2 Reconstructive Surgery

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Introduction

This chapter deals with the broad subject of reconstructive surgery in the management of pediatric head and neck tumors. The nature of the subject mandates a somewhat different format in that a wide array of tumor types and anatomic locations are considered. As such, an overview of the thought processes and management principles that guide the reconstructive surgeon will be outlined. Preoperative planning, intraoperative management, and specialized areas for reconstruction will be emphasized. Some details for specific defects and commonly used flaps and techniques will also be presented.

A few important caveats should also be stated at the outset. Many of the tumor types and resultant defects found in pediatric head and neck oncology are rare, and in some cases represent unique situations. As such, reconstructive treatment recommendations are rarely evidence-based and depend more on principles and experience rather than established protocols or algorithms. The literature supporting a given reconstructive modality is often quite limited, especially in pediatric patients and prospective well-controlled studies are lacking. The authors recognize that there is always more than one reconstructive option and that the patient's, parents', and surgeon's familiarity and comfort with the risk and rewards of various approaches may also play a role in determining the type of reconstruction method that is selected. As such, the material presented below should be viewed as a guide rather than a series of definitive treatment recommendations.

Preoperative Planning: General Considerations

Successful reconstruction of the pediatric head and neck invariably begins with careful preparation [1]. The reconstructive surgeon should be engaged as soon as it is determined that some form of reconstruction may be needed. Ideally, this should occur well in advance of tumor extirpation. This allows for a complete understanding of the diagnosis, adjuvant treatments and prognosis, as well as interdisciplinary communication by all treatment teams, including radiology. In particular, the reconstructive surgeon should be aware of what anatomic structures are definitely, likely, or possibly involved. Will immediate reconstruction be required? How will surgical margins be assessed? How likely is tumor involvement at the margins and will this mandate reexcision? What is the likelihood of local recurrence and subsequent resection? These questions should be openly discussed as the answers to these questions may influence the type and timing of reconstruction.

Adjuvant therapy and its timing should also be discussed. Radiation can significantly affect the choice of reconstructive procedure. When administered prior to resection and reconstruction, radiation can cause local tissues to be edematous and microcirculation poor [1, 2]. In this setting, local tissue rearrangement or local flaps may have a higher rate of failure. Conversely, radiation after reconstruction can produce long-lasting deleterious changes that may lead the reconstructive surgeon to defer certain elements of the reconstruction until later in childhood to avoid the direct effect of radiation on the reconstructed element in question (Fig. 2.1). In some instances, neoadjuvant chemotherapy may severely lower the ability of the patient to tolerate prolonged reconstructive procedures such as free-tissue transfers and necessitate less invasive procedures. In other cases, delays in wound healing from reconstructive complications can dangerously delay postoperative chemotherapy. In these instances, less complex reconstructive choices may be necessary initially to increase the likelihood of early, uncomplicated wound closure.

Once the reconstructive surgeon fully understands the anatomic requirements and other treatment modalities to be employed in management of the tumor, a series of reconstructive options should be generated. In some instances there may be one clear "first option", in other instances there

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Fig. 2.1 Radiation effect. This adolescent patient underwent orbital extenteration for a rhabdomyosarcoma at the age of 4. She had free tissue transfer elsewhere followed by radiation. This case demonstrates the dramatic ill effects of radiation therapy on the growing maxillofacial skeleton. The mandible, maxilla, and orbit are substantially underdeveloped on the affected side

may be two or three equivocal options. Regardless, it is necessary to have at least one alternative procedure going into the operating room. This "lifeboat" may be deployed when intraoperative conditions change (e.g., unrecognized tumor progression, patient instability) or if the primary reconstruction modality is unsuccessful (e.g., partial or complete flap loss). When the reconstructive surgeon meets the patient and family, the rationale for the various the options should be fully discussed along with the advantages and disadvantages inherent to all reconstruction choices.

Equally important to interprovider consultation, preoperative planning must involve the parents and, when appropriate, the patient as well. The family will be overwhelmed by the diagnosis and there is often a sense of urgency to proceed as quickly as possible. The family may have been told that some form of "plastic surgery" or "reconstruction" will be required prior to the consultation with the reconstructive surgeon. A fine line must be walked between giving the family hope and inadvertently leading the family to have unrealistic expectations for the reconstruction. In addition to defining the defect and the reconstruction needs of the patient, the preferred treatment option(s) will be outlined. These may change based on anatomic considerations following physical examination or psychosocial considerations. For example, scarring from previous surgery may preclude specific donor sites for tissue or recipient vessels in case a microvascular procedure is required. Fortunately, unlike adult head and neck cancer patients, the effects of tobacco, diabetes, and other chronic comorbidities are rarely encountered. However, psychosocial considerations especially in adolescent patients, must be accounted for. It is important for the reconstructive surgeon to assess the family's and patient's understanding and tolerance for the reconstructive procedure being considered. In some cases, a simpler reconstruction with a less than ideal aesthetic outcome may be preferred if the surgical risks, recovery time, or postoperative restrictions are unacceptable to the patient or family.

