Maxillary Removal and Reinsertion in Pediatric Patients

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Objective: To examine outcomes after the maxillary removal and reinsertion (MRR) approach for the treatment of anterior cranial base tumors in pediatric patients.

Design: Eligible patients were identified by medical record review. Consenting patients were studied via rhinoscopy, fiberoptic endoscopy, standard facial photographs, and cephalometric radiographs.

Setting: A tertiary care otolaryngology clinic.

Patients: Inclusion criteria were age younger than 16 years at time of initial procedure and a follow-up period of at least 6 months. Nine patients were eligible, and 5 enrolled. All were male patients (mean age, 13.8 years; age range, 11-15 years) treated for juvenile nasopharyngeal angiofibroma.

Main Outcome Measures: History and examination were performed to evaluate occlusion, vision, facial growth, and tumor status. Cephalograms were used to calculate 3 standard cephalometric measurements: sella to A point, basion to A point, and condylion to A point. Cephalograms were examined for plate migration and bony resorption.

Results and Conclusions: No major long-term complications were identified in the patients after MRR. Cephalometric analysis revealed minor abnormalities in 2 children, but no plate migration or bony resorption was identified in the removed and reinserted maxillae. No abnormal development patterns were detected on physical examination or when cephalometric measurements were compared with age- and race-matched normative data. Although further study is warranted, MRR seems safe and effective for treatment of pediatric patients with anterior cranial base tumors.


THE ANTERIOR cranial base, a site crowded with functionally important structures, is a locus of various benign and malignant lesions in adults and children. Recent advances in cranial base surgical techniques have improved access to and repair of this complex anatomic region.1 Maxillary removal and reinsertion (MRR) is one such technique. This procedure was reported in 1992 by Schuller and colleagues2 as a method to gain wide surgical access to the anterior cranial base for tumor resection while preserving adjacent critical structures. Since 1992, MRR has been performed on several pediatric patients by the members of the Department of Otolaryngology at The Ohio State University, Columbus. Most of these cases involved surgical treatment of juvenile nasopharyngeal angiofibroma (JNA). Although benign, JNA is an aggressive and extremely vascular neoplasm that is capable of bony destruction and intracranial extension.3 These characteristics make surgery the most frequently used treatment modality for JNA, typically via transpalatal and transantral approaches.4,5

Surgery of the anterior cranial base, however, is associated with frequent postoperative complications. In 1994, Kraus and colleagues6 reported a 31% incidence of local major complications, such as infection, orbital injury, or neurologic injury, in 85 patients after craniofacial resection of anterior cranial base neoplasms. For JNA, postoperative hemorrhage and tumor recurrence are the most common complications.3

One potential complication of facial skeletal surgery in children is injury to facial growth centers with sequelae such as malocclusion, visual disturbance, or cosmetic deformity.7 Correction of these sequelae may require additional surgery. The major growth centers of the face are the mandibular condyle, the nasal septum,
PATIENTS AND METHODS

Medical record review identified 9 MRR procedures performed on pediatric patients at The Ohio State University and Columbus Children’s Hospital between 1992 and 1998. The technique is summarized in Figure 1. A detailed description of this technique has been previously reported. Inclusion criteria for this study were age younger than 16 years at the time of surgery and a follow-up period of at least 6 months postoperatively to monitor tumor recurrence and evaluate for postoperative facial growth asymmetries.

A complete history and head and neck examination and transnasal fiberoptic nasopharyngoscopy were performed on participating patients at The Ohio State University Department of Otolaryngology outpatient clinic. Specifically, patients were questioned and examined for visual disturbances (altered acuity, diplopia), occlusion or bite abnormalities, palpable reconstruction plates, facial symmetry, and presence or absence of residual or recurrent tumor. Standard lateral cephalograms were obtained at The Ohio State University School of Dentistry radiology suite. Analysis of cephalograms was performed by calculation of 3 standard cephalometric measurements: basion (tip of clivus) to A point (deepest point on the anterior maxillary alveolus), sella to A point, and condylion (posterosuperior border of the mandibular condyle) to A point. These measurements were chosen because age-, race-, and sex-matched normative data exist for these criteria.

