

# Le Fort I Osteotomy and Skull Base Tumors

## *A Pediatric Experience*

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**Background:** The Le Fort I maxillary osteotomy approach for skull base tumor removal in the pediatric age group has not been widely discussed in the literature except for sporadic case reports and limited case series.

**Objectives:** To review our experience with the Le Fort I osteotomy and to propose that it be used as an alternative approach because of its many advantages for the removal of tumors of the central skull base and paranasal sinuses.

**Design:** Case series.

**Setting:** Tertiary academic center.

**Patients and Methods:** A 5-year retrospective chart review of cases involving children who had undergone skull base tumor resection via the Le Fort I osteotomy approach.

**Interventions:** Skull base tumor removal via the Le Fort I osteotomy approach.

**Main Outcome Measures:** Tumor type, location, and size; intraoperative and postoperative complications; and residual tumor and/or tumor recurrence associated with the surgical approach.

**Results:** Eleven patients (9 boys and 2 girls; mean age, 14.3 years) were identified through the chart review. The tumor types included 8 angiofibromas, 1 malignant fibrous histiocytoma, 1 giant cell tumor, and 1 cavernous hemangioma. All these lesions had extensive tumor growth into at least 1 of the following sites: pterygomaxillary space, sphenoidal sinus, and areas adjacent to the optic nerve, cavernous sinus, clivus, and anterior cranial fossa. The mean follow-up for this cohort was 12.8 months. No intraoperative complications were noted. Postoperative complications were reviewed with respect to the approach. To date, there have been no cases of residual tumor or tumor recurrence that can be attributed to the procedure.

**Conclusions:** Our experience suggests that the Le Fort I osteotomy approach is a useful technique for the removal of extensive central skull base tumors and paranasal sinuses in the pediatric age group. It has distinct advantages over traditional anterior or lateral approaches, including a more direct line of vision and improved exposure and cosmesis.

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**C**LASSIFICATION OF fractures of the middle third of the face was originally formulated by Rene Le Fort<sup>1</sup> in 1901. The Le Fort I type describes a fracture that extends from the nasal pyramid to each of the pterygoid plates, resulting in detachment of the upper jaw from the cranial base.

Removal of extensive central skull base and paranasal sinus tumors is a significant challenge that is often hampered by limited access and exposure. Approaches using the Le Fort I maxillary osteotomy were first described by Langenbeck<sup>2</sup> in 1861 for a benign tumor of the pterygopalatine fossa in 2 patients, and in 1867 by Cheever<sup>3</sup> for a nasopharyngeal tumor. Brown<sup>4</sup> reported on a modification

of the technique that combined division of the nasal septum and lateral pterygoid lamina and excision of the inferior turbinates and vomer with the standard Le Fort I maxillary osteotomy. This modification greatly improves access because it provides exposure from the pituitary fossa to the arch of the atlas.

The safety and efficacy of the Le Fort I osteotomy approach to the skull base have been well established in the adult patient population.<sup>4-7</sup> The purpose of this article is to describe our experience with the procedure in a solely pediatric patient population.

## RESULTS

We identified a total of 11 patients (9 boys and 2 girls; mean age, 14.3 years) who had

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## PATIENTS AND METHODS

We conducted a 5-year retrospective chart review (July 1993 to June 1998) of cases involving children ( $\leq 18$  years of age) who had undergone skull base tumor resections by means of the Le Fort I osteotomy approach. All procedures were performed at either the Children's Hospital in Denver, Colo, or the University of Kentucky Hospital, Louisville. The project was approved by the appropriate hospital review board. In addition to demographic information, other relevant clinical data were recorded, including tumor location by radiographic studies, histologic diagnosis, status of margins, operative and postoperative complications, and clinical outcome.

undergone resection of a skull base tumor via the Le Fort I osteotomy approach. The demographic data and histologic diagnoses are listed below.

Patient No./ Age, y/Sex	Histologic Diagnoses
1/17/M	Angiofibroma
2/15/M	Angiofibroma
3/15/M	Angiofibroma
4/14/M	Angiofibroma
5/14/M	Angiofibroma
6/17/M	Angiofibroma
7/17/M	Angiofibroma
8/16/M	Angiofibroma
9/17/F	Hemangioma
10/11/F	Giant cell tumor
11/4/M	Malignant fibrous histiocytoma

