Orthognathic Surgery for Patients with Maxillofacial Deformities

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ABSTRACT

Orthognathic surgery is performed to alter the shape of the jaws to improve dental occlusion stability, improve temporomandibular joint function, open the oropharyngeal airway, and improve the patient’s facial proportions. Surgery must be coordinated with orthodontic treatment. The surgeon develops a plan based on the patient’s measurements and performs the planned procedure on plaster models of the patient’s jaw and teeth to obtain the proper jaw position. Surgical techniques include LeFort procedures and distraction osteogenesis. Possible complications of orthognathic procedures include airway compromise, numbness, and nonunion or malunion of the bones. Postoperative instructions include an emphasis on the need for the patient to consume a blended diet for six weeks after surgery. AORN J 92 (July 2010) 28-49. © AORN, Inc, 2010. doi: 10.1016/j.aorn.2009.12.030

Key words: jaw surgery, orthognathic surgery, maxillofacial deformities, maxillofacial surgery, bilateral sagittal split osteotomy, mandibular advancement surgery, intermaxillary fixation, LeFort osteotomy, cranial bone graft, distraction osteogenesis, sleep apnea.

The term orthognathic comes from the Greek terms ortho, meaning “straight, normal, in proper order,”¹ and gnatho, meaning jaw²; thus, orthognathic surgery is surgery to straighten the jaws. Deformities of the jaws (ie, maxilla, mandible) and midface and the resulting misalignment of the teeth create functional and aesthetic difficulties for patients. These difficulties can be corrected through the combination of orthodontics (ie, braces) and orthognathic surgery.

ANATOMY

The maxilla contains the upper teeth, and the mandible contains the lower teeth. The mandible articulates or functions against the base of the skull in conjunction with the temporal bone, just anterior to the ear canal, to form the temporomandibular joint (TMJ). For best function and aesthetics, the top teeth should fit in a precisely defined position with the bottom teeth (Figure 1). If

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ORTHOGNATHIC SURGERY FOR MAXILLOFACIAL DEFORMITIES

Figure 1. For best function and aesthetics, the teeth of the maxilla (ie, upper jaw) should fit in a precisely defined position with the teeth of the mandible (ie, lower jaw). The mandible articulates with the temporal bone to form the temporomandibular joint.

growth problems occur as a result of genetics, trauma, or functional habits, however, a person’s jaws may not be proportional, and this can cause difficulties (ie, malocclusion) that affect chewing, joint function, airway patency, and facial aesthetics. Growth discrepancies can occur in either the maxilla or mandible. A person also may have a combination of unequal growth causing an “open bite” in which the teeth do not touch (Figure 2). Some of these issues can be corrected by orthodontia. An orthodontist, however, may recommend that a patient consult with a maxillofacial surgeon if the growth difference between the jaws cannot be corrected by orthodontics alone (ie, if there are discrepancies of more than 2 mm to 3 mm).

Jaw deformities may cause TMJ pain and dysfunction. A person may experience excessive tooth wear as well as difficulty chewing, speaking, or breathing. Some cases of jaw deformity can lead to obstructive sleep apnea, which may result in problems with lung and heart function. Restoring the proper anatomic relationship between the jaws

- helps reestablish normal function,
- helps protect against further deterioration of the TMJs and teeth, and
- opens the posterior pharyngeal airway to treat severe sleep apnea.

Figure 3 shows the preoperative and postoperative airway change when maxillary and mandibular advancement is combined with rigid fixation to open the posterior pharyngeal airway. This surgery is especially helpful for patients who cannot tolerate continuous positive airway pressure for treatment of severe obstructive sleep apnea.

COMMON MAXILLOFACIAL PROBLEMS
Evaluating the relationship between the patient’s teeth and face is important to help diagnose and treat maxillofacial problems. Maxillofacial surgeons evaluate the relationship of the patient’s mandible to his or her face and classify the occlusion (ie, bite) by using Angle’s classification of malocclusion, named after Edward H. Angle, MD, the father of modern orthodontics. A class I occlusion is a normal bite and facial relationship (Figure 4A). With a class II malocclusion, the mandible is smaller than the maxilla, which makes the chin look small (Figure 4B). With a class III malocclusion, the mandible is larger than the maxilla, making the chin protrude in relationship to the rest of the face (Figure 4C). In addition, the face can grow disproportionately in all three planes (ie, vertical, horizontal, transverse).

Figure 2. Growth discrepancies of either jaw can lead to problems such as an “open bite” in which the teeth do not touch.
Furthermore, midline discrepancies and right-to-left cants (ie, angles from the right to the left) can occur. These types of skeletal problems, combined with dental crowding, explain why no person is truly symmetrical or perfectly proportioned.

Proper diagnosis is important to determine whether surgery is necessary and, if so, what particular surgical procedure should be performed. The four elements of the diagnostic process include:

- clinical facial examination (ie, measurements of the patient’s soft tissue relationships are taken with his or her head in a neutral position),
- clinical dental examination (ie, evaluation of tooth position),
- study model analysis (ie, measurement of the jaw/tooth relationship), and
- cephalometric analysis (ie, comparison of the patient’s facial skeleton to normal relationships and ratios based on a standard lateral head radiograph).

Residual facial growth analysis may be performed in some younger patients to help determine the appropriate timing of surgery and relapse potential. All of these diagnostic elements are combined with functional and aesthetic information to arrive at a diagnosis and treatment plan.

Patients requiring alteration of their dental bite or jaws fall into one of three groups.

- **Group 1**—The patient has minimal dental crowding or rotation that can be treated with orthodontics alone and has no skeletal deformity.

- **Group 2**—The patient has both dental and skeletal problems but the skeletal problems are not obvious and could possibly be masked by orthodontic treatment. The resulting face shape may not be satisfactory, however, and the patient’s bite may be unstable because the position of the teeth and shape of the skull or jaws are compromised. The instability of the maxillofacial position for this group of patients can lead to relapse of the malocclusion and TMJ problems. The orthodontist and surgeon must work together to determine whether a patient requires surgery. These patients may require repeated evaluation during the course of treatment. In general, not performing orthognathic surgery on patients with this level of deformity is compromised treatment.

- **Group 3**—The patient has both dental and skeletal problems and requires both orthodontics and surgery to resolve the problem.  