Human subjects research protocol approval was obtained for this study from the Institutional Review Board at The Ohio State University. Informed consent was obtained from each participant and his or her legal guardian.

RESULTS

Of the 9 eligible pediatric patients who had undergone MMR, 5 consented to participate in the study. Table 1 summarizes operative report, postoperative course, and follow-up history and examination findings for these patients. The average age at time of presentation was 13.8 years, the average follow-up age was 15.0 years, and the average follow-up period was 14 months (range, 7-26 months). Treatment of JNA was the indication for surgery in all participating patients, although 2 of the non-participating patients underwent MRR for malignant tumor resection. The average operative time was 6.9 hours, and the average blood loss was 1440 mL. Average transfusion requirement was 2.2 U of packed red blood cells per patient. No perioperative complications were encountered in all cases.

Postoperative examination confirmed normal visual acuity and extraocular motions in all cases; no complaints of diplopia were encountered. Facial symmetry, assessed by examination of the maxillary alveolar arches, malar projection, and zygomatic arch width, revealed that no grossly appreciable growth disturbances occurred (Figure 2). Specifically, it was not possible to determine clinically which maxilla had been removed and reinserted until examination of the gingivobuccal sulcus revealed the surgical scar. Occlusion was class I in all cases, and no bite abnormalities were observed in any patient.

One long-term complication was encountered: epiphora in patient 5. All patients reported some degree of postnasal drainage and/or nasal crusting in the early postoperative course (ie, within the first 6 months postoperatively); 2 subjects had minor crusting on follow-up examination.

Table 2 summarizes cephalometric measurements and radiographic interpretation of the standardized lateral cephalograms. Additionally, the cephalograms were also reviewed by a pediatric radiologist (J.R.D.) for plate migration and bony resorption. Plates were in appropriate position in all cases. Clearly visible right and left anterior maxillary sinus walls were identified in all 5 cases, and an absence of cortical thinning around screws was observed in all cases. According to the pediatric radiologist, it was not possible to determine which maxilla had been removed and reinserted based on radiograph signal density of the anterior maxillary wall. These findings were interpreted as adequate evidence that reinserted maxillae did not resorb and that the removed and replanted bone remained viable (Figure 3).

COMMENT

Postoperative evaluation of pediatric patients who underwent MRR for treatment of anterior cranial base tumors demonstrates that this procedure provides adequate exposure for tumor removal without jeopardizing adjacent important structures. No residual tumor, tumor recurrences, or serious complications were identified in the 5 participating patients. However, further follow-up will be necessary to confirm that surgery was successful in completely eradicating the tumor in our study cohort. Although the participating patients for this study had all undergone JNA, MRR may be appropriate for surgical treatment of any anterior base neoplasm. Operating blood loss and number of transfusions for these
subjects were similar to those reported in other series of surgically treated patients with JNA.11,12

Cephalogram analysis identified 2 patients (patients 2 and 3) who had cephalometric measurements outside the normal distribution range. Preoperative medical record review revealed that patient 3 had a preexisting palatal developmental abnormality described by his primary physician several years before JNA diagnosis. Pa-

Figure 1. Summary of technique. A, Drawing of maxillary removal and reinsertion in a young male patient. Procedure begins with partial osteotomy at nasofrontal angle to allow extended midfacial degloving. B, After extended midface degloving, left maxilla is exposed. Partial osteotomies allow accurate plate placement before maxilla removal. C, Left maxilla has been extracted, exposing anterior cranial base tumor. D, Photograph of extracted left maxilla, held in anatomic orientation. E, Tumor has been extracted. F, Maxilla restored to original anatomic position. In this photograph, maxilla was secured with absorbable plates (LactoSorb system; W. Lorenz Surgical, Jacksonville, Fla). Gingivobuccal incision closure, maxillary and nasal packing, nasofrontal plate placement, and nasal casting complete the repair.
Patient 2 was diagnosed as being “small for age,” but otherwise deemed proportionate and bilaterally symmetrical by the author who performed cephalometric analysis (S.S.), based on a comparison of the measurements to the available normative data. Although normative data provide a helpful context for loose interpretation of cephalometric measurements, further analysis of measurements obtained longitudinally during the postoperative period will provide more valid information on the nature of postoperative facial growth.

