Skull Base Surgery with Minimal Resources

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■ BACKGROUND: **Skull base surgery needs advanced equipment and is performed at few public sector hospitals in India. For financial and infrastructure reasons, the facilities available are insufficient for the large number of poor patients who need this surgery.**

■ METHODS: **Neurologically deteriorating poor patients who failed to receive skull base surgery at overloaded public sector hospitals underwent surgery with basic neurosurgical instruments, using the available resources and indigenously designed instruments adhering to the basic principles of skull base surgery. Various lesions operated on in the study were analyzed based on their location and surgical approach.**

■ RESULTS: **Ninety-one skull base surgeries in 84 patients were performed during 2013—2015. There were 46 males and 38 females, with an average age of 35 years. Surgical treatment included surgery of the craniovertebral junction ($n = 43$) and lesions of the anterior skull base ($n = 7$), middle skull base ($n = 10$), and posterior skull base ($n = 31$). Lesions were operated on through anterior ($n = 10$), lateral ($n = 14$), and posterior and posterolateral ($n = 67$) skull base approaches.**

■ CONCLUSIONS: **The facilities available in low-income countries such as India are insufficient to take care of poor patients who need skull base surgery. Indigenous innovations, use of the available resources, and interdisciplinary coordination help overcome the challenges of resource scarcity to a reasonable extent in many ill-equipped public sector hospitals for the safe and efficient management of many patients who need skull base surgery.**

INTRODUCTION

Skull base surgery is a recent addition to the various subspecialties of neurosurgery, which has become a conglomeration of various disciplines in addition to neurosurgery such as head and neck surgery, faciomaxillary surgery, and otolaryngology. Advancements in techniques and technologies in recent decades and the coordinated efforts of various disciplines have made it possible to safely remove many lesions that are difficult to treat. However, in low-income countries such as India, advanced equipment and coordinated highly trained professionals are available at only a few centers situated in large cities.[1-3] Private health care facilities have developed significantly in the last decade in India and it has some excellent centers of international repute. However, public sector hospitals have lagged behind because of poor infrastructure, workforce deficiency, and poor budgetary support. Because less than 20% of the population has any kind of health care insurance and around 80% of the population depends on free treatment provided by public sector hospitals, skull base surgery is beyond the reach of most of the population, especially poor people.[3-6] There is a need for innovative means to accomplish advanced surgery using simple tools and techniques devised by stalwarts in the field without compromising the basic principles of skull base surgery.

We report our experience of performing 91 skull base surgeries in 84 patients over the last 3 years at a public sector hospital with meager resources.

METHODS

The study was carried out at a tertiary-level public sector health care institute with a neurosurgery operating theatre and intensive care unit without advanced facilities in the neurosurgery intensive care unit such as operating microscopes, ultrasonic aspirators, image intensifiers, high-speed drills, headlights, and ventilators. Although the neurosurgery department had a neurophysiologic monitoring system, it could not be used because there was no trained

Key words
- Craniovertebral junction
- Endoscope assisted
- Equipment
- Resource scarcity
- Skull base surgery

Abbreviations and Acronyms
CT: Computed tomography
CVJ: Craniovertebral junction
RMSO: Retromastoid suboccipital

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neurophysiologist or personnel who could operate it during surgery. However, an endoscopic awake intubation system with a 2.7-mm flexible telescope (Broncho-Fiberscope), a single-chip camera, light source, and monitors (Karl Storz, Tuttlingen, Germany) were obtained in 2012 by the neuroanesthesia department for awake intubations in cervical spine and craniovertebral surgeries.

All surgery was performed with the help of a 2.5× binocular magnifying loupe for magnification. In addition to the magnifying loupe, an 18-cm, 4-mm, 0° rigid telescope was used along with the awake bronchoscopic intubation system to perform endoscope-assisted surgery in conjunction with nonendoscope-assisted surgery with the help of magnifying loupes. The endoscope provided further magnification, when required, and was also effective at providing light in the depths of the surgical corridors, which otherwise was not possible using a ceiling light. For superficial lesions, an autoclavable handle on the ceiling light was used by the senior author and chief surgeon (D.K.J.) to direct light at the surgical field and the endoscope was rarely used.

Patients were selected stringently and only those were admitted for surgery who:

1) showed progressive neurologic deterioration despite conservative treatment;
2) could not find a bed in at least 2 public sector health care institutes and were unable to afford a private sector hospital;
3) did not need mechanical ventilation at the time of admission. However, patients admitted to the neurology intensive care unit of the hospital, irrespective of their respiratory involvement, were included and were moved there after surgery.