![Figure 3. Maxillofacial abnormalities that compromise a patient’s airway (A) often can be improved by surgery (B).](image)}
TREATING A PATIENT WITH A MAXILLOFACIAL DEFORMITY

An orthodontist and a maxillofacial surgeon must work together to treat a patient with a maxillofacial deformity. The orthodontist must first align the teeth in the maxilla and mandible with braces. This may make the bite look worse until after surgery. The orthodontist has to remove the dental compensation to show the full degree of abnormality. If the orthodontist were to bring the teeth as close to normal as possible with orthodontia, the patient would still have the original maxillofacial problems (eg, airway compromise, TMJ-related pain); furthermore, the surgeon would not have the space necessary to make full correction in the bones. This misguided effort would result in the patient’s teeth being in the wrong position after surgery, with increased potential for relapse, and could limit the surgical correction. This problem commonly occurs when patients with group 2 or group 3 defects initially elect not to proceed with surgery and only have orthodontia. If one of those patients chooses surgery later, the orthodontist must reverse the tooth position to prepare for the surgery, which adds months to the orthodontic treatment time.

An orthodontist usually requires 12 to 18 months to align the patient’s dentition. In some patients, a bite splint is required to help position the joints, and the patient wears this splint for two to three months. Attaining consistent joint position preoperatively helps the surgeon set the jaws correctly. The patient returns to the orthodontist after surgery to finalize the bite correction. This usually takes an additional three to six months to complete. Some patients also may require some tooth reshaping by a general dentist. The reshaping (ie, odontoplasty) corrects the dental anatomy so that the teeth fit together in a precise, comfortable manner.

The role of the maxillofacial surgeon is to move the facial bones to restore correct facial relationships so that the teeth fit together and the jaw functions normally. An oral surgeon is responsible for removing the wisdom teeth six
months before surgery. This timing is important to allow the extraction sites to heal before the orthognathic surgical procedure occurs. After the orthodontist positions the teeth, the surgeon moves the maxilla or the mandible or both to correct the facial and dental positions. The surgeon then monitors the patient’s healing until the bones have ossified in the new position. The bones must be allowed to heal for approximately six to eight weeks before normal chewing is allowed.

The surgeon develops a surgical plan based on various patient measurements. The plan then is tested and confirmed on a cephalometric tracing using computer software (Figure 5). The surgeon then performs the planned surgical procedure on plaster models of the patient’s jaws and teeth (Figure 6) and uses these models for reference during the actual surgery. The surgeon makes a plastic transitional splint or jig on the model and uses this splint or jig in surgery to position the mandible according to the maxillary position or to position the maxilla based on the position of the mandible, depending on his or her preference. The surgeon determines the final bite position by making cuts between the teeth on the plaster maxillary model (Figure 7). The jaw may be reshaped on the model until the proper position is obtained; this then guides the changes to the patient’s mouth to improve the final bite position.

PREOPERATIVE PREPARATION

The surgeon may perform the orthognathic procedure in an ambulatory surgery center or a hospital. Before the day of surgery, the surgeon or the patient’s primary care provider obtains a history and performs a physical examination. Depending on the patient’s age and health status, the patient may need preoperative tests (eg, complete blood count, blood type and cross-match for blood transfusion, urinalysis, chest x-rays).

During the preoperative appointment, the patient has final x-rays and photographs taken, which the surgeon places in the patient’s chart for

![Figure 5. Cephalometric tracing showing how maxillofacial surgery is planned.](image1)

![Figure 6. The surgeon performs the procedure in advance on anatomically accurate plaster models to relate the mandible with the maxilla: lateral view (A), frontal view (B).](image2)
The reference. The surgeon takes final surgical movements, bite registration, and dental impressions for plaster study models and makes a special jaw joint registration called a facebow registration (i.e., a device used to determine the positional relationships of the maxilla to the TMJ for the purpose of properly positioning the dental cast on an articulator). The nurse and the surgeon provide preoperative teaching, placing particular emphasis on ensuring that the patient and his or her family members fully understand the need for a diet that does not require chewing (i.e., blended so that it can be swallowed easily) for six weeks after surgery. The nurse instructs the patient that he or she should not eat any food eight hours before surgery but that clear liquids (e.g., water, apple juice) may be consumed up to four hours before surgery. When the questions of the patient and his or her family members have been answered, the surgeon obtains informed consent from the patient or, if the patient is a minor, from the patient’s legal guardian.

On the day of surgery, the preoperative nurse identifies the patient and obtains a medical and surgical history and performs a physical assessment. The nurse determines the patient’s knowledge and understanding of the surgical procedure, postoperative recovery, and discharge instructions.

After having the patient change into a hospital gown, the nurse helps the patient put on anti-thromboembolic device stockings. When the patient is settled in the preoperative bed or recliner, the nurse provides the patient with warm blankets to maintain normothermia and then inserts a peripheral IV line. The nurse prepares preoperative antibiotics to be administered 60 minutes before the surgical incision is made.

The anesthesia care provider arrives in the preoperative area to assess the patient and discuss plans for anesthesia. The surgical procedure lasts three to six hours and requires general anesthesia. After explaining the anesthesia process, the anesthesia care provider obtains informed consent for anesthesia from the patient or the legal guardian. The surgeon arrives to meet with the patient and his or her family members and to answer any last-minute questions regarding surgery. After all questions have been answered, the patient or legal guardian signs the informed consent for surgery.