Radiographic interpretation of cephalograms revealed several important findings. A bilateral anterior maxillary wall was identified in all subjects, and bone adjacent to screws and plates showed no sign of cortical

**Table 1. Operative Record and Follow-up History and Examination Findings**

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>Age at Surgery</th>
<th>Diagnosis</th>
<th>Procedure</th>
<th>Operative Time, h</th>
<th>Blood Loss, mL</th>
<th>Transfusions, Units of Packed Red Blood Cells</th>
<th>Postoperative Complications</th>
<th>Age at Evaluation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>15 y 11 mo</td>
<td>JNA (4 x 3 x 3 cm)</td>
<td>Left MRR</td>
<td>8.3</td>
<td>2400</td>
<td>4</td>
<td>None</td>
<td>18 y 2 mo</td>
</tr>
<tr>
<td>2</td>
<td>11 y 9 mo</td>
<td>JNA (8 x 3 x 3 cm)</td>
<td>Left MRR</td>
<td>8.3</td>
<td>900</td>
<td>1</td>
<td>None</td>
<td>12 y 4 mo</td>
</tr>
<tr>
<td>3</td>
<td>14 y 6 mo</td>
<td>JNA (5 x 3 x 3 cm)</td>
<td>Left MRR with left external ethmoidectomy</td>
<td>8.2</td>
<td>1200</td>
<td>3</td>
<td>None</td>
<td>15 y 11 mo</td>
</tr>
<tr>
<td>4</td>
<td>11 y 5 mo</td>
<td>JNA (2 x 3 x 3 cm)</td>
<td>Right MRR</td>
<td>5.5</td>
<td>2000</td>
<td>2</td>
<td>None</td>
<td>12 y 5 mo</td>
</tr>
<tr>
<td>5</td>
<td>15 y 4 mo</td>
<td>JNA (6 x 5 x 4 cm)</td>
<td>Left MRR with left external ethmoidectomy</td>
<td>4.2</td>
<td>700</td>
<td>1</td>
<td>None</td>
<td>16 y 3 mo</td>
</tr>
</tbody>
</table>

*JNA indicates juvenile nasopharyngeal angiofibroma; MRR, maxillary removal and reinsertion.

**Table 2. Lateral Cephalometric Analysis and Radiographic Interpretation for Maxillary Development in 5 Patients After Maxillary Removal and Reinsertion**

<table>
<thead>
<tr>
<th>Patient No.</th>
<th>A Point of Sella, mm</th>
<th>A Point of Basion, mm</th>
<th>A Point of Condylion, mm</th>
<th>Bony Resorption</th>
<th>Plate Migration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>96.5 (96.7 ± 4.3)</td>
<td>109 (109.1 ± 4.8)</td>
<td>102.5 (103.9 ± 3.9)</td>
<td>Negative</td>
<td>None</td>
</tr>
<tr>
<td>2</td>
<td>80.5 (91.1 ± 4.4)</td>
<td>87.5 (101.3 ± 5.0)</td>
<td>89 (92.1 ± 4.1)</td>
<td>Negative</td>
<td>None</td>
</tr>
<tr>
<td>3</td>
<td>83 (96.0 ± 4.8)</td>
<td>92 (105.2 ± 5.0)</td>
<td>93 (95.2 ± 3.2)</td>
<td>Negative</td>
<td>None</td>
</tr>
<tr>
<td>4</td>
<td>88 (91.1 ± 4.4)</td>
<td>101 (101.3 ± 5.0)</td>
<td>97.5 (92.1 ± 4.1)</td>
<td>Negative</td>
<td>None</td>
</tr>
<tr>
<td>5</td>
<td>91 (98.5 ± 5.4)</td>
<td>99.5 (107.8 ± 5.2)</td>
<td>95 (98.9 ± 4.4)</td>
<td>Negative</td>
<td>None</td>
</tr>
</tbody>
</table>

*Numbers in parentheses represent age-, sex-, and race-matched norms with SDs.
These data strongly suggest that replanted maxillae are not resorbed and that they remain viable or possibly serve as a template for replacement by adjacent viable bone.