All donor sites or potential donor sites for tissue, areas of scarring, and secondary deformities should be disclosed along with expectations for functional and aesthetic limitations at both the donor and recipient sites following surgery. Furthermore, depending on the age of the child, special attention should be given to the effects of growth on both of these locations. In many instances, additional procedures later in childhood will be required to address growth differences in the area of reconstruction. When this can be anticipated, the family should be made fully aware of a secondary procedure. In some instances, optimal reconstruction may require a series of staged procedures over time. Each patient and family should be viewed as unique with specific anatomic, psychological and social considerations. Care by the reconstructive team should be viewed as individualized, long-term, and may even exceed that of all other care team members.

Intraoperative Considerations

Timing and Sequence

A two-team approach is often helpful to minimize patient anesthesia and surgeon fatigue. In these situations, the free tissue flap is raised simultaneously with the extirpative operation. Clear communication between the oncologic and reconstructive teams is vital in these cases, especially when a skin flap is required. With poor communication between the teams, it is not uncommon to raise a flap that is too small for the defect. Certainly, the safest approach is to wait until the defect is complete. In our experience, however, most cases are amenable to a two-team approach.

Anesthesia

If combined with cancer ablative operations, head and neck reconstructive procedures are often lengthy. An experienced anesthesia team is crucial for optimizing care and minimizing complications.

Airway In cases that involve the oropharynx, a nasal ray endotracheal tube is obligatory. The tube can be secured to the caudal septum with a heavy silk stitch. To avoid alar rim skin necrosis, the entire tubing apparatus should be brought inferiorly and secured to the patient's foam-padded forehead with tape. A straight accordion tube extender is often useful to lengthen the circuit and avoid kinks. The tubing closer to the anesthesia machine can also be secured to the back of the headrest for additional security. Once this process is complete, the surgeon should check the integrity of this construct by turning the head in either direction.

Positioning The positioning of the patient will depend to some extent on the reconstructive plan. In the case of pedicled flaps and most free tissue flaps, supine positioning is adequate. If a large defect is anticipated and a latissimus flap is considered for reconstruction, it may be prudent to harvest the muscle flap first in a lateral decubitus position, then partially close the donor site and turn the patient supine for the extirpative operation.

Tubes and Lines Hemodynamic instability is rare during resection and reconstruction of most pediatric head and neck tumors. The main exception to this is in large vascular malformations, especially arteriovenous malformations. As such, invasive monitoring is typically limited to an arterial line and at least one and usually two peripheral intravenous lines. If postoperative chemotherapy or frequent blood sampling is anticipated postoperatively, a central venous catheter may be placed at the outset of the procedure. In patients coming to the operating room with a previously placed port-a-cath™ or long-term indwelling central venous catheter, special care must be taken to ensure appropriate handling and interrogation of these sites if they are to be used. The use of such devices should be cleared with the oncology team, parents, and the surgical team caring for the line. A nasogastric or orogastric tube is usually needed—initially for decompressing the stomach and potentially following surgery for nutrition.

Medication A broad-spectrum antibiotic that covers oral/nasal flora is routine and should be continued in the perioperative period. Other medications to consider for postoperative comfort are antiemetics and pain medications. The surgeon should communicate early with the anesthesiologist about the use of vasopressors. Too often, a wide-open arterial anastomosis has been redone only to find that the agent responsible for the pale flap was the vasopressor. Fluid, colloid, or blood product administration should be the first line of treatment in these cases.

Technical Considerations

Several important technical considerations are related to the actual execution of the operation merit discussion. Careful attention to these issues separates the good outcomes from the potential disaster cases.

Oral Cavity Separation One of the most difficult complications of oropharyngeal reconstruction is the dreaded fistula [3–12]. Fistulas may develop between the oropharynx and the nasal cavity or the skin. Typically, they occur at the flap and native mucosa juncture. To minimize the risk of fistulas, one should consider the causative factors: poor healing and inadequate seal. Poor healing may result from ischemia, infection, or a suboptimal environment (such as bathing in saliva or a radiated tissue bed). Ischemia can be controlled by bringing healthy, well-vascularized tissue to the defect and by resecting all poorly perfused tissues. Inadequate seal is almost always a result of poor surgical planning or execution. The most problematic areas for obtaining a tight seal are at the gingiva, the palate, and posterior mouth. Patients with intraoral tumor involvement, radiation, or poor oral hygiene may present with mucosa that is friable. The right approach is to remove all of the friable and suboptimal tissue from the area so that a tight seal can be created with the newly transferred flap and the surrounding tissues.

