Case Report

Access To Anterior Skull Base Via Lefort I Approach

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Abstract

Tumours of the anterior skull base require a multispecialty approach for adequate resection and reconstruction. Panoramic access to the anterior skull base is frequently required for massive tumours that traverse this region and invade the complex anatomy of the craniofacial compartment. The Le Fort I osteotomy with maxillary down-fracture is one of the well-explained trans-facial approaches to gain access to anterior skull base. This approach significantly improves visualization of the central skull base and also the infratemporal fossa when the posterior wall of maxillary sinus and the pterygoid plates are removed.

We will review the anatomy of the anterior skull base, the operative procedure of surgical exposure with the Le Fort I osteotomy, its advantages and complications.

Keywords: Anterior skull base; Le Fort I osteotomy; Skull base tumours

1. Introduction

The skull base is a complex anatomical floor of the cranial cavity, which separates the brain from other structures in the vicinity such as the orbit, nasal cavity and the sinuses and harbours significant neurovascular structures entering and exiting through it. Any pathology arising from it may originate within the skull or skull base or extend to the cranial base by direct extension. Anterior skull base tumours are relatively rare, widely diverse and variable in the extent of local structures. Earlier, this anatomic area was considered to be a ‘‘No man’s land’’ in surgical management. Panoramic access to the anterior skull base is frequently required for massive tumours that traverse the anterior skull base and invade the complex anatomy of the craniofacial compartment. Therefore, the key to a successful approach depends on wide exposure of the area to facilitate in-toto pathological excision with minimal morbidity of the surrounding craniofacial structures. Cranial base surgery presents significant challenges not only

for the surgeon but also the patient. The radical approach employed to obtain a disease-free margin is the purpose of ablative surgery, and more often than not, is in contrast with the patient's need of function and aesthetics. As a consequence, there are a limited number of effective surgical approaches, which serve both these purposes. Owing to the technological advances of the last two decades, minimally invasive surgical treatment of cranial base lesions has been made possible. Traditional approaches like the Weber Ferguson and lateral rhinotomy, which require external facial incisions, are no longer used due to the extensive morbidity involved. The more commonly used techniques include the midface degloving/sublabial incision with transnasal, transpalatal, transsphenoidal, transantral, Le Fort I and the newly introduced endoscopic approaches. The choice of a particular approach depends on the site and extent of the tumour, aesthetic considerations and the experience of the surgeon as described previously.

The Le Fort I osteotomy which is popularly used as a standard technique for maxillary repositioning in orthognathic procedures, was initially performed by Langenbeck [1] and later on by Cheever [2] to access tumours in the skull base. Today even with the emergence of minimally invasive endoscopic procedures, the Le Fort I osteotomy is still considered to be a valuable choice of approach.

This procedure requires no extra-oral incision and offers wide access to difficult sites, which are common territories for tumour invasions and residual lesions. Hence this article reviews the Le Fort I osteotomy approach to the anterior cranial base in comparison to other approaches considering the patient's aesthetic needs and the overall objective of appropriate disease-free resection.

2. Steps In Lefort I Osteotmy

2.1 Patient position and anaesthesia

The patient is positioned at a 10-degree head end elevation with a head ring for a stable head position. The LeFort I access to the anterior cranial base is performed under hypotensive general anaesthesia preferably with nasotracheal intubation. Hypotensive anaesthesia is routinely employed for head and neck surgeries as it minimizes intra-operative blood loss (systolic pressure of 90 mm of Hg should be maintained). Nasotracheal intubation is ideal as occlusion can be checked without difficulty.

If Orotracheal intubation is chosen, retromolar positioning of the tube is imperative. The airway tube is then secured to the membranous portion of the nasal septum close to the nostrils with 2-0 silk suture preventing its dislodgement during surgery. Local anaesthesia with a vasoconstrictor (Lignocaine hydrochloride 2% with epinephrine 1: 100,000) is infiltrated into the buccal sulcus from the midline to the maxillary tuberosities and further posteriorly into the pterygomaxillary areas.