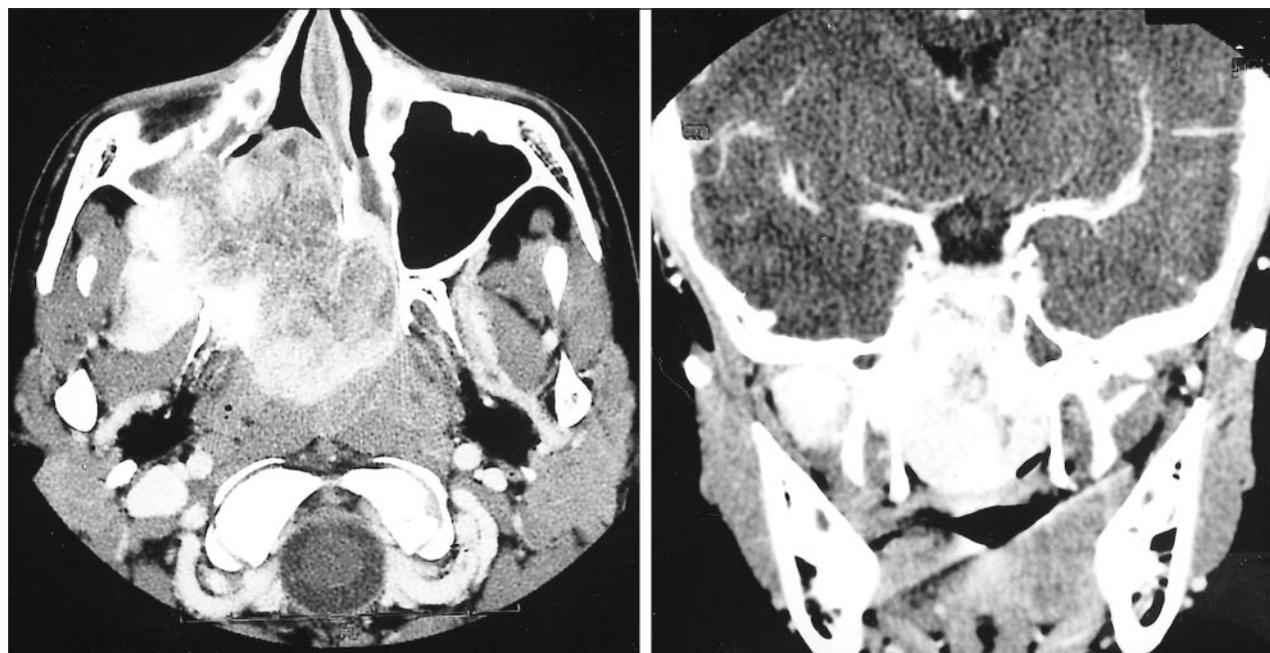
The preoperative assessment included radiographic imaging (computed tomography and/or magnetic resonance imaging) and angiography with embolization.

The preoperative computed tomographic scans of patient 4 showed a large angiofibroma involving the nasopharynx, the right infratemporal fossa, the right pterygomaxillary space, and the clival region (**Figure 1**). The preoperative magnetic resonance imaging scans of patient 10 demonstrated a giant cell tumor of bone that had essentially replaced the clivus (**Figure 2**). The distribution of tumors in the study group is summarized in the **Table**. Since the Le Fort I osteotomy is generally reserved for the treatment of larger tumors, there is a bias toward more extensive nasal, pterygomaxillary space, sphenoidal sinus, and clival region involvement. All 8 patients with an imaging diagnosis of angiofibroma underwent angiography and embolization 24 to 72 hours before surgical extirpation.

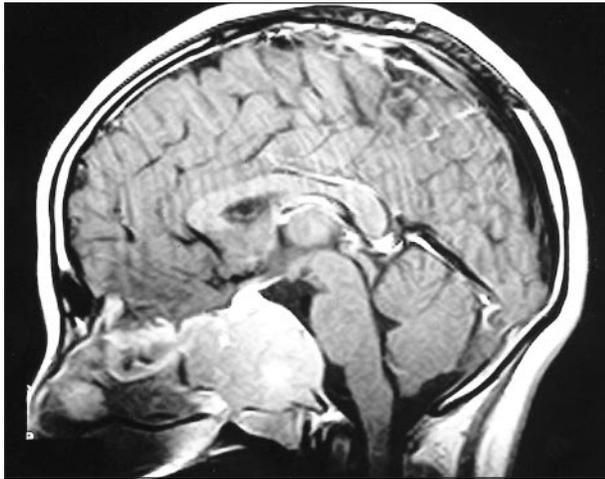
Three of the 11 patients underwent planned tracheotomy at the initiation of the procedure, and the rest were treated with orotracheal intubation after surgery. Prior to the Le Fort I procedure, ipsilateral neck exploration with isolation of the carotid artery was performed in 3 patients with angiofibroma, and carotid ligation was unnecessary in these cases. Intraoperative dacryocystorhinostomy was performed prophylactically in 5 patients, according to the preference of one of us (K.C.).

