Open-Door Maxillotomy Approach for Lesions of the Clivus

Abstract—The transpalatal route to the clival region has been used to approach both extradural and intradural lesions. Classic transpalatal surgery, however, entails a partial splitting of the soft palate or some form of palatal retraction, which leaves behind a bony palate that hinders surgical exposure. When necessary, operative exposure can be enhanced by an open-door maxillotomy approach that uses a combination of a Le Fort I osteotomy of the maxilla and a paramedian sagittal split of the hard palate. The nasal septum is translocated to create a wide contiguous oronasal aperture through which the clival region can be reached unobstructed. This technique was used in three patients. No significant complications were observed in any patient. Features of this extended transpalatal approach, including indications and adjunctive measures to minimize potential complications, are discussed. (*Skull Base Surgery, Volume 1, Number 4, 1991, p. 217*)

The transoral approach to the clivus and upper cervical region is a direct route for treating lesions ventral to the brainstem and upper cervical spinal cord.¹⁻²⁰ Low morbidity and mortality rates can be achieved with this method. The risks of cerebrospinal fluid (CSF) leakage and infection exist, however, because of the difficulty ensuring adequate dural closure in the narrow field of the contaminated nasopharyngeal cavity. The classic transoral approaches either split the soft palate or use catheters or transoral retractors to expose the caudal-clival region. The limitations imposed by the retracted soft palate, an intact bony palate, and the depth at which surgery takes place through the narrow field hamper exposure and dural closure. Consequently, a number of anterior surgical approaches have emerged that allow exposure of the clivus.^{4,5,8,21-32} We describe an anterior surgical approach that enhances exposure of the upper clivus by displacing the entire palate (soft and bony) from the surgical axis. We found that this method offers easier instrumentation through the contiguous oronasal exposure with little post-operative morbidity or complications. Harkey et al⁵ combined a Le Fort osteotomy with a paramedian split of the hard and soft palates to expose the midline skull base from the sphenoid to the third cervical vertebra. In our three

patients, the enhanced exposure gained by this approach through a wide oronasal aperture was found to have a distinct advantage.

CASE REPORTS

Patient 1, a 57-year-old woman, presented to her local physician with headaches and transient memory loss. A biopsy of the nasopharynx yielded the diagnosis of a chondroid chordoma. At this point, the patient was referred to our facility for evaluation and treatment.

When the patient presented to us, we observed a firm, white mass in the superior and posterior nasopharyngeal walls with an extension into the sphenoid region. No neurologic deficits were evident at the time of clinical examination. The patient had effusion of the right middle ear, requiring placement of a tympanostomy tube. She had diabetes mellitus, thrombocytopenia of an idiopathic nature, and a history of a pancreatic adenocarcinoma, which was apparently cured. Magnetic resonance (MR) images revealed that the lesion was confined to the clivus and upper nasopharyngeal (superior and posterior) walls (Figs. 1, 2). The mass had no intracranial extension and

Figure 1. Coronal magnetic resonance image demonstrating the midline nature of the clival chordoma, which impinges on the cavernous sinus regions bilaterally.

Figure 2. Sagittal magnetic resonance image of patient 1 demonstrating the extent of involvement of the clival region with a chordoma. The relationship of the internal carotid artery and cavernous sinus to this mass is clearly demonstrated.

did not exhibit abnormal vascularity on arteriographic examination.

Because of its location, we decided to approach the lesion via the transpalatal route. We could not achieve adequate exposure using conventional transpalatal avenues. The open-door maxillotomy approach was therefore used, resulting in surgical exposure from the dorsum sella to the second cervical vertebra, allowing removal of the chordoma from the clivus. The tumor was removed from the floor of the sella and the medial walls of the cavernous sinuses. The patient recovered from surgery with no significant complications and an MR image obtained 8 months after surgery showed no intracranial extension of the mass (Fig. 3).

Patient 2, a 39-year-old woman, was referred to our facility with a diagnosis of basilar impression secondary to osteogenesis imperfecta. Her primary symptoms and signs included headaches, nystagmus, and sleep apnea. In addition, she had dentigerous imperfecta and malocclusion that had not been treated. A computed tomography (CT) scan of her cervical spine with sagittal reconstruction

images revealed evidence of platybasia and basilar invagination (Fig. 4). The tip of the odontoid process and the anterior arch of the C1 vertebral body projected about 2 cm above the basiocciput, while the clivus was displaced to a nearly horizontal position. An MR image confirmed the basilar invagination and demonstrated marked distortion of the neuroanatomic structures. Significant pontomedullary compression was present due to upward infolding of the clivus and odontoid, and the cerebellar tonsils were herniated through the foramen magnum (Fig. 5). We selected the modified transpalatal approach because of the need to resect the distal clivus, the anterior arch of C1, and the odontoid peak.