Normally, anteroposterior and vertical facial growth continue into late adolescence and early adulthood. Thus, continued growth of replanted maxillae, which could prevent late cosmetic or functional deformity, may represent a benefit of primary facial skeletal reconstruction aside from the immediate restoration of normal facial contours. Admittedly, the small number of patients limits the power of this study, and serial cephalograms collected at regular intervals would provide further data regarding midface growth and the fate of replanted maxillae after MRR is performed in pediatric patients. Although our series of participating patients is admittedly small, this study provides important evidence that MRR is safe and effective and does not result in serious cosmetic or functional impairment when it is performed on pediatric patients.

Maxillary removal and reinsertion has undergone considerable changes at our institution since its inception. Early in our experience with this procedure, patients occasionally complained of palpable facial plates at the nasal dorsum and maxilla. The procedure was subsequently modified by placing 1.0-mm microplates, rather than larger miniplates, at osteotomies where thin skin appeared to predispose to plate palpation, specifically, the nasal dorsum and medial maxilla. This modification has eliminated this complication (Table 1).

Recent investigations of facial plating have heightened awareness of other potential complications of MRR. Resnick and colleagues reported a 10% reduction in cranial growth when miniplates were placed across craniofacial suture lines in juvenile rabbits. Although we did not identify facial growth disturbance on cephalogram or physical examination in our patients, inhibited growth remains a theoretical concern because miniplates and microplates are placed across nasofrontal and zygomaticomaxillary sutures in MRR. Additionally, recent studies have demonstrated the incidence of intracranial migration of microplates in juvenile animals. Although this concerning phenomenon appears to occur primarily in neonates, one may consider absorbable plates such as the LactoSorb system (W. Lorenz Surgical, Jacksonville, Fla) to minimize the likelihood of growth inhibition or plate migration when performing MRR in pediatric patients (Figure 1F). Absorbable plating systems have been used successfully by multiple investigators for craniofacial surgery, most commonly in pediatric patients.

<table>
<thead>
<tr>
<th>Follow-up, mo</th>
<th>Complaints</th>
<th>Examination Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>27</td>
<td>None</td>
<td>No recurrence, normal mucosa, no crusting, no palpable plates, normal occlusion, normal vision</td>
</tr>
<tr>
<td>7</td>
<td>Occasional rhinorrhea, postnasal drip</td>
<td>No recurrence, lateral wall crusting, no palpable plates, normal occlusion, normal vision</td>
</tr>
<tr>
<td>17</td>
<td>None</td>
<td>No recurrence, normal mucosa, no palpable plates, no crusting, normal occlusion, normal vision</td>
</tr>
<tr>
<td>12</td>
<td>None</td>
<td>No recurrence, normal mucosa, no palpable plates, no crusting, normal occlusion, normal vision</td>
</tr>
<tr>
<td>11</td>
<td>Left epiphora, postnasal drip</td>
<td>No recurrence, lateral wall crusting, no palpable plates, left epiphora, normal occlusion, normal vision</td>
</tr>
</tbody>
</table>

Figure 3. Lateral cephalogram (A) and detail from cephalogram (B) of a young male patient 11 months after left maxillary removal and reinsertion. Note absence of plate migration, absence of bony resorption around cortical screws, and bilateral presence of anterior maxillary sinus wall in cephalogram detail.
CONCLUSIONS

Maxillary removal and reinsertion is safe and provides adequate access for surgical removal of anterior cranial base tumors in pediatric patients. Postoperative facial examination and lateral cephalometric measurements suggest that MRR does not negatively affect subsequent facial growth and development in pediatric patients and provide evidence that removed and replanted maxillae remain viable.

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REFERENCES