Patients were positioned with the help of a Sugita head frame. The basic principles of skull base surgery were followed so that no retraction or minimal retraction of the brain was required. Burr holes and craniotomies were performed with the help of a Hudson brace and Gigli saw wires. Various osteotomies, including orbital, orbitozygomatic, and zygomatic, were performed in addition to craniotomies, depending on the location of the lesion and surgical approach undertaken. After craniotomies to expose the skull base, bony removals in the superficial locations were performed using conventional instruments such as chisels, Kerrison punches, and nibblers. Different sizes of chisels were used to expose sigmoid and transverse sinuses in retromastoid suboccipital (RMSO) approaches or other bony structures at other locations for adequate skull base exposures. Care was exercised to avoid any damage to the sinuses and neurovascular structures by using the chisel to thin out the bone over these structures, which were later removed with the help of fine dissectors, curettes, and bone punches. Various types of chisels, hooks, fine dissectors, and curettes were made by the senior author (D.K.J.) (Figure 1). The surfaces of the cutting edges and direction and force of tap/stroke of the hammer were placed appropriately to decide the thickness of bone removals. Bony removals in deeper locations such as the internal auditory meatus and anterior clinoid were not attempted because of the risk of neurovascular injuries.

Surgical goals varied depending on the characteristics of the lesions, their locations, and the symptoms and signs that they produced. However, care was taken not to create new neurologic deficits by surgical maneuver. Decompression by spinal alignments/reduction of displacements, distraction of joints, and fusion with or without fixation were the goals for craniovertebral junction (CVJ) compressions caused by basilar invagination or posttraumatic dislocation. Patients with Arnold Chiari malformation were treated by augmentation of the posterior fossa by suboccipital craniectomy and laminectomies along with augmented duraplasty. For mass lesions, despite keeping the goal of gross total removal, the option of leaving bits of lesion to save neurologic function or staging of surgery was always kept in mind. The decision to stage surgery was taken only when complications appeared imminent because of excessive blood loss, prolonged anesthesia, tumor characteristics, or surgeon's fatigue. Further, the decision to leave the residual lesion for second-stage removal was taken only if the residual lesion did not seem to cause cerebrospinal fluid flow obstruction or postoperative clinical deterioration as a result of postoperative changes. Second-stage surgery, when required, was planned after 3 months. Informed consent was obtained before surgery.

Postoperatively, patients were extubated in the operating theater, once surgery was completed. However, when the neuroanesthetist considered postoperative ventilation essential, the patient was moved to the intensive care unit of the neurology department, where ventilators were provided for the postoperative period.

The location of the lesions (anterior, middle, or posterior skull base) and approaches (anterior, lateral, posterior, or posterolateral) for surgery were noted for analysis. Aneurysms of the anterior circulation that were operated on through pterional approaches were classified as middle skull base lesions and a pterional approach was classified as the lateral skull base approach. Lateral orbitotomy for intraorbital lesions was categorized as the lateral approach for anterior skull base lesion and the RMSO approach was categorized as the posterolateral approach for posterior skull base lesions. The C1-2 joint space for bony fusions and autograft insertions was prepared with the help of curettes and fine chisels after proper protection of the vertebral arteries lateral to and the cervical cord medial to the working area.

Magnifying loupes (2.5×) without a headlight in conjunction with endoscopic assistance, as and when required, were used for surgery. An autoclavable handle on the ceiling light was used intermittently to direct light at the surgical field. An endoscope with all the attachments (light source, camera, and monitors) was kept ready on the trolley and was used for further magnification and/or light in the depths of the surgical corridor. Endoscope-assisted surgery was performed when the surgical corridor was narrow and deep and as and when required for superficial lesions (Figure 2). An assistant held the endoscope during surgery, which allowed the surgeon to use both hands.

The bony architecture of the CVJ and other operative areas were studied in detail preoperatively on the computed tomography (CT) console and relevant measurements, including length, diameter, and direction of the screws, were ascertained a day before surgery. For surgery of the CVJ that needed reduction, fusion, and fixation, a Sugita frame was used for head fixation and the cranial end of the table was kept elevated to approximately 15°—20° during surgery (Figure 1A). Because an image intensifier was not available, a mobile radiography machine was used