Brain–Mucosa Separation When reconstructing defects that involve the cranial base, it is critical to obtain a good seal to separate the brain from the mucosa [13]. Tumor extirpation operations that involve the cranial base typically leave a large soft tissue defect. Obliteration of the resulting dead space is paramount to avoid cerebrospinal fluid leakage and infection. It is not uncommon to have to utilize a muscle flap in addition to a fasciocutaneous flap in these cases—the former for obliteration of the dead space and the latter for mucosal reconstruction.

Microsurgery The importance of adequate vessels for microvascular anastomosis cannot be overstated—the larger the vessels, the higher the likelihood of success. Source vessels found in the neck have reliable anatomy and flow. These vessels may be too distant for more cephalic defects such as the scalp or orbit; in which case, the facial or superficial temporal vessels may be substituted [14]. In head and neck reconstruction, one rarely encounters difficulty in finding a suitable artery. However, finding an appropriate vein can sometimes be challenging. Good communication between the extirpative team and the reconstructive team from the outset of the procedure may allow for the identification and preservation of useful recipient vessels later in the procedure. In situations where the area is heavily scarred or has been previously radiated, one should consider (a) vein grafting to the opposite side or (b) use of the ipsilateral cephalic vein. It is rarely worth the risk to use less than optimal vessels in a zone compromised by scarring or radiation, to avoid the additional effort of vein grafting, using the contralateral side or the ipsilateral cephalic vein. We have found the cephalic vein quite useful in difficult outflow situations. A long segment can be harvested from the ipsilateral arm using multiple stab incisions. Minimal morbidity, anatomic consistency, and long length make this vein a perfect “bail out” strategy in difficult situations. There is ongoing debate in the literature about immediate versus delayed use of arteriovenous loops. The most recent literature suggests that staging of arteriovenous loops is not necessary [15].

Flaps

In this section, we will outline common flaps that are utilized for head and neck reconstruction. These flaps have consistent anatomy, low donor site morbidity, and long, reliable pedicles that allow a wide reach in the head and neck—they are the workhorse flaps of head and neck reconstruction [16].

Radial Forearm Flap [17, 18] This flap provides thin, reliably perfused tissue based on a long pedicle for reconstruction of small to moderate sized defects. The anatomy is consistent, the flap is easy to harvest, and outcomes have been excellent [6, 7, 11, 12, 16, 19–21]. It can be harvested as a fasciocutaneous flap or an adipofascial flap. Inclusion of the medial or lateral antebrachial cutaneous nerve creates a neurosensory flap that may be useful, to restore sensation to areas such as the palate. For small flaps, the donor site can be closed linearly. For larger flaps, a skin graft is required. The healing of this skin graft can be problematic if the paratenon over the flexor carpi radialis tendon is stripped [21–24]. Prior to harvesting this flap, one must perform an Allen’s test to confirm integrity of the superficial palmar arch.

Anterolateral Thigh Flap Based on the descending branch of the lateral femoral circumflex artery, this versatile flap provides a substantial surface area of skin for reconstruction of large defects in the head and neck [16, 25–30]. The anatomy of the flap and pedicle are reliable and consistent. A large amount of skin and subcutaneous fat can be harvested with the flap and the donor site morbidity is minimal [31]. In some cases, the vascular pedicle courses along the fascial interface between the rectus femoris and the vastus lateralis muscles. However, in most cases, the vascular pedicle is intramuscular, thus making the dissection more tedious. In larger patients, its relatively remote location from the head and neck, as well as its anterior location makes it amenable to a two-team approach.

Rectus Abdominis (Myo or Myocutaneous) This flap is used in a variety of anatomic locations and in head and neck reconstruction can provide cutaneous coverage or fill large cavities (Figs. 2.2–2.7) [6, 8, 13, 32]. The flap is harvested from the lower abdomen, preferably through a low transverse incision when only muscle is required or with an ellipse of skin and fat contiguous with the underlying muscle when coverage or lining is needed. The blood supply to the flap is via the inferior epigastric system. The pedicle is typically large, long, and easy to dissect. Depending on the amount of fascia taken with the muscle, the abdominal defect can be prepared directly or with a small mesh patch. Attention must be paid to proper closure as bulges or hernias may result. Abdominal wall function and trunk support is not impacted as long as the contralateral rectus muscle is functional. When placed low enough, the donor site scar is fairly inconspicuous.