2.2 Incision

Electrocautery is used and two vertical reference points are made in the maxillary labial frenum area to ensure that the flaps are repositioned accurately during suturing. The incision along the buccal mucosa can be made with a no.

15 blade or with monopolar electrocautery on a low setting. Placing the incision with electrocautery can cause excessive scarring around the nasal base and beneath the upper lip leading to a change in the length of upper lip and distortion of morphology of the vermilion border. Hence its use is discouraged. The incision line is placed in the buccal sulcus 5 mm anterior and superior to the opening of the parotid duct and is continued anteriorly and slightly downwards till it crosses the labial frenum in the midline and then the same cut is continued on the contralateral side. The incision is made keeping in mind to leave a healthy cuff of 5 mm of free gingiva. The width of gingival cuff left on the maxilla should be overstated to compensate for the amount of soft tissue stretch that occurs with retraction of the upper lip. This is a crucial step to circumvent the troublesome complication of exposed hardware due to improper closure. The incision is made through the superficial mucosa, submucosa and the underlying facial muscles all the way to the bony periosteum. Care should be taken not to extend the incision beyond the first molar, to prevent risk of bleeding from the pterygoid venous plexus. Also, an incision placed too buccally which extends beyond the first molar may cause the buccal pad of fat to herniate, which can prove a nuisance to the operative field accessibility.

2.3 Dissection

The periosteal dissection is performed in a systematic fashion. Periosteal elevators are used to raise the soft tissues in the subperiosteal plane to expose the pyriform rims, anterior maxillary wall, nasal apertures and zygomaticomaxillary buttresses. The subperiosteal dissection is then continued into the region of the maxillary tuberosity and the pterygomaxillary fissure by tunnelling behind the zygomatico-maxillary buttress. The tip of the periosteal elevator should always be kept in close contact with the bony surface. An accidental perforation of the periosteum and slippage of the instrument into the soft tissues can either cause the buccal pad of fat to herniate obscuring the surgical field or result in bleeding from the pterygoid venous plexus. Dissection at the level of the pyriform aperture should be carried out with caution to avoid any perforations in the nasal lining. The floor of the nose and nasal septum should be bared all the way posteriorly so that the superior surface of the palate can be visualized. Superiorly, the dissection is carried out to the level of the infraorbital foramen. The infra-orbital nerves are then identified and preserved. Laterally, the dissection is completed around the lateral maxillary buttress and should end at the pterygomaxillary junction. Carrying out a tunnelling dissection in this area preserves a broad-based intact mucosal pedicle.

2.4 Osteotomy

Horizontal supra-apical osteotomies are performed from the pyriform rim to the pterygomaxillary junction using rotatory osteotomies/reciprocating saw. The osteotomy is designed so that it terminates below the pyriform aperture at the level of inferior turbinate. This is done to prevent any injury to the nasolacrimal system. The osteotomy initiates at the zygomaticomaxillary buttress with a reciprocating saw and continues anteriorly to the nose. The posterior lateral wall of maxilla is sectioned beneath the mucosal tunnels under direct vision. A retractor is positioned at the junction of maxilla and pterygoid plate to ensure adequate exposure and safety. The posterior osteotomy is then directed inferiorly from the zygomaticomaxillary buttress toward the junction of maxilla and the pterygoid plates. This minimizes the risk of damage to the maxillary artery or any of its terminal branches as they

descend into the pterygopalatine fossa. The posterior osteotomy should be at least 5 mm superior to the apex of the second molar teeth (approximately 25 mm from the occlusal plane) to minimize risk of devitalisation of roots. Presence of third molars should not alter the osteotomy design. These should be removed after down fracturing of the maxilla if they are exposed or interfere with repositioning of maxilla. After the posterior cut, saw is reversed and blade is placed within the maxillary sinus and the osteotomy is complete from the sinus to the exterior. When the bone cuts are complete, the wound is packed with moistened gauze and the same procedure is carried out on the other side. The anterior nasal spine and the cartilaginous septum are addressed by a septal osteotome malleted posteriorly, freeing the cartilage and bone of the nasal septum and vomer from maxilla. A Howarth's elevator is positioned subperiosteally on the medial aspect of the lateral nasal wall to shield the nasal mucosa while sectioning with an osteotome. It should be held at the pyriform rim, directed posteriorly and inferiorly along the lateral nasal wall towards the perpendicular plate of the palatine bone. Lateral nasal wall is thin and provides little resistance until the palatine bone is contacted. Any damage to the descending palatine artery should be controlled by pressure and injecting more of a vasoconstrictor. The level of osteotomy in the paediatric age group with unerupted teeth should be carried out more superiorly to avoid injury to unerupted tooth roots.