The circulating nurse arrives in the preoperative area to assess the patient and review the patient’s medical record. After comparing the patient’s verbal identity confirmation with the patient’s medical record, identification band, and blood identification band, the circulating nurse ensures that all documentation, including consents, is complete and appropriately signed. The circulating nurse assesses the patient for any conditions that might affect perioperative nursing care (e.g., allergies, musculoskeletal problems, procedure-specific positioning needs, current medications and when last taken, existing or previous airway complications, previous anesthetic problems) and ascertains when the patient last ate or drank fluids. The nurse ensures that the patient’s and family members’ questions have been answered, after which he or she prepares a care plan specific to this patient (Table 1). In the OR, the circulating nurse and scrub person perform all necessary counts and confirm that all needed implants, equipment, supplies, and hardware are available before the patient’s arrival in the OR.
### TABLE 1. Nursing Care Plan for Patients Undergoing Orthognathic Surgery for Maxillofacial Deformities

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Nursing interventions</th>
<th>Outcome indicator</th>
<th>Outcome statement</th>
</tr>
</thead>
</table>
| Ineffective airway clearance and risk for aspiration | ■ Identifies baseline respiratory status  
■ Identifies physiological status  
■ Reports deviation in diagnostic study results  
■ Reports deviation in arterial blood gas studies  
■ Monitors physiological parameters  
■ Monitors changes in respiratory status  
■ Uses monitoring equipment to assess respiratory status  
■ Evaluates respiratory status | ■ The patient is breathing spontaneously with supplemental oxygen without assistance on transfer at the time of discharge from the OR or procedure room to the postanesthesia care unit.  
■ The patient’s oxygen saturation and respiratory rate are in the expected range at discharge from the postanesthesia care unit. | ■ The patient’s respiratory status is maintained or improved from baseline levels. |
| Risk for injury and risk for perioperative positioning injury | ■ Confirms patient identity  
■ Assesses baseline skin condition  
■ Identifies baseline tissue perfusion  
■ Identifies baseline musculoskeletal status  
■ Identifies physical alterations that require additional precautions for procedure-specific positioning  
■ Verifies the surgical procedure, surgical site, and laterality  
■ Implements protective measures before the surgical or invasive procedure  
■ Applies safety devices  
■ Positions the patient  
■ Implements protective measures to prevent skin/tissue injury caused by mechanical sources  
■ Uses supplies and equipment within safe parameters  
■ Performs required counts  
■ Maintains continuous surveillance  
■ Evaluates tubes and drains to ensure they are functioning as planned  
■ Evaluates musculoskeletal status  
■ Evaluates for signs and symptoms of physical injury to skin and tissue  
■ Evaluates results of the surgical count | ■ The patient’s skin condition other than the incision is unchanged between admission and discharge from the OR.  
■ The patient’s pressure points demonstrate hyperemia for less than 30 minutes.  
■ The counts are accurate, correct, or reconciled according to facility policy. | ■ The patient is free from signs and symptoms of injury caused by extraneous objects.  
■ The patient is free from signs and symptoms of injury related to positioning.  
■ The patient is free from unintended retained foreign objects. |
INTRAOPERATIVE CARE
The circulating nurse transports the patient to the OR and assists the patient onto the OR bed. To confirm the patient’s identity, planned surgical procedures, allergies, and any necessary equipment and supplies, all surgical team members stop to introduce themselves, greet the patient by name, and perform the surgical time out with the patient, the informed consents, and the OR schedule. The circulating nurse places sequential

TABLE 1. (continued) Nursing Care Plan for Patients Undergoing Orthognathic Surgery for Maxillofacial Deformities

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Nursing interventions</th>
<th>Outcome indicator</th>
<th>Outcome statement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk for infection</td>
<td>■ Assesses susceptibility for infection</td>
<td>■ The patient has a clean, primarily closed surgical wound covered with a dry, sterile dressing at discharge from the OR.</td>
<td>■ The patient is free from signs and symptoms of infection.</td>
</tr>
<tr>
<td></td>
<td>■ Implements aseptic technique</td>
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<tr>
<td></td>
<td>■ Classifies the surgical wound</td>
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<tr>
<td></td>
<td>■ Minimizes the length of the invasive procedure by planning care</td>
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<tr>
<td></td>
<td>■ Protects from cross-contamination</td>
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<tr>
<td></td>
<td>■ Initiates traffic control</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>■ Administers prescribed prophylactic treatments</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>■ Performs skin preparation</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>■ Maintains continuous surveillance</td>
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<td></td>
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<tr>
<td></td>
<td>■ Administers care to wound sites</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>■ Monitors for signs and symptoms of infection</td>
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<tr>
<td></td>
<td>■ Evaluates factors associated with increased risk of postoperative infection</td>
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<td></td>
<td>■ Evaluates progress of wound healing</td>
<td></td>
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<tr>
<td></td>
<td>■ Evaluates for signs and symptoms of infection through 30 days after the perioperative procedure</td>
<td></td>
<td></td>
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<tr>
<td>Imbalanced nutrition: less than body requirements and ineffective health maintenance</td>
<td>■ Identifies baseline gastrointestinal status</td>
<td>■ The patient describes the recommended postoperative nutritional intake regimen for the recovery period at the time of discharge.</td>
<td>■ The patient or designated support person demonstrates knowledge of nutritional management related to the surgical procedure.</td>
</tr>
<tr>
<td></td>
<td>■ Assesses nutritional habits and patterns</td>
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<tr>
<td></td>
<td>■ Assesses psychosocial issues specific to the patient’s nutritional status</td>
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<tr>
<td></td>
<td>■ Provides instruction regarding dietary needs</td>
<td></td>
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<tr>
<td></td>
<td>■ Includes the patient or designated support person in perioperative teaching</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>■ Evaluates response to nutritional instruction</td>
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</tbody>
</table>
compression device leggings on the patient and turns on the sequential compression device unit. The circulating nurse observes the patient for correct anatomic alignment and physiological positioning, places pillows under the lower legs to prevent the patient’s heels from resting on the OR bed, and secures the safety strap over the patient’s thighs. To allow the surgeon and assistant adequate access to the head of the bed, the circulating nurse carefully pads and tucks the patient’s arms at his or her sides, placing the patient’s arms in a neutral position with palms facing inward and confirming with the patient that the position is comfortable. The nurse ensures that the patient remains warm by placing a full-body, temperature-regulating blanket on the patient.

Patients with maxillofacial deformities can present airway challenges that may require additional equipment and supplies. Emergency airway carts contain specialized anesthesia equipment (eg, a fiber-optic intubating endoscope). The circulating nurse, therefore, ensures that an emergency airway cart or any equipment the anesthesia care provider anticipates needing is in the room and remains with the anesthesia care provider to assist with intubation. After inducing general anesthesia, the anesthesia care provider intubates the patient with a nasotracheal tube. Typically, he or she secures the nasotracheal tube over the patient’s forehead to keep it out of the way of the surgeon. In some instances, when more extensive midface, craniofacial, or nasal procedures are to be performed at the same time, the anesthesia care provider may insert a reinforced endotracheal tube orally. When surgery begins, the surgeon makes a submental incision and passes the connecting end of the tube through the floor of the patient’s mouth to avoid the need for a tracheotomy or for changing the tube position later in the procedure (Figure 8). The anesthesia care provider applies ophthalmologic ointment to the patient’s eyes and gently tapes them closed. The surgeon then injects local anesthesia with epinephrine into the surgical area to minimize intraoperative bleeding and postoperative pain.