Fibula Flap (Osseous or Osseofasciocutaneous) This is another workhorse of head and neck reconstruction, especially in cases where bone is needed (Figs. 2.8–2.10) [3, 6, 16, 33–35]. The fibula flap relies on the peroneal vascular pedicle for blood flow. Dissection of this flap requires thorough anatomical knowledge of the leg and its neurovascular structures—so as to recover a healthy flap and to avoid injury to normal structures. Dissection of the skin flap along with the bone (osseofasciocutaneous flap) can be a bit more cumbersome given that there is a very thin fascia separating these structures, and the number and caliber of perforators within this fascia can be few and small, respectively. However, the long leash of the fascia provides significant versatility in positioning the skin appropriately to fit the given defect.

Summary

Reconstructive surgery is an integral part of treatment for children with head and neck tumors. Inclusion of the reconstructive surgeon at the outset of treatment improves the likelihood of an optimal outcome by facilitating interdisciplinary

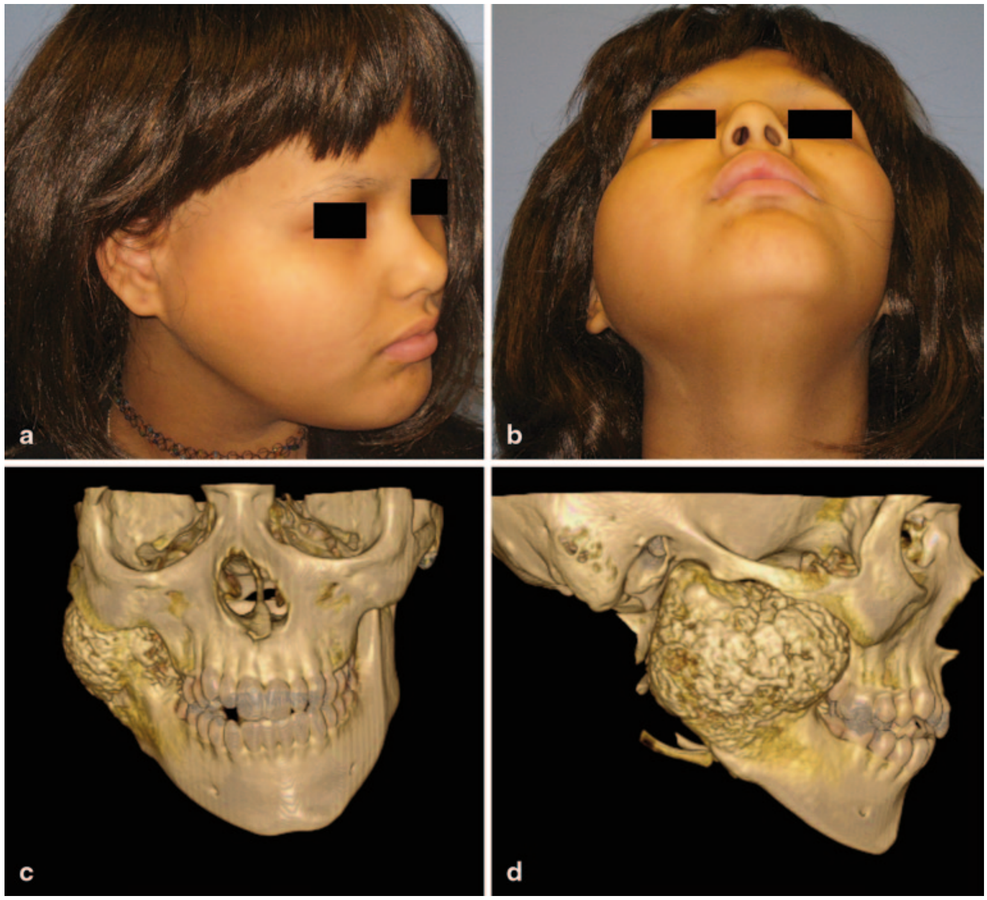

Fig. 2.2 Ten-year-old girl following neoadjuvant chemotherapy and radiation for a high grade osteogenic sarcoma of the right mandibular body (**a, b**). The 3D maxillofacial CT scans (**c, d**) demonstrate the large tumor extending up to and involving the adjacent skull base on the affected side