The procedure was performed as previously described in the literature.<sup>4,6</sup> **Figure 3** is an intraoperative photograph of patient 4 that was taken after the bony cuts of the Le Fort I osteotomy were made. **Figure 4** shows the anterior operative site after downfracture with the tumor being removed. The importance of prefitting and drilling of the plates for later reconstruction deserves emphasis. This step is extremely important for the maintenance of preosteotomy maxillary position and occlusion (**Figure 5**).

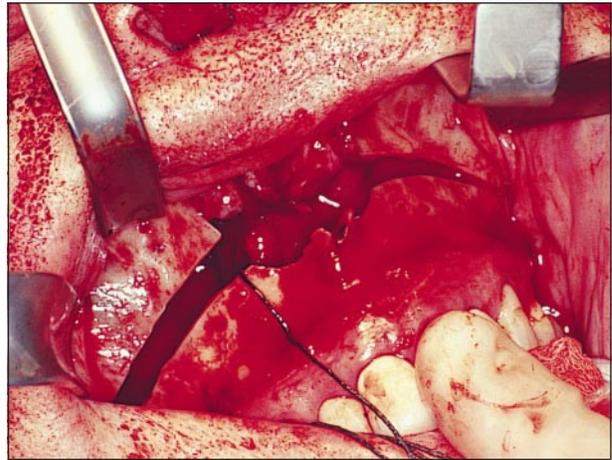
Because of the intracranial extension of tumors suggested by imaging studies and the uncertainty of dural involvement, a combined neurosurgical/otolaryngologi-



**Figure 1.** Patient 4. Preoperative axial (left) and coronal (right) computed tomographic scans of a 14-year-old boy with angiofibroma. The tumor involves the nasopharynx bilaterally, the right infratemporal fossa, the pterygomaxillary space, and the clival region.



**Figure 2.** Patient 10. Preoperative sagittal magnetic resonance imaging scan of an 11-year-old girl with giant cell tumor of bone. The tumor has essentially replaced the clivus.



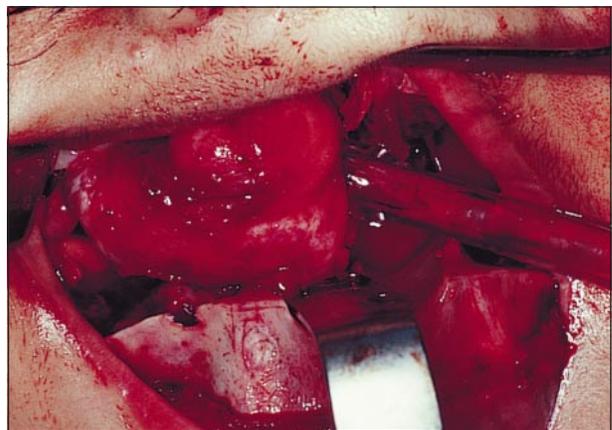
**Figure 3.** Intraoperative photograph of patient 4 after the bony cuts of the Le Fort I osteotomy have been made. Subsequent downfracture of the maxilla will provide excellent exposure and facilitate tumor removal.

Tumor Distribution								
Patient No.	Tumor Location*							
	NC	PM	ES	SS	NP	CL	IT	IC
1	+	++	++	++	-	-	-	-
2	+	-	+	+	+	+	-	+
3	+	-	-	+	+	+	+	-
4	-	-	+	+	+	+	+	-
5	+	-	+	+	-	+	-	+
6	-	-	++	++	-	+	+	-
7	+	+	-	-	-	-	-	-
8	++	-	-	+	+	+	+	-
9	++	-	-	-	+	+	-	-
10	-	-	-	-	-	+	-	-
11	-	+	-	-	-	-	-	+

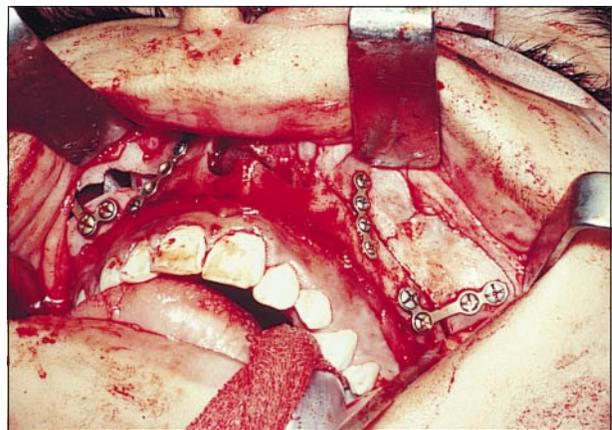
\*NC indicates nasal cavity; PM, pterygomaxillary fossa; ES, ethmoidal sinus; SS, sphenoidal sinus; NP, nasopharynx; CL, clival region; IT, infratemporal fossa; IC, intracranial extension; plus sign, present; minus sign, no tumor involvement; and double plus signs, bilateral involvement.

cal approach was used in 4 patients and a frontal craniotomy was performed in 1 patient (No. 8).