A Le Fort I osteotomy and a paramedian sagittal osteotomy were combined with septal translocation to expose the clivus and upper cervical region (Figs. 6, 7). Because of the enhanced operative exposure gained by this technique, a small dural tear could be closed primarily with 5-0 ethylene sutures. After discharge from the hospital, the patient resumed her normal activities (Fig. 8). Two and a half months postoperatively, exposure of one of the right maxillary plates necessitated partial removal. No other complications ensued. Postoperative sleep studies

Figure 3. Eight-month postoperative magnetic resonance image of patient 1 demonstrating improvement.

Figure 4. Reconstructed sagittal computed tomography scan demonstrating the degree of platybasia and basilar invagination in patient 2.

revealed significant improvement in apnea, although the improvement in nystagmus was not complete. A delayed occipitocervical arthrodesis was performed to prevent further invagination.

Patient 3, a 58-year-old woman, presented with symptoms of progressive bilateral nasal obstruction. Ophthalmologic examination demonstrated a partial loss of peripheral visual fields. MR images showed a nasopharyngeal mass filling the nasal choanae bilaterally with extension of the mass into the posterior ethmoidal region. The

sphenoid sinuses were well-aerated and appeared to be uninvolved. The upper clival region, however, showed mild bony erosion on CT scans. An endoscopic biopsy performed by the referring physician diagnosed an invasive pituitary adenoma. In view of the destructive nature of the neoplasm and its extent, the open-door maxillotomy approach was used after the classic transseptal-transsphenoidal approach failed to expose the lower extension of the tumor along the clivus adequately. The exposure facilitated extensive drilling of the clival bone, which was required because of histologically positive bony invasion by the tumor. The patient's appearance 3 days after surgery is shown in Figure 9. No complications ensued and the patient recovered her full visual field.

SURGICAL TECHNIQUE

Before surgery, nasoflora cultures were obtained. The patient used Peridex mouthwashes for 3 days before surgery and received intravenous antibiotics for 24 hours beforehand. A lumbar shunt may be used intraoperatively if intradural work is required. Brainstem and somatosensory evoked potentials may be monitored intraoperatively. In addition, the patient is allowed to breathe spontaneously, providing alternative monitoring of brainstem function.

A tracheostomy is performed under general endotracheal anesthesia and the oral cavity is exposed using a Dingman mouth gag. After an adequate amount of cocaine is topically administered, an intranasal examination is carried out. The site of the paramedian sagittal osteotomy of the hard palate is selected based on the anatomic configuration of the nasal septum. Septal mucoperi-

Figure 5. Sagittal magnetic resonance image of patient 2 revealing the extent of basilar invagination. Pontomedullary compression and herniation of cerebellar tonsils is evident.

Figure 6. Intraoperative photograph demonstrating paramedian sagittal osteotomy of the hard palate. The anterior portion of the osteotomy is carefully placed between two incisors.

chondrial infiltration is performed with 1% lidocaine and 1/100,000 epinephrine. An extended transfixion incision is made to allow degloving of the upper lip and nasal soft tissues (Fig. 10A).

Gingivobuccal mucosal incisions are made from one maxillary tuberosity to the other, and the mucoperiosteum is elevated. Compression plates are contoured and drill holes are made over both maxillary buttresses and the prenasal area before osteotomies are carried out (Fig. 10B). The mucoperichondria is elevated along the floor of the nose, as well as unilaterally over the septum at the site of the proposed paramedian sagittal osteotomy. This facilitates the osteotomy and avoids injury to the nasal mucosa.

A Le Fort osteotomy is performed carefully to avoid injury to the dental roots. A paramedian sagittal osteotomy is then performed with a Gigli saw and the anterior portion of the osteotomy is carefully placed between two incisors (Fig. 10C). The septum is fractured horizontally with a 3 mm chisel to parallel the nasal floor. Posteriorly, the vomer is removed to expose the sphenoid sinus and the nasopharynx. The maxilla is carefully mobilized and retracted with a hard palate retractor (Crockard, Codman & Shurtleff, Randolph, MA). The soft palate is split as a continuation of the hard palate osteotomy. The nasopharyngeal mucosa is incised, allowing the necessary exposure in the nasopharyngeal region.

Based on the extent of the lesion, a midline incision is made in the posterior pharyngeal mucosa and carried through the longus colli muscles. The fossa of Rosenmüller, which marks the lateral limit of resection, is carefully identified. The sphenoid and odontoid are therapy exposed and appropriate surgical steps are undertaken according to the lesion (Fig. 10D, E). The sphenoid sinus ostea provides a useful surgical landmark. If intradural

Figure 7. Intraoperative photograph showing the wide exposure of the clivus through a contiguous oronasal cavity. The two segments of the maxilla are displaced inferolaterally.