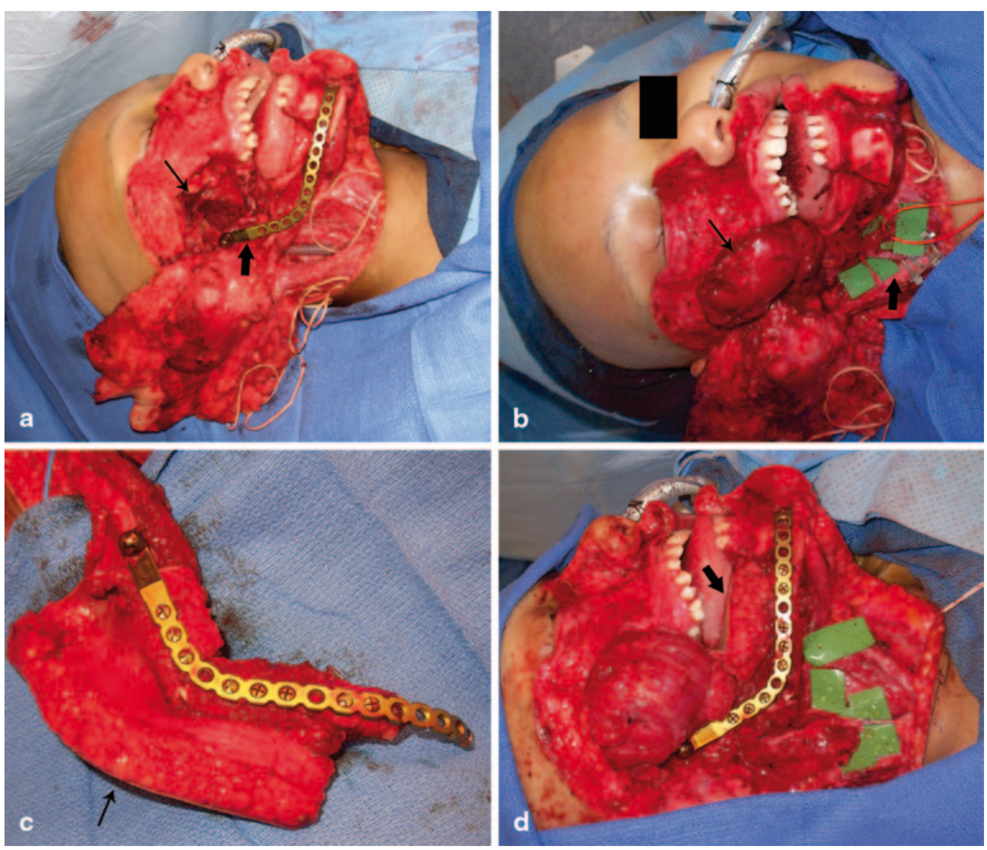

Fig. 2.3 **a** Following extirpation of this tumor via an extended Weber–Ferguson approach, loss of soft tissue and bone has created a large void adjacent to the infratemporal fossa (*thin, black arrow*). A mandibular reconstruction plate has been placed to demonstrate the absent right hemimandible (*thick, black arrow*). **b** A rectus abdominis muscle flap has been inset into the large skull base defect (*thin, black arrow*) and microvascular coaptations have been performed (*thick, black arrow*). **c** An osseofasciocutaneous fibula flap has been contoured and fixed to a mandibular reconstruction plate bent preoperatively to match the contralateral side (*thin, black arrow*). The skin paddle and soft tissue are shown inferiorly (*short, black arrow*). **d** Both flaps have now been inset. The closure of the oral lining has been completed prior to skin closure to allow for a meticulous two-layer closure under direct visualization (*thick, black arrow*)

Fig. 2.4 Three years postoperatively. **a** The anteriorposterior (AP) view demonstrates some chin asymmetry secondary to differential right and left mandibular growth and soft-tissue loss on the right side. **b** Submental view demonstrating widened scarring where secondary local tissue rearrangement was required because of native skin flap loss. **c** Some degree of temporomandibular joint (TMJ) stiffness with maximal interincisal opening of 23 mm. The cutaneous portion of the flap (*thin, black arrow*) is well-healed to the adjacent pink oral mucosa

Fig. 2.5 Seventeen-year-old male who presented with swelling on the right side of his face (**a, b**). An axial (**c**) and coronal (**d**) computed tomogram demonstrate an expansile mass obliterating the right maxillary sinus. The 3D CT (**e**) view demonstrates the extent of the lesion and marked thinning of the maxillary bone. A transgingival biopsy revealed an odontogenic myxoma