The circulating nurse inserts an indwelling urinary catheter because of the length of the procedure and then applies an electrosurgical unit dispersive pad to the patient’s thigh. After re-checking the patient’s position, particularly his or her tucked arms and hands, the circulating nurse performs the facial, mouth, and cranial bone graft (CBG) site preps. The nurse ensures that prep solution does not run under the tape on the patient’s eyes or pool under the patient’s shoulders, neck, or head.

After the completion of the surgical preps, the surgeon and scrub person drape the patient and position the suction, drill, and electrosurgical unit hand piece in its holster on the field. The surgeon inserts an x-ray-detectable throat pack to minimize blood draining into the patient’s stomach during surgery. The circulating nurse notes the throat pack placement on the count sheet to facilitate closing counts.

THE SURGICAL PROCEDURE
Some surgeons perform the mandibular portion of the procedure first; others perform the maxillary portion first. In a procedure requiring work on
both mandible and maxilla, when the surgeon performs the mandibular portion first, he or she places a bite block and retractor and makes an incision in the patient’s mouth inside the cheek, followed by an osteotomy on the outer or lateral surface of the body of the mandible next to the first or second molar. The surgeon makes a horizontal osteotomy on the inside of the mandibular ramus (ie, the vertical part of the jaw that contains the joint) above the mandibular nerve where it enters the lower jaw. The surgeon joins the osteotomy on the outside of the ramus with the one on the inside by a third osteotomy behind the molars in the area where the wisdom tooth used to be. He or she then gently fractures the jaw along these incisions so that it splits in a sagittal plane (ie, a sagittal split osteotomy). Hugo Obwegeser, MD, DDS, who is considered the father of orthognathic surgery, developed this maneuver. It is performed on both sides (ie, bilateral sagittal split osteotomies) and is referred to as BSSO.

One key aspect of the sagittal split procedure is protection of the mandibular nerve, which travels through the bone and supplies sensation to the lower lip and chin. The nerve is stretched during this procedure, so all patients experience numbness for a few months after surgery. After the surgeon completes the splits, he or she moves the distal part of the mandible containing the teeth to its new position and temporarily wires it to the maxillary teeth using a transitional splint. The surgeon uses the braces and extra hooks for the securing wires. The surgeon positions the patient’s TMJs using two directions of force to ensure that they are in the proper position. This technique is called bivector seating and is important because a proper bite must be built around proper joint position.

In mandibular advancement surgery, the surgeon produces a gap to bring the lower jaw forward. He or she spans this gap with titanium bone plates and screws on each side to hold the mandible rigidly in position (Figure 9). In some instances, a patient may be able to feel the bone plates, and this may require that the plates be removed at a later date. Generally, this is not a problem, and the plates and screws remain in place permanently. In mandibular setback surgery, the surgeon may trim some extra bone to obtain the proper fit. This type of plate fixation is gentle on the joints and does not cause them to torque out of position. Other fixation techniques include transosseous screw fixation placed through the patient’s mouth or cheek with a transcortaneous trocar.

When the surgeon has secured the mandible, he or she unwires the patient’s teeth while the patient is still on the OR bed and checks the joint position to ensure everything is in the right position. If the surgeon determines that something is out of alignment, he or she moves the plates as necessary until the right position is achieved. In rare instances, the surgeon must wire the teeth together for six weeks. This was common in the past, and although some surgeons still use this technique in single jaw surgery or when other types of osteotomies are performed (eg, bilateral vertical oblique ramus osteotomy), it usually is not required.

If osseous wire fixation is used, the surgeon must provide postsurgical intermaxillary fixation (ie, wire the mouth shut) after removing the throat pack. After completing the mandibular portion of the surgical procedure, the surgeon...
corrects the maxilla, if necessary, using the LeFort I osteotomy procedure developed by René LeFort, MD, a French anatomist who studied facial fractures and published his work in 1901. The bone cuts used to correct maxillary and craniofacial deformities continue to bear his name. Building on LeFort’s work, Paul Tessier, MD, a French surgeon considered the father of craniofacial surgery, developed the LeFort III procedure to compensate for even more severe craniofacial midface and orbital deformities.

There are three levels of LeFort osteotomy:

- **LeFort I**—Also known as a horizontal maxillary osteotomy, the fracture or surgical cut occurs at the base of the upper jaw above the apices of the teeth roots (Figure 10A).

- **LeFort II**—Also known as a pyramidal osteotomy because the surgical cuts begin in the midfacial bones (especially the upper jaw) and meet above the nasal bones to form a triangular section of bone that is detached from the skull (Figure 10B).

- **LeFort III**—Also known as a craniofacial disjunction or transverse osteotomy, the facial bones are separated from the cranial base (Figure 10C).

The LeFort I procedure is used for the orthognathic surgery described in this article. First, the surgeon makes an incision inside the patient’s mouth under the upper lip. The surgeon makes cuts in the bone below the eyes, above the teeth, and through the nasal passages. He or she then breaks the bone free from the base of the skull at the pterygomaxillary suture and moves it so the upper teeth fit together with those of the lower jaw. Often, to obtain the best results, it is necessary for the surgeon to perform a multiple-piece LeFort I osteotomy to expand the palate. Usually, the surgeon makes the incisions between the lateral incisors and the canines, but the osteotomies can be made between any teeth.

The surgeon temporarily wires the patient’s teeth together again to give him or her the best possible result.
bite. The surgeon places bone grafts between the incisions to provide stability and promote faster healing. The surgeon may harvest a CBG from the patient’s skull for this purpose (Figure 11). The patient’s head is not shaved, and harvesting grafts from this area does not cause the patient much postoperative pain. The surgeon closes the incision with staples that are removed two weeks after surgery.