Figure 8. Three-week postoperative appearance of patient 2.

Figure 9. Patient 3, 3 days after surgery.

Figure 10. A: Degloving of the upper lip and soft tissues of the cheek is carried out. Osteotomy sites are shown in dotted lines. B: Septal translocation is performed after elevation of mucoperichondrial flaps from the septum and nasal floor. C: Soft palate mucosa and musculature is incised. The paramedian sagittal osteotomy of the hard palate is a direct extension of this incision. D,E: Illustration of the intraoperative exposure of the clivus and odontoid achieved with the open-door maxillotomy approach.

work is required, the dura is incised and lumbar drainage carefully employed. At the end of the procedure, the dura is closed using microrepair techniques with fascia lata and fibrin glue. The wound is thoroughly irrigated with clindamycin.

The posterior pharyngeal mucosa is closed using interrupted Vicryl sutures. The retractors are relaxed and the osteotomy sites are carefully reapproximated using the Howmedica plating minifixation system and the previously marked drill holes. Three plates are usually employed, one on each maxillary buttress and one anterior to the paramedian osteotomy site. The hard palate mucosa does not need to be closed. The soft palate mucosa, however, is closed in three layers with interrupted sutures. The nasal septum is repositioned and the mucoperichondrial flaps are repositioned and maintained in place with transfixation sutures in the nasal septum. A nasogastric feeding tube is employed. The gingivobuccal mucosa is approximated.

DISCUSSION

The first description of an anterior transoral approach to the cervical spine is credited to Kanavel,¹⁴ who removed a bullet from C1 using this approach. The midline anterior approaches to the spine and clivus have emerged as a direct surgical extension of transoral approaches to the retropharyngeal space.^{4,5,8,21–32} Many extradural lesions of the cervical spine and clivus are best exposed through transoral or transpalatal midline approaches. These lesions include: ventrally placed tumors in the foramen magnum and vertebral column¹¹ (such as schwannomas¹⁵ and chordomas^{13,16,17}), osodontoideum, odontoid fractures, atlantoaxial dislocation,³ rheumatoid arthritis,^{12,18–20} tuberculosis,³ craniocervical anomalies such as those in Klippel-Feil syndrome,^{10,18,33} and basilar impression.^{5,6} The use of anterior approaches to intradural lesions, such as vertebrobasilar aneurysms and tumors, is still controversial and less enthusiastically accepted.^{9,34,35} Regardless, the distinct advantage of the anterior midline approach is direct exposure of ventral lesions of the neural axis near the upper cervical spine and clivus. In such lesions, lateral or posterior approaches may not only be inadequate, but may also create significant risk.¹⁸ The major obstacles to adequate use of the anterior approach (depth and narrow operative exposure) have been lessened by advancements in surgical instrumentation and technology (such as image intensifiers, microsurgical drill systems, and methods of intraoperative spinal cord monitoring). Some surgeons advocate dividing and retracting the soft palate using special retractors to facilitate exposure¹⁹; some even remove part of the hard palate.²⁵ Even with these surgical maneuvers, however, exposure of the upper clival region is best described as marginal.

The obstruction imposed by the maxilla and nasal structures was first recognized and dealt with directly by

downward displacement of the hard palate in an approach to the upper clival region by Archer and colleagues.⁸ They describe removing the inferior nasal turbinates and nasal floor mucosa. Complications of this maneuver, which were not reported, would appear to include significant nasal airway obstruction from synechial fibrosis. Furthermore, maintenance of the bony palatal arch, albeit inferiorly displaced, would be a disadvantage for surgical instrumentation. More recently, Harkey and colleagues⁵ and James and Crockard³² split the hard and soft palates and used a Le Fort I osteotomy to reach the clivus in a patient with osteogenesis imperfecta. This extended maxillotomy provides extensive exposure of the midline skull base from the sphenoid to the third cervical vertebra.

Different degrees of transgression or dismantling of the facial skeleton have been used by various authors in attempts to perform surgery in this deep, narrow area. These approaches include the pterygomaxillary,²³ Le Fort I,⁸ extended maxillotomy,^{22,32} maxillary swing,²⁴ facial translocation,²¹ and labial mandibulotomy.^{26,30,31} Each approach has distinct applications and inherent morbidity.

The open-door maxillotomy approach described herein combines the transseptal-transsphenoidal and a true transpalatal midline approach, circumventing the hindrance created by the maxilla. In our first and third patients, when a transseptal-transsphenoidal approach alone or in combination with a transpalatal approach failed to provide adequate exposure to the upper clivus, the open-door maxillotomy was incorporated, resulting in a significantly enhanced exposure that facilitated tumor visualization and the use of drills and instruments to excise adequately pathologic tissue in the upper clivus and the floor of the sphenoid sinus. This approach also allowed us to preserve the mucosa of the nasal septum, the nasal floor, and the paranasal sinuses, thereby maintaining preoperative nasal function, dental occlusion, facial resthetics, and lacrimation.