The postoperative follow-up period ranged from 6 months to 2.5 years, with a mean of 12.8 months. Five patients required nasal packing removal under general anesthesia from postoperative days 6 to 11. Computed tomography or magnetic resonance imaging was used for postoperative evaluation. **Figure 6** shows the 1-year postoperative computed tomographic scans of patient 4, whose preoperative scans are pictured in Figure 1. One patient (No. 10) had radiographic evidence of residual tumor in the anterior aspect of the sphenoidal sinus on postoperative day 4 and underwent endoscopic removal on postoperative day 8. Three patients (Nos. 8, 10, and 11) required adjuvant radiotherapy. One of them (No. 8) had a very large angiofibroma that was in contact with the orbital contents, including the optic nerve, and underwent postoperative proton beam therapy. The other 2 had the diagnoses of malignant fibrous histiocytoma and giant cell tumor of bone and underwent standard external beam radiation therapy.

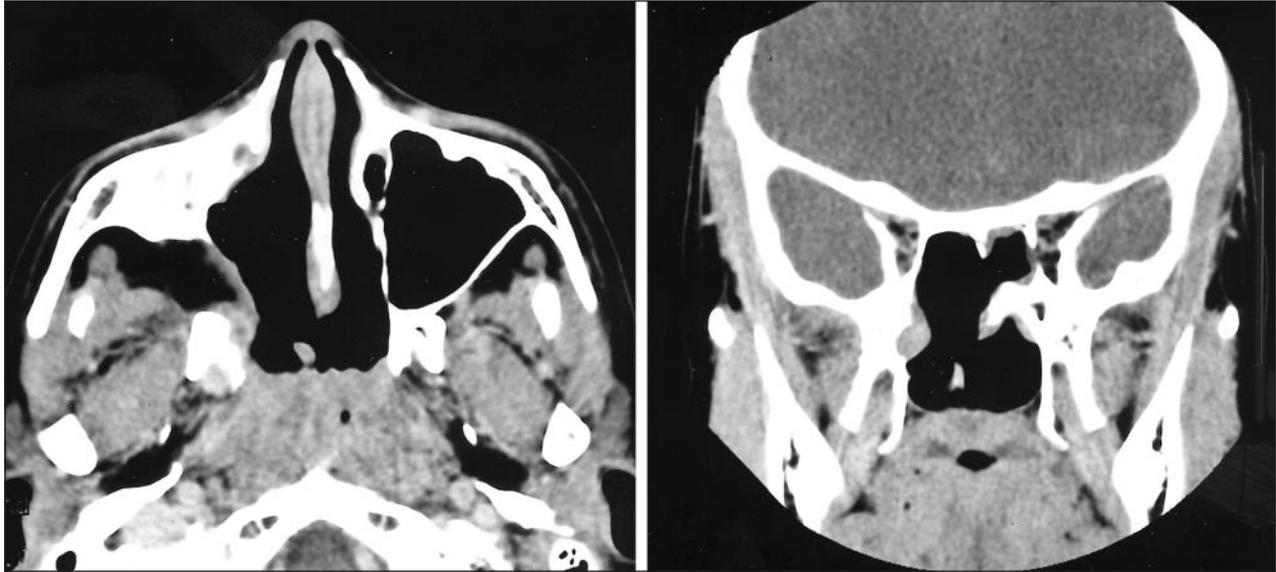


**Figure 4.** Intraoperative photograph of patient 4 after Le Fort I osteotomy and downfracture of the maxilla. The tumor, an angiofibroma, can be seen as it is removed.



**Figure 5.** Intraoperative photograph of patient 4 after Le Fort I osteotomy and removal of the tumor. Reconstruction plates are affixed in place and are providing maxillary stability. Pre-drilling and fitting of the plates ensure maintenance of the preoperative occlusion despite the small loss of bone from the upper maxillary segment on the right.

One patient (No. 5) subsequently underwent endoscopic removal of granulation tissue. All other patients have remained disease free.



**Figure 6.** One-year postoperative axial (left) and coronal (right) computed tomographic scans of patient 4, who was diagnosed as having angiofibroma. The tumor involved the nasopharynx bilaterally, the right infratemporal fossa, the right pterygomaxillary space, and the clival region. There is no evidence of residual tumor.