The final and crucial step in the Le Fort I osteotomy is separation of maxilla from the pterygoid plates. This is achieved with a 6-mm curved/pterygoid osteotome, which is directed medially and anteriorly at the lowest part of the junction of the maxilla and the pterygoid plate. The osteotome is malleted to achieve bony separation, and the maxilla is then ready to be down fractured. With hand pressure, the anterior aspect of the maxilla is gently depressed. Smith's spreaders are used simultaneously to separate the osteotomised segment from the cranium. The down fracture is then carefully completed with a Rowe's disimpaction forceps using in a rocking motion in an inferior and anterior direction. Any bleeders at this point are cauterized. As the maxilla moves downward the remaining attached nasal soft tissues are elevated from the nasal floor. It is desirable to keep the nasal mucosa intact to prevent post-operative nasal congestion and discomfort.

The infratemporal fossa is encountered by removal of the posterior wall of the antrum, up to the level of the inferior orbital fissure and foramen rotundum. The pterygoid muscles must be detached with judicious use of electrocautery to avoid any unnecessary post-operative bleeding. A modified Dingman's gag may be used to keep the mucosa and maxillary segment retracted, which opens up a wide view of the surgical site.

2.5 Tumour removal

After wide exposure of the surgical field, the entire tumour mass along with its extensions into maxillary sinus and infratemporal fossa are resected. The maxilla is repositioned and the pre-adapted plates are inserted and secured with 1.5mm x 6mm titanium monocortical screws. Haemostasis is achieved; the surgical site is irrigated with povidone and iodine solution. The maxillary antrum and the nasal cavity is packed with a medicated ribbon gauze.

2.6 Closure

Before the closure, the nasalis muscle is sutured back into place to reduce flaring of the nose post-operatively. This is called the Alar base cinch suture. The muscle layer is closed at the Zygomatico-maxillary buttress and at the lateral nasal region. The mucosa is closed in two layers with 3-0 resorbable sutures. The mucosal layer is closed in a V-Y pattern with horizontal mattress sutures.

2.7 Exposure

This approach exposes posterior wall of sphenoid sinus, sella turcica, cribriform plate, clivus, greater wing of sphenoid bone and C1 spine. There is adequate access to the posterior ethmoid air cells, posterior orbit, and inferior orbital fissure.

3. Discussion

Surgical intervention has been the main stay for malignancy of the anterior skull base. Indications for skull base surgery involve benign and malignant tumours approaching or encompassing the skull base, intracranial tumours with extra-cranial extensions and neurovascular tumours. Anterior skull base tumours mostly are tumours of the nasal and paranasal cavities, which include Juvenile naso-pharyngeal fibromas, Pituitary adenomas, Chordomas and Neuroblastomas. With the complex anatomy of the skull base, the risk of CSF leak, haemorrhage, inadequate exposure and incomplete resection should be taken into consideration during a surgical intervention. Originally described by Ketcham et al., in 1963 [3] craniofacial resection was undertaken with a combined approach that included a transfacial incision and a craniotomy. But this approach caused significant morbidity.

Subsequently, anterior skull base surgery has advanced notably, with superior understanding of the anatomy, pathology, imaging and surgical techniques. Over the past 2 decades, the Le Fort I osteotomy has been explored as an adjunct to skull base tumour surgery. The Le Fort I maxillary osteotomy lines were described by Le Fort as the tendency of midface fractures to occur along the lines of natural weakness. Conversely, osteotomies along these lines were carried out for tumour access decades before Le Fort's description [4].