In our opinion, the restrictions imposed laterally by the hypoglossal nerve, the vertebral arteries, and the jugular foramina do not allow further lateral exposure and constitute the primary limitations of this approach, as in any other anterior approach to the clivus. The degree of required lateral exposure is dictated by the extent of the lesion, which may be determined using reformatted CT and preoperative MR images.

Technical difficulties in achieving watertight closure of the dural defect, especially in the sphenoidal and upper clival regions, are well known.³³ Steps advocated to reduce the chance of postoperative leakage of CSF include the use of fascia lata, abdominal fat, the sternocleidomastoid muscle, and pharyngeal or posterior flaps incorporating nasal septal mucosa, and lumbar drainage.^{35–37} In extensive lesions of the sphenoid, clivus, and upper cervical regions for which intradural work is required, however, the facial translocation approach or extended maxillotomy allow more extensive exposure and reconstruction using the temporalis muscle or free flaps.^{21,22}

Hayakawa and colleagues³⁸ have laid out specific guidelines to avoid the complications of transoral approaches to intra-arachnoid lesions such as basilar aneurysms and arteriovenous malformations. In our opinion, the use of meticulous microsurgical repair techniques for closure of dural defects is essential to reduce the incidence of postoperative CSF leaks.³⁹ The enhanced operative exposure afforded by this open-door maxillotomy approach allows the use of microsurgical instrumentation to conduct such repair. In patients 1 and 2, small dural tears could be sutured primarily because of the required exposure. An overlaid fascial graft with fibrin glue reinforced this closure. However, the possibility of septic intracranial complications remains a threat to successful surgical outcome when using anterior approaches.^{40,41} Some series have reported overall mortality rates of 50% and even higher rates of CSF leaks and meningitis.^{9,34,36,37} Judicious selection of patients and a surgical approach, however, is required for intra-arachnoid work when using anterior approaches.

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REVIEWER'S COMMENTS

Although this article identifies three case reports, the authors have brought to our attention important features of any skull base approach—complete removal of the tumor and/or correction of a structural abnormality with watertight closure of the dura supplemented in selective cases with lumbar spinal drainage. The authors are to be complimented for contributing this technique for minimal skull base exposure. Its strict limitations are defined and one should only employ this technique after becoming familiar with the numerous other techniques for exposing this anatomic area and with the etiology and natural history of each condition that may be confronted at the skull base. Inadequate dural closure is life threatening. Adequate exposure is critical. The technique should be limited only to expose lesions requiring very conservative removal of a neoplasm or correction of an uncomplicated structural abnormality (basilar invagination). I am concerned that the entire clivus cannot be removed by the exposure described in this article. Residual disease and additional notochordal remnants subject to neoplastic change risk being left behind unless one feels confident that the entire clivus can be removed by this exposure. The postoperative scan in the chordoma patient shows only that the patient was improved. It was not implied that the entire chordoma was removed.

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REVIEWER'S COMMENTS

Anand et al describe the “open-door” maxillotomy approach for lesions of the clivus based on their experience in three cases. The authors recommend this technique for lesions of the clivus and sphenoid region, citing its improved visualization and accessibility for dural repair. They correctly point out that the anterior transoral approaches to the spine and clivus provide suboptimal exposure of the *upper* clival region. A variety of approaches have been described to access this surgical region. Certainly minimizing the surgical extent of these approaches and yet exposing the tumor site adequately are goals of skull base surgeons. In our previously reported experience with 13 clivus chordomas, we found that the midline lower clival region could be adequately accessed transorally with (and sometimes even without) soft palate splitting. Resection of the hard palate with hard palate ostectomy (but without maxillotomy) allows further superior increase in the midline exposure to approximately the middle one third of the clivus. The extent of clival exposure was further enhanced by utilizing an inferiorly based flap, as opposed to the midline posterior pharyngotomy proposed herein. Hence, for midline lesions of the lower clivus, it is unnecessary to divide the alveolar portions of the maxilla.¹ For higher lesions, a transantral “pterygomaxillotomy” provides excellent access of the upper clival region. This exposure can be increased by a down fracture of the ipsilateral maxilla, taking care to preserve its blood supply.² In summary, I applaud the authors in expanding the frontiers of skull base surgery. However, the reader should proceed with caution in utilizing this extensive a maxillotomy approach for smaller midline lesions of the upper or lower clivus in which less extensive surgery has proven more than adequate.

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