In more extensive situations with larger bone movement and, therefore, larger gaps, the surgeon may determine that it is necessary to take a bone graft from the hip. Another source of bone grafts is a bone bank. The advantage of using bone bank grafts is that no bone is harvested from the patient. Bone bank tissue, however, does not work as well as a patient’s own bone, which carries no donor risks and does not involve bone bank costs. Another option is the use of bone morphogenetic protein. This option is reserved for special situations, such as for patients who experience relapse or for osteotomy nonunion because of its expense. To hold the final position of the maxilla, the surgeon places more titanium bone plates and miniscrews on the patient’s top jaw to fasten the bone alongside the nose and over the first molars along the zygomatic maxillary buttress. Occasionally, patients can feel these plates as well. Figure 12 shows preoperative and postoperative photos of a patient who underwent LeFort I orthognathic surgery.

Additional procedures may be performed at the same time as jaw surgery to enhance the patient’s facial balance and aesthetics or to improve airflow through the patient’s nose. Some examples...
of additional surgeries include genioplasty (ie, chin surgery), rhinoplasty (ie, nasal surgery), cheek augmentation (eg, zygomatic, malar augmentation), or distraction osteogenesis.

Genioplasty, also known as mentoplasty, involves advancing, shortening, or lengthening the chin or adjusting the chin to a more midline position (Figure 13). If further correction of the jaw deficiency is required, the surgeon may perform a sliding advancement by horizontally cutting the bone above the chin and below the teeth in the anterior part of the mandible. He or she then slides the bone forward to make the final correction to any vertical, midline, or anterior-posterior deformity. The surgeon fixes the bone using screws, plates, or wires. Rarely does this hardware need to be removed. One important advantage of the sliding genioplasty is that it advances the suprathyroid muscles and increases the retroglossal space, thus improving the patient’s airway dimensions. Some surgeons use a chin implant, but most of the time, a chin implant is not used because it has a tendency to shift and look unnatural and does not advance the suprathyroid musculature.

Rhinoplasty is used to correct the shape of the nose, the patient’s ability to breathe through the nose, or both. Procedures that correct the appearance of the nose include reducing bumps on the upper nose or reshaping the tip. The goal is to ensure that the nose is proportioned to fit the face and is as close as possible to the patient’s ideal. Sometimes, reducing a bump on the upper nose makes the tip look more rotated and proportional. Sometimes, the surgeon must take the patient’s nose completely apart and then sculpt and graft it to turn up and narrow the tip. To improve nasal breathing, a septoplasty or inferior turbinate reduction can be performed.

Malar (eg, zygomatic) augmentation is another adjunctive procedure that may be performed (Figure 14). In malar augmentation, the surgeon attaches an implant to the bone just under the eye to help build up the cheekbone. This may be considered cosmetic; however, it can also be a part of the total reconstruction procedure. For example, in cleft lip or palate repair, the cheek implant procedure is part of the overall reconstruction of the facial deformity. Building up the cheeks gives better facial proportions and restores the patient’s appearance. Use of cheek implants in more severe cases helps avoid the need for a LeFort III procedure.

Distraction osteogenesis is the process of lengthening a bone by cutting it, allowing it to

Figure 13. Genioplasty is performed to give facial balance and to reposition the mentalis muscle to improve lip elevation and advance the suprathyroid muscles in cases of sleep apnea. Illustration of the proposed procedure (A) and postoperative x-ray with hardware in place illustrating how the chin, lips, and nose are aligned (B).
heal in a latency phase for seven days, and then stretching it 1 mm per day during the activation phase (Figure 15). The surgeon mounts an internal device on either side of the surgical bone cuts to hold them in place and then distracts the pieces so that new soft bone grows into the gap. It is then allowed to calcify during the consolidation phase. When the lengthening is achieved, the small activation pin in the cheek is removed and the resulting scar fades to a fine white line.

Figure 14. Preoperative (A and B) and postoperative (C and D) views of a patient who has undergone malar augmentation, maxillary and mandibular surgery, and rhinoplasty.
Distraction osteogenesis may be used when a patient has TMJ problems or more severe jaw deficiencies. Distraction corrects the patient’s bite and may transfer less force into the joint. Distraction can also be used in the midface when the advancement required is large (Figure 16). The patient requires an external halo for approximately six weeks to maintain proper alignment until the bones heal. With distraction, bone grafting is not needed. Distraction provides greater long-term stability in large advancements.

Additional cosmetic procedures that can be performed at the same time and under the same anesthesia include:
- a blepharoplasty (ie, eyelid surgery);
- liposuction;
- TMJ surgery; or
- a face-lift.

At the end of surgery, the surgeon rinses and suctioning the patient’s mouth to remove blood and debris and then removes the throat pack. The circulating nurse notes on the count sheet that the throat pack is removed. The anesthesia care provider temporarily inserts a nasogastric or orogastric tube to empty the stomach of any bloody drainage.

If the patient has not completely emerged from the effects of anesthesia at the time of discharge from the OR, the anesthesia care provider may insert a nasal airway to help the patient maintain his or her airway until fully alert. An oral airway should be avoided as it can shift the maxillary and mandibular bones if the patient bites down on it while emerging from anesthesia. The surgeon does not usually wire the patient’s jaws shut. If wiring the jaws together is necessary, however, the circulating nurse ensures that the patient leaves the OR with wire cutters in a secure and easily accessible location in case of an emergency that requires access to the airway. The anesthesia care provider leaves the nasogastric tube in place postoperatively if the patient’s jaws are wired shut.

The surgeon and scrub person wrap the patient’s head with a bulky, compressive head dressing to minimize oozing from the CBG site and help reduce swelling along the jaw. After the anesthesia care provider has extubated the patient, the surgical team transfers the patient to a supine position on the recovery bed and elevates the head of the bed 30 degrees. The circulating nurse covers the patient with a warm blanket and assists the anesthesia care provider to transfer the patient to the postanesthesia care unit (PACU).
POSTOPERATIVE RECOVERY
The PACU nurse administers humidified oxygen to the patient via a mist mask and instructs the patient to take deep breaths. The PACU nurse monitors the patient’s vital signs and oxygen saturation levels and elevates the head of the bed to 30 degrees. Monitoring the patient’s oxygen saturation is crucial because of the risk of postoperative airway complications (eg, acute airway obstruction as a result of edema). The nurse applies ice packs to the patient’s mandible and maxilla for comfort and to reduce soft tissue swelling. When the patient is fully awake from anesthesia, he or she may have a sore throat from the endotracheal or nasogastric tube. The patient will experience a moderate amount of blood oozing from

Figure 16. A patient shown before distraction osteogenesis(A), with distraction device applied (B and C), and after a successful distraction osteogenesis procedure of the midface using an external device (D).
the incisions and from the nose. The PACU nurse assists the patient with intraoral suctioning as needed to manage these secretions (Figure 17) because bloody drainage, if swallowed, can contribute to postoperative nausea and vomiting.

