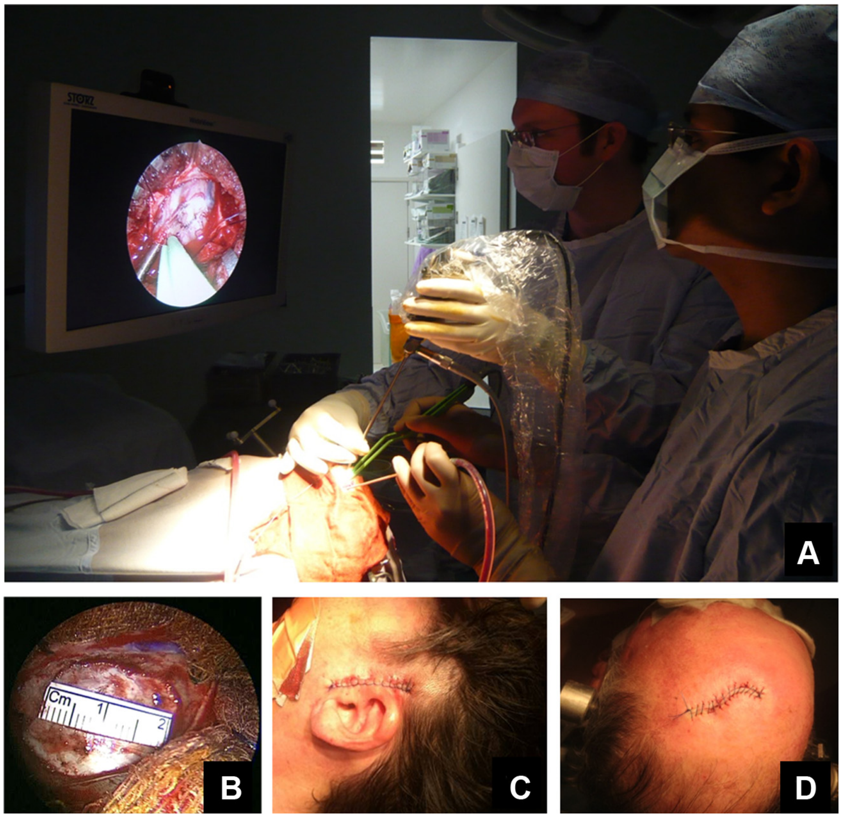

Figure 1. (**A**) Endoscopic operating room setup with high-definition screen positioned in line of sight of both surgeon and assistant. Assistant is to the right of the surgeon holding endoscope. (**B**) Standard 2-cm minicraniotomy. (**C**) Standard temporal incision. (**D**) Standard frontal incision.

TUMOR