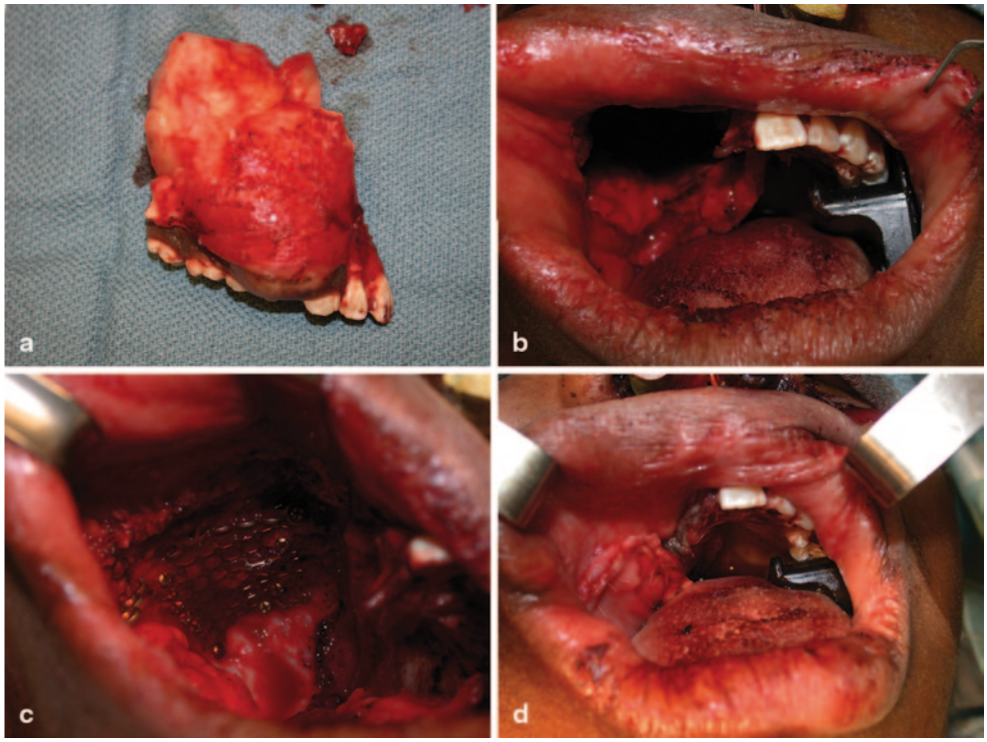

Fig. 2.6 **a** The specimen following an entirely transoral resection. **b** The resultant voluminous defect extending up to and including the orbital floor. **c** Titanium mesh plates have been placed to support the globe and a rectus myocutaneous flap was used to fill the sinus and separate the sinus and oral cavity from hardware (not shown). **d** Following closure

Fig. 2.7 One year after surgery with a partial denture in place (**a**). Some flattening of the right cheek and mild enophthalmos are appreciated on the submental view (**b**) but were not clinically significant

communication and integrating the reconstructive treatment into a long-term care plan. Specifically, the anatomic requirements of the reconstruction can be articulated by the extirpative team, and the rationale for, and timing of adjuvant therapy can be worked out. Preoperative consultation by the reconstructive team provides the opportunity to assess the unique patient factors (e.g., comorbidities, available donor sites, family support) that help determine the most appropriate type of reconstruction. Intraoperative coordination between surgical teams and anesthesia is also vitally important. Patient positioning, type and location of lines and tubes, and simultaneous versus staggered surgery between extirpative and reconstructive teams should be agreed upon. Although many local, regional, and distant flaps exist, a select group of workhouse flaps are commonly used. Special attention should be paid to sealing potentially problematic areas such as the oral cavity, sinuses, or cranium. The reconstructive process in the pediatric patient does not end at discharge but often extends over years. The effects of growth and time often mandate revisions as the child ages and this possibility should be fully disclosed to families at the initial consultation. Although successfully treating the patient's