Typically, the patient stays overnight for airway monitoring and pain management. Postoperative pain is an individual experience. Many patients describe areas of lip paresthesia (eg, burning, itching, tingling) related to intraoperative tissue stretching but seem to need very little pain medication. Other patients may require strong IV or intramuscular pain medications (eg, morphine, meperidine, fentanyl) to relieve their pain.

The nurse ensures that the head of the patient’s bed remains elevated 30 to 40 degrees to minimize oozing and swelling and that wire cutters are conspicuous, secure, and accessible if the patient’s jaws have been wired shut. The nurse teaches the patient and family members how to perform oral suctioning to help the patient avoid swallowing bloody drainage. Some patients are very sensitive to even a small amount of swallowed drainage, so the nurse should be prepared to administer antiemetic medications if needed. He or she administers oxymetazoline hydrochloride nasal spray to minimize intranasal edema and bleeding and rotates the patient’s facial ice packs to minimize facial edema. If the patient is not experiencing nausea or vomiting, the nurse provides ice chips and fluids as tolerated by the patient.

On the first postoperative day, the nurse removes the patient’s urinary catheter several hours

Figure 17. The first postoperative night can be difficult for the patient as he or she deals with discomfort, swelling, and learning to handle secretions using suction.
before the patient is scheduled for discharge to allow time to assess whether the patient can pass urine normally. After helping the patient ambulate to the bathroom, the nurse helps the patient dress and then removes the bulky head dressing at the discretion of the surgeon.

Although it is not normally necessary to wire the patient’s teeth together, the surgeon typically applies orthodontic rubber bands (ie, elastics) on the patient’s braces the morning after surgery. Elastics are important to

- control the patient’s bite during the healing process (Figure 18),
- compensate for postoperative swelling that tends to shift the patient’s bite,
- help give some small movement to the teeth, and
- seat the TMJs.

Most patients find that the elastics help decrease some of the initial discomfort; however, the bands make eating and drinking more difficult, and it may require some persistence on the patient’s part to drink adequate fluids. Eventually, the patient is able to remove the elastics without assistance, drink the prescribed blended diet, perform oral care, and put the elastics back on the hooks on the braces. Most patients are not able to do this very well during the first postoperative week because of swelling. The placement of the elastics is important, but the patterns of placement vary from surgeon to surgeon. In some cases, the surgeon uses skeletal suspension wires from the anterior nasal spine and the chin to create stability without placing excessive force on the teeth.

The nurse discusses discharge instructions with the patient and the patient’s family members or caregiver (Table 2). Most patients will lose 7 lb to 15 lb during the six-week recovery period because of the difficulty of consuming adequate calories. To combat problems with inadequate nutrition and dehydration, the discharge nurse reminds the patient and his or her family members of the importance of maintaining the blended diet and consuming enough fluids for optimal healing. The nurse provides the patient with a 60-mL irrigation syringe on which a rubber catheter has been placed. This works well for injecting the blended foods and fluids into the patient’s mouth. Squeeze bottles also are available for this purpose.

The nurse also instructs the patient not to blow his or her nose for up to four weeks after surgery. Nasal secretions are managed with suction, the use of oxymetazoline, and saline nasal spray.

The discharge nurse informs the patient or support persons to call the surgeon’s office with any questions or concerns. Specific reasons to call include that the patient is experiencing

- excessive bleeding beyond the normal oozing that does not resolve or is bright red;
- a temperature greater than 100.4°F (38°C);
- excessive swelling that is unexpected, rapid, and unilateral;
- shifting of his or her bite or a change in bone position;
- severe pain or pain that is uncontrolled with pain medications;
- nausea or vomiting that does not resolve; and
- problems with medications, such as a rash or itching.

The nurse and surgeon ensure that the patient and his or her family members understand the discharge instructions.
**TABLE 2. Discharge Instructions**

- **Oozing of blood and swelling**
  - Expect oozing of blood from the incisions in your mouth and nose. This is normal for two to three days after surgery.
  - Consider renting a home suction machine for oral suctioning; obtain a prescription for the rental from your surgeon.
  - Use ice packs to the face and jaw for 24 to 48 hours to decrease swelling.
  - Keep your head elevated while sleeping for approximately two weeks after surgery to decrease swelling (eg, sleep with several pillows behind your back and neck).

- **Personal care**
  - Keep the elastic bands on your braces for six to eight weeks to guide the bite and support the jaws; you may remove the bands to eat and perform oral care, then replace them.
  - Brush your teeth with a soft child’s toothbrush after eating.
  - Rinse your mouth with water after eating and brushing; do not use alcohol-based mouthwashes.
  - You may shower the day after surgery but use a stool or a bench in the shower or have someone present in case you experience light-headedness.
  - You may gently wash your hair the day after surgery to remove blood and surgical prep solution from the cranial bone graft site.
  - Do not blow your nose for four weeks because this causes air to move into your cheeks and may increase the risk of infection.
  - Use saline nasal spray as needed to wash out any dried blood and mucus.
  - Rinse your mouth with warm saltwater rinses four times per day to help the incisions heal.

- **Medications**
  - Take liquid antibiotics according to instructions to prevent infection.
  - Take liquid pain medication according to instructions to prevent postoperative pain.
  - Take steroid pills, which can be crushed and taken with juice or yogurt, to decrease swelling; these are to be taken in decreasing doses and should not be discontinued abruptly. Follow instructions carefully.
  - Contact your surgeon to obtain a prescription for antinausea medication if you experience nausea or vomiting.
  - Use oxymetazoline nasal spray, 2 puffs in each nostril, twice a day for 3 days to decrease oozing of blood from the nose; after 3 days, switch to saline nasal spray.