Complications attributable to the Le Fort I osteotomy in this series were minimal. One patient (No. 11) lost several unerupted tooth buds during the procedure. One patient (No. 5) developed unilateral mild enophthalmos. Another patient (No. 2) required revision dacryocystorhinostomy for epiphora after surgery. No cases of cerebrospinal fluid leak, postoperative hemorrhage, motor nerve palsies, or subcutaneous emphysema were encountered. Preoperative occlusion was maintained, and the postoperative cosmetic result was excellent in all patients.

#### COMMENT

Primary tumors of the central skull base or tumors with direct extension to this anatomical region present a surgical challenge that includes access, exposure, potential complications, and cosmesis. Traditional methods to the central skull base can be categorized into midfacial (transoral, transpalatal, lateral rhinotomy, and midfacial degloving) and lateral (infratemporal and transcochlear) approaches. Each has its inherent advantages and limitations and deserves a brief discussion. The transoral route, and specifically the labial-mandibulotomy approach,<sup>8-10</sup> provides adequate exposure, but destroys a pediatric patient's central incisors, potentially jeopardizes other tooth buds, and requires a large facial and neck incision. When a transpalatal approach is used in combination or alone, the major concern is the formation of a palatal fistula or wound dehiscence. Also, the bulk of soft tissue that must be retracted restricts exposure of the upper clival and sphenoidal regions.<sup>6,7</sup> The midfacial degloving approach<sup>11,12</sup> offers excellent anterior exposure and, when combined with complete ethmoidectomy or medial maxillectomy, provides good central skull base exposure. Sensory disturbances involving the teeth and infraorbital nerve distribution are common with midfacial degloving. The infratemporal fossa technique<sup>13</sup> has the disadvantages of conductive hearing loss, numbness

of the lower lip, and temporal depression caused by use of the temporalis muscle flap. It also may result in facial paresis as a result of translocation of the facial nerve. The transcochlear approach described by House and Hitselberger<sup>14</sup> is an extension of the procedure that is used to remove lesions of the cerebellopontine angle. It offers only limited exposure to the lateral aspect of the clivus.

The Le Fort I osteotomy is a standard orthognathic procedure that has been shown to be safe. Rare complications include postoperative hemorrhage,<sup>15</sup> subcutaneous emphysema,<sup>16</sup> unilateral abducens nerve palsy,<sup>17</sup> and aseptic necrosis of the maxilla.<sup>18</sup> The principal advantage of the Le Fort I osteotomy approach to the central skull base is one of exposure. In contrast to the palatal-splitting techniques, downward displacement of the maxilla gives a direct line of site for tumor removal that is not hindered by the soft palate. In addition to aiding tumor extirpation, this approach facilitates closure of an associated dural or mucoperiosteal defect and control of hemorrhage. By avoiding an external facial scar, the Le Fort I approach affords excellent cosmetic results. Pre-drilling for plate fixation prior to osteotomy avoids postoperative occlusal problems, and the necessity for performing this step cannot be overemphasized. Disruption of facial growth is unlikely, as the osteotomy does not pass through growth centers.<sup>19</sup> However, the osteotomy may damage unerupted teeth in patients younger than 5 or 6 years. Adjusting the level of the osteotomy to avoid unerupted tooth roots can help avoid this complication.

Our experience with the Le Fort I approach to the central skull base has been generally very favorable. There is no question that this approach is superlative in terms of access, exposure, and cosmesis. For the majority of the cases in our cohort, a midfacial degloving approach combined with a unilateral or bilateral medial maxillectomy might have provided similar exposure but would have required additional access time. A transoral approach would have given limited superior clival exposure and definitely a poorer cosmetic result. We consider

mild enophthalmos (patient 5), loss of tooth buds (patient 11), and epiphora (patient 2) significant complications in our series. Enophthalmos was the result of tumor resection and not a result of the Le Fort I approach. Loss of tooth buds in a 3-year-old patient was not ideal but, as a desperate attempt to resect this patient's tumor, it was deemed justified. Epiphora was attributable either to cutting of the nasolacrimal ducts during tumor extirpation or to failure of the initial dacryocystorhinostomy. As stated earlier, primary dacryocystorhinostomy was the preference of one of us (K.C.), and its importance has not been established.

No single surgical procedure is best suited for all presentations of skull base lesions in children. The Le Fort I approach is suited for large skull base lesions, especially if the pterygomaxillary space, the sphenoidal sinus, and the clival regions are involved. Also, it is appropriate for the removal of these lesions in pediatric patients.

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