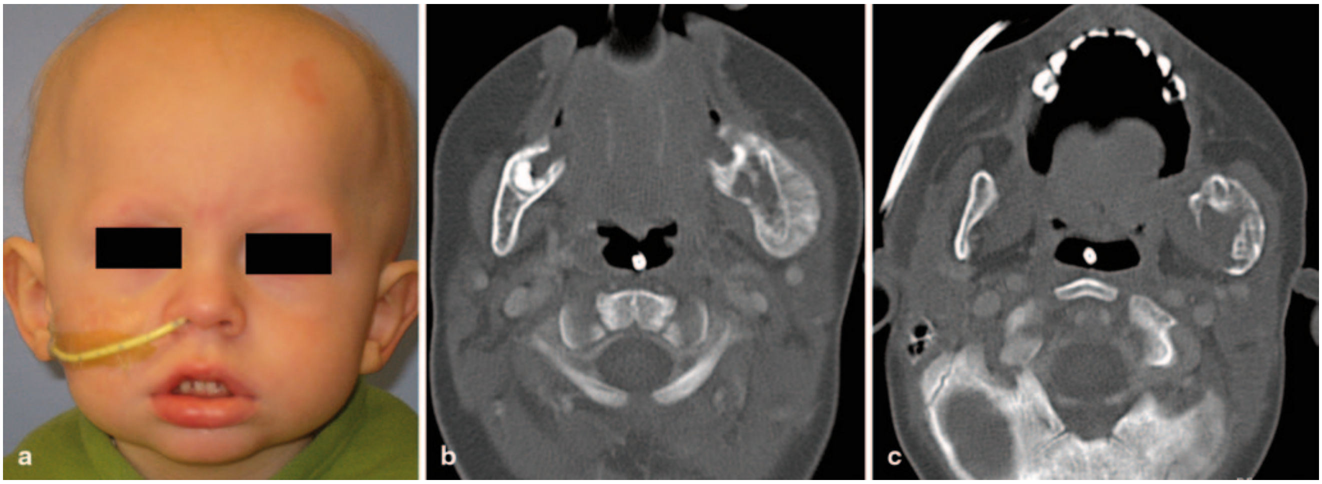

Fig. 2.8 Two-year-old boy after neoadjuvant chemotherapy for a Ewing sarcoma of the left mandible (**a**). Axial computer tomograms of the tumor involving the left mandibular body prior to (**b**) and following chemotherapy (**c**). Because of the proximity of the tumor to the oral lining, it was felt that autogenous reconstruction rather than a temporary reconstruction plate would be required

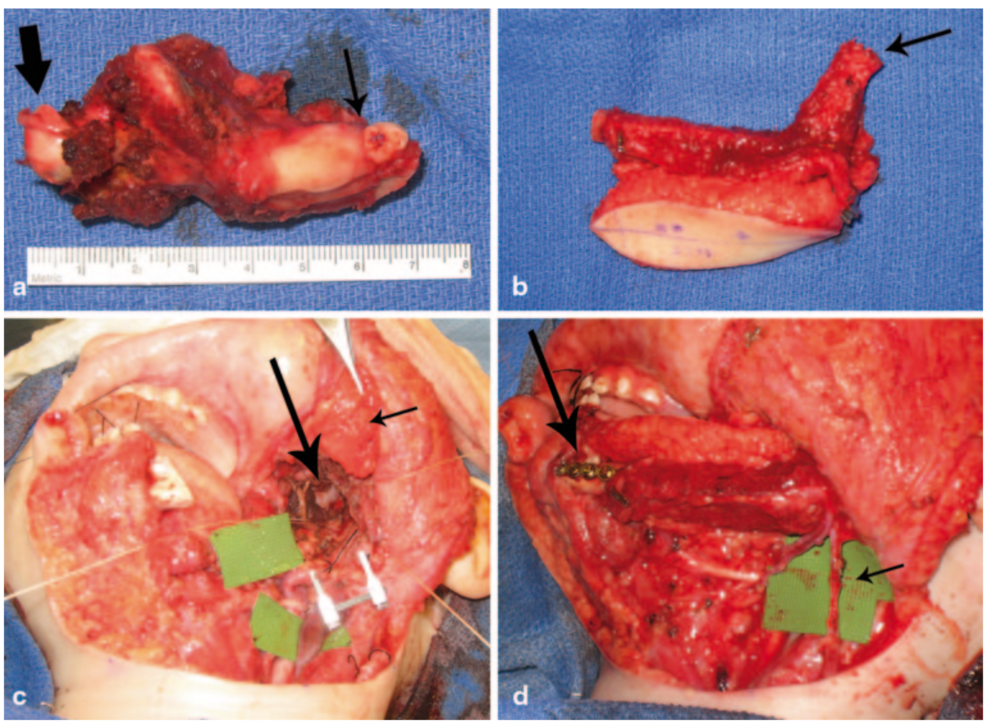

Fig. 2.9 **a** The specimen following extirpation. The condyle (*thick, black arrow*) and the oral lining and dentition (*thin, black arrow*) are seen. **b** Osseofasciocutaneous fibula flap has been harvested and contoured. The new condyle has been contoured and covered with vascularized muscle and periosteum to diminish chances of ankylosis (*black arrow*). The single osteotomy at the angle of the construct was fixed with a resorbable plate to facilitate future distraction (not shown). **c** Reconstruction of the temporomandibular joint was accomplished using vascularized buccal fat pad (*short, black arrow*) and resorbable suspension sutures to hold the new condyle in position. The glenoid fossa seen at the depths of the incision (*long, black arrow*) was not involved. **d** The mandibular construct has been inset with the distal fixation at the left parasymphysis visible (*long, black arrow*). Microvascular anastomoses between the peroneal artery and its two venae comitantes and the facial artery, facial vein, and an external jugular vein are shown (*short, black arrow*)