- **Diet**
  - Remain on a blended diet that does not require chewing (eg, fruit smoothies, applesauce, soft scrambled eggs, thin mashed potatoes) to ensure adequate nutrition.
  - Drink extra fluids to prevent dehydration; do not use a straw.

- **Activity**
  - You may return to work after 2 weeks.
  - You may resume light exercise after 4 weeks.
  - Do not resume contact sports for 8 weeks. Facial protection at that time is required; ask your surgeon about particular sports or activities you wish to pursue to determine whether there are contraindications after orthognathic surgery.

- **Specific reasons to call your surgeon after discharge include**
  - Excessive bleeding (beyond the normal oozing) that does not resolve or is bright red;
  - Temperature greater than 100.4°F (38°C), which indicates a fever;
  - Excessive swelling that is unexpected, rapid, and on one side of the face or jaw;
  - Shifting of the bite or a change in the bone position;
  - Severe pain or pain that is uncontrolled by prescribed medications;
  - Nausea or vomiting that does not resolve; or
  - Problems with medications (eg, rash, itching).

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**THE POSTOPERATIVE EXPERIENCE**

How patients perceive their recovery differs; however, Figure 19 demonstrates the common progression of five typical aspects of surgical recovery (ie, swelling, bruising, energy, pain, mood) during the first two weeks of a patient’s postoperative course. This information comes from the surgeon author’s 26 years of experience caring for
patients undergoing orthognathic surgery. Swelling (ie, the dark blue line) and bruising (ie, the green line) begin soon after surgery and are most obvious on the third to fifth postoperative day and begin to decrease thereafter. Sometimes, the bruising of the face may take up to four weeks to resolve. A small amount of residual swelling may continue for several months.

Most patients feel tired after surgery. This lack of energy (ie, the purple line) results from having general anesthesia, the moderate amount of blood loss experienced during surgery, and difficulty eating and drinking during the first week. Blood loss usually is less than 500 mL, but combined with the stress of surgery, this is enough to leave the patient feeling fatigued. Blood loss can be significant enough for the patient to require a transfusion, but this is rare. When performing maxillary surgery, surgeons usually order a type and cross-match to ensure blood availability should the need arise.

Pain after orthognathic surgery is less than for some surgeries but is still significant. Most patients describe it as a sense of fullness or a pressure-type pain. The red line indicates that the pain is the greatest the first night after surgery. The surgeon orders strong oral pain relief medications for the patient to take at home the first week after surgery. During the second week, the patient often needs narcotic pain relief only at night. The surgeon may instruct the patient to replace narcotics with a nonsteroidal anti-inflammatory medication (eg, ibuprofen) after the second week if possible.

The last aspect of surgical recovery, the patient’s mood (ie, the light blue line), is seldom discussed, but it is important. Most patients feel relieved initially to have the surgery behind them and anticipate resolution of their problems, so their emotions are labile. After the swelling and bruising set in and the patient experiences a low energy level, pain, difficulty eating, and the inconvenience of manipulating the elastic bands, he

Figure 19. Although recovery is different for each patient, there are similarities. This graph plots the average intensity of swelling, bruising, energy, pain, and mood levels that patients experience during the first two postoperative weeks. (Reprinted with permission from R. Robinson, MD, DDS)
or she may experience depression and irritability. Generally, these feelings are most pronounced on the third or fourth postoperative day. Usually by the seventh postoperative day, when the patient is eating and drinking more easily and can change the elastic bands without assistance, his or her spirits begin to improve. The nurse should spend time discussing this with the patient and family members to prepare them and to suggest means to successfully weather the aftermath of surgery.

**COMPLICATIONS AND RISKS**

There are risks associated with any surgery and general anesthesia. General surgical risks and anesthetic risks can range from mild and reversible to severe, permanent, and in some instances fatal. The surgeon and anesthesia care provider give the patient and family members information about possible complications so that they have the opportunity to ask questions and become as informed as possible. Complications can permanently affect the patient and his or her family.

Underlying conditions may increase a patient’s risk for certain complications; however, the potential for complications exists with all patients. There is a risk of death related to anesthesia (ie, five to six deaths per one million patients\(^\text{14}\), for example, as with any procedure. Health care providers should encourage the patient to disclose a complete medical history, including all previous tests, hospitalizations, surgeries, injuries, infections, medications, allergic reactions, illicit drug use, smoking, alcohol consumption, and psychological treatments.

At least one episode of nausea and vomiting occurs in approximately 40% of patients undergoing orthognathic procedures; more severe complications are rare but still possible.\(^\text{15}\) The surgeon should inform the patient and family members of the complications specifically associated with jaw surgery (eg, TMJ problems, nonunion, malunion, relapse, tooth damage, numbness, blood loss, bone infection, scarring, distraction device failure).

- Temporomandibular joint problems can present as joint pain, limited ability to open the mouth, degenerative joint disease, or internal disk dislocations. Complications resulting from TMJ problems may require bite splints and medications for the rest of a person’s life, revision jaw surgery, or actual TMJ surgery.
- Nonunion occurs when bones cut during surgery do not heal correctly and may require further surgery and bone grafting procedures to successfully heal.
- Malunion occurs when bone that has been cut heals in the wrong position, which, if severe enough, will require further surgery to refracture and reset the bone correctly.
- Relapse happens when there is a shift of teeth or bones to their original position after correction, requiring further treatment. In some cases this may be related to late residual growth of the facial bones.
- Tooth damage may present as chipping, discoloration, and tooth death and subsequent loss. This may require crowns, fillings, root canals, extraction, bone grafting, or implants to repair.
- Numbness is present in all patients for six to eight weeks after surgery because the jaw must be split around the nerve that supplies sensation to the lower lip and chin. The return of sensation can take up to two years. At the end of two years, 15% of patients continue to have numbness, which should be considered permanent.\(^\text{16}\)
- Blood loss averages 500 mL. Although rare, severe blood loss can occur that requires transfusion and can be life threatening.
- Bone infection may occur at the site of the surgery or around the fixation plates that are used, in which case, additional antibiotics and surgery may be required.
- Scarring that does occur is rarely seen because most of the incisions are inside the mouth. In cases where skin incisions are necessary, the scars can be large and visible. Treatment of
ORTHOGNATHIC SURGERY FOR MAXILLOFACIAL DEFORMITIES

this complication may require scar revision or steroid injections. Although all scars are permanent, their effect on the patient depends on how visible or problematic the scars are.