Bernard Von Langenbeck first performed it in 1859 and again in 1861 for a benign tumour of the pterygopalatine fossa [5]. In 1867 David W. Cheever described a horizontal maxillary osteotomy for removal of a nasopharyngeal tumour [2]. The Le Fort I osteotomy appeared again in the literature in Martin Wassmund's 1927 attempt to correct a malocclusion [6].

Microangiographic studies conducted by Bell et al., in 1975 showed that adequate perfusion to the Le Fort I segment is obtained through the soft tissue pedicles attached to the buccal and palatal mucoperiosteum. The major contributing vessels are the ascending palatine branch of the facial artery and the anterior branch of the ascending pharyngeal artery [7].

The major impetus behind the Le Fort 1 approach is the lack of facial skin incisions and the other is providing broad sagittal and axial exposure to the nose, pterygopalatine fossa, infratemporal area and anterior skull base. Fayette et al., noted that the sagittal and axial exposure provided by the Le Fort 1 was significantly more in comparison with the sublabial, transnasal and endonasal approach [8]. Similarly, a study of 22 cases conducted by Girish Rao et al., concluded that the Le Fort I osteotomy access to the anterior cranial base was excellent for large to extensive tumours in that region [9].

The access obtained with a Le Fort I osteotomy is that of direct visualization due to the downward displacement of maxilla. Increased visibility and exposure can be obtained by altering the angle of the retractor to open beyond the margins of the anterior nasal aperture. The broad exposure facilitates a layered closure. Le Fort I osteotomy also has the advantage of a reduced surgical time. According to study conducted by Bleier et al., in 2009, the mean time for endoscopic resections in their experience was 312 min and that for Le Fort was 216 minutes [10].

The Le Fort I osteotomy, when performed by proficient surgeons, has the least associated morbidity when compared to the other approaches to skull base. However, Lanigan et al., reported 36 (1%) cases of avascular/aseptic necrosis of maxilla [11]. This was attributed to perforation of palatal mucosa, multiple segmentations of maxilla and its repositioning none of which is attempted during Le Fort I osteotomy for cranial base surgery. Disruption of facial growth is unlikely, as the osteotomy does not pass through growth centres. Evaluating its effect on growth and dental denervation, Lowlitch et al., observed that the Le Fort I osteotomy caused substantial interruption in the vertical growth but did not cause any obvious cosmetic deformity. Also, sensory innervation to the teeth was disrupted following the transection of branches of maxillary nerve; but this was not of any noticeable concern to the patients [12].

Another possible complication following a Le Fort I osteotomy is major haemorrhage from the internal maxillary artery. Although it is rare, it can be controlled by direct ligation in the pterygopalatine fossa, which is accessible once the maxilla is down fractured [13]. Direct control of haemorrhage in other approaches seems almost unattainable. The number of life-threatening complications associated with Le Fort I osteotomy appears to be low with rare complications of blindness [14] and carotid-cavernous fistula [15].

Progress in skull base surgery is hindered by the disease biology and physiology of the cerebrovascular system. Transfacial approaches including the lateral rhinotomy incision, Weber-Ferguson incision, Lynch incision, Dieffenbach incision and its modifications are no longer used. The trans-palatal, trans-antral, trans-sphenoidal approaches used currently offer very limited exposure to the anterior skull base. The endoscopic technique for resection of anterior skull base tumours has been stated in recent literature [16]. This technique avoids facial incisions, requires no craniotomies or facial osteotomies, avoids brain retraction, decreases pain, and requires shorter hospital stay with faster recovery. Mostly employed for early lesions, the main limitation of this approach is the poor control of major haemorrhages. Additionally, the decrease in the operational area and the difficulty in repairing any associated defect predominates the advantages of this technique. Endoscopic techniques may someday prove

superior to direct surgical approaches for the removal of large and invasive skull base tumours, but at this time, the various advantages provided by a Le Fort I maxillary osteotomy makes it valuable for skull base surgery. The Le Fort I approach to the anterior cranial base provides a safe technique with minimal to no major complications, wide exposure of the region and cosmetically excellent results.

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