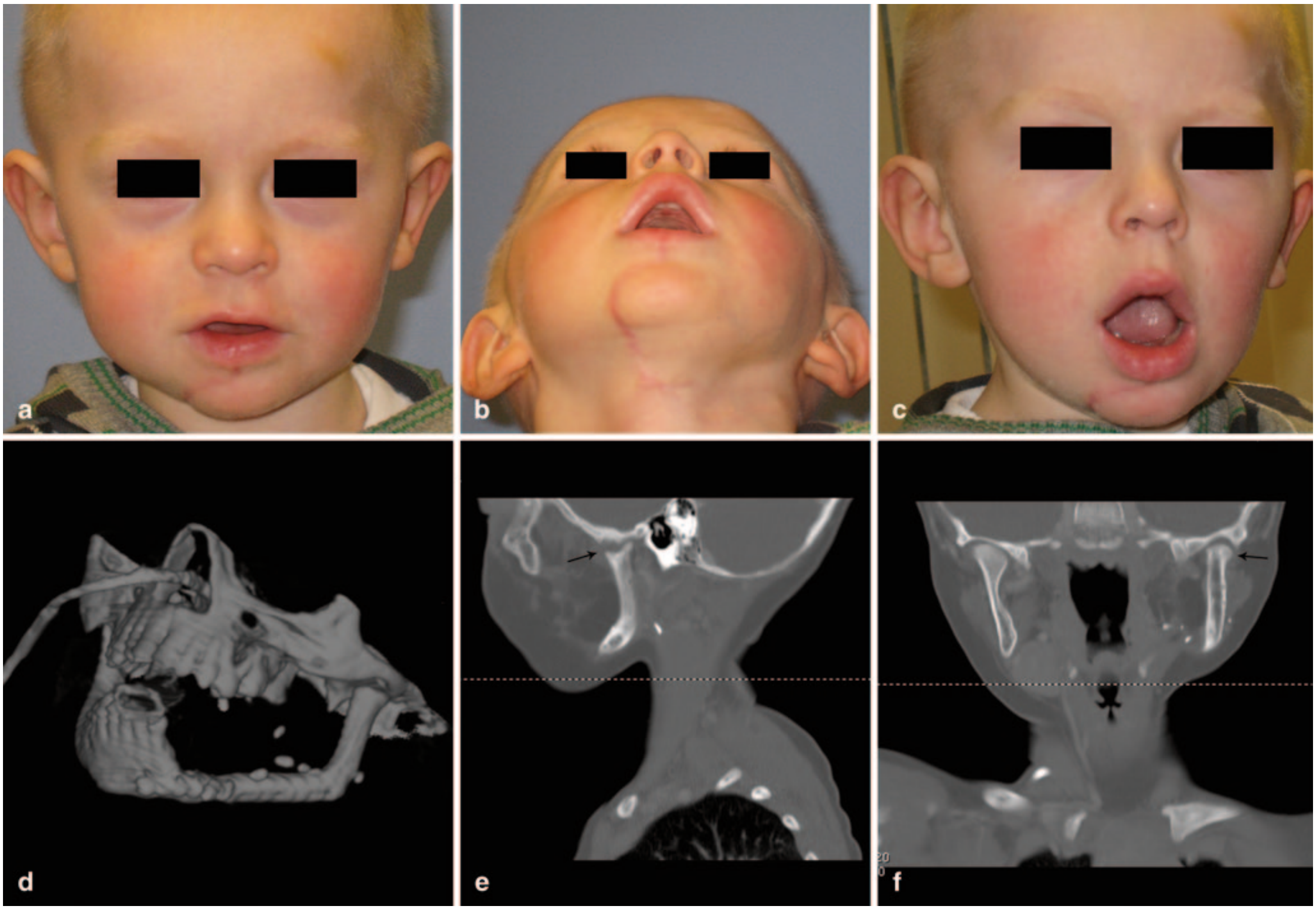

Fig. 2.10 Seven months postoperatively. The AP and submental views demonstrate healing incisions and good symmetry (**a, b**). There were no limitations in mouth opening noted on examination or by the parents (**c**). Postoperative 3D computed tomogram demonstrating the mandibular construct (**d**). Sagittal (**e**) and coronal (**f**) computed tomograms demonstrate the reconstructed condyle well-seated in the glenoid fossa with adequate joint space between condyle and glenoid seen (*long, black arrows*)

tumor remains the primary goal of therapy, the quality of the life that has been saved will be improved by a well-planned and well-executed reconstruction.

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