Distraction devices that lengthen bones can fail or jam. If this occurs, the device may need to be replaced or removed. If the distraction is delayed, the bone may heal too quickly and require reoperation. The screws holding the device can also loosen and require replacement.

CONCLUSION

Jaw deformities may cause pain, dysfunction, excessive tooth wear, and difficulty chewing, speaking, or breathing. Many people live with these problems all their lives, but there is an alternative. Restoring the proper anatomic relationship of the jaw helps reestablish normal function and helps protect against further deterioration of the teeth and the TMJs. Maxillofacial surgery can help resolve these problems and improve a person’s comfort and self-esteem, allowing him or her to live a happier and healthier life.

References


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Orthognathic Surgery for Patients with Maxillofacial Deformities

PURPOSE/GOAL

To educate perioperative nurses about care of patients undergoing orthognathic surgery for maxillofacial deformities.

OBJECTIVES

1. Describe how maxillofacial deformities affect patients.
2. Explain treatment options for maxillofacial deformities.
3. Discuss perioperative nursing care of patients undergoing orthognathic surgery.
4. Describe postoperative complications that can occur after orthognathic surgery.

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QUESTIONS

1. Jaw deformities may cause
   a. excessive tooth wear.
   b. temporomandibular joint (TMJ) pain and dysfunction.
   c. difficulty chewing, speaking, or breathing.
   d. obstructive sleep apnea.
   e. problems with the heart and lungs.
      a. 1 and 2  b. 3 and 4
      c. 1, 2, 3, and 4  d. 1, 2, 3, 4, and 5

2. A class II malocclusion occurs when the patient’s
   a. bite and facial relationship are normal.
   b. mandible is larger than the maxilla.
   c. mandible is smaller than the maxilla.
   d. teeth are misaligned and there is no difference in the jaw size.

3. The orthodontist should bring the teeth as close to normal as possible with orthodontia before maxillofacial surgery.
   a. true  b. false

4. The maxillofacial surgeon
   a. moves the facial bones to restore correct facial relationships so that the teeth fit together and the jaw functions normally.
   b. aligns the teeth in the maxilla and mandible to remove the preexisting dental compensation.
   c. removes the wisdom teeth six months before surgery.
   d. corrects the dental anatomy by reshaping the teeth so they fit together properly.

5. Patient education that the nurse provides during the preoperative appointment includes
   a. ensuring that the patient and his or her family members fully understand the need for a blended diet for six weeks after surgery.
2. instructing the patient not to eat any food eight hours before surgery.
3. explaining that the patient may drink clear liquids (eg, water, apple juice, black coffee) up to four hours before surgery.
4. obtaining informed consent from the patient or, if the patient is a minor, from the patient’s parents or legal guardian.
   a. 1 and 2
   b. 3 and 4
   c. 1, 2, and 3
   d. 1, 2, 3, and 4

6. Because patients with maxillofacial deformities can present airway challenges, preoperative and intraoperative nursing interventions should include
   1. using monitoring equipment to assess respiratory status.
   2. evaluating respiratory status.
   3. monitoring changes in respiratory status.
   4. identifying baseline respiratory status.
   5. reporting deviation in arterial blood gas studies.
      a. 1 and 3
      b. 2, 4, and 5
      c. 2, 3, 4, and 5
      d. 1, 2, 3, 4, and 5

7. In the LeFort ___ procedure, the surgical cuts begin in the midfacial bones and meet above the nasal bones.
   a. I
   b. II
   c. III
   d. IV

8. Postoperatively, the nurse should elevate the head of the patient’s bed at least 30 degrees to reduce swelling of the face and airway.
   a. true
   b. false

9. The surgeon places orthodontic rubber bands on the patient’s braces to
   1. control the patient’s bite during the healing process.
   2. make eating and drinking easier.
   3. help seat the TMJs.
   4. decrease discomfort.
   5. help prevent shifting of the bite.
      a. 1 and 2
      b. 2 and 4
      c. 1, 3, 4, and 5
      d. 1, 2, 3, 4, and 5

10. After maxillofacial surgery, the patient may experience
    1. swelling.
    2. blood oozing from incisions.
    3. lip paresthesias.
    4. nausea or vomiting.
    5. pain.
       a. 1 and 3
       b. 4 and 5
       c. 1, 2, and 5
       d. 1, 2, 3, 4, and 5

The behavioral objectives and examination for this program were prepared by Rebecca Holm, RN, MSN, CNOR, clinical editor and Helen Starbuck Pashley, RN, MA, CNOR, clinical editor, with consultation from Susan Bakewell, RN, MS, BC, director, Center for Perioperative Education. Ms Holm, Ms Pashley, and Ms Bakewell have no declared affiliations that could be perceived as posing potential conflicts of interest in the publication of this article.
Orthognathic Surgery for Patients with Maxillofacial Deformities

This evaluation is used to determine the extent to which this continuing education program met your learning needs. Rate the items as described below.

OBJECTIVES
To what extent were the following objectives of this continuing education program achieved?

1. Describe how maxillofacial deformities affect patients. Low 1. 2. 3. 4. 5. High
2. Explain treatment options for maxillofacial deformities. Low 1. 2. 3. 4. 5. High
3. Discuss perioperative nursing care of patients undergoing orthognathic surgery. Low 1. 2. 3. 4. 5. High
4. Describe postoperative complications that can occur after orthognathic surgery. Low 1. 2. 3. 4. 5. High

CONTENT
5. To what extent did this article increase your knowledge of the subject matter? Low 1. 2. 3. 4. 5. High
6. To what extent were your individual objectives met? Low 1. 2. 3. 4. 5. High
7. Will you be able to use the information from this article in your work setting? Yes 2. No
8. Will you change your practice as a result of reading this article? (If yes, answer question #8A. If no, answer question #8B.)

8A. How will you change your practice? (Select all that apply)
1. I will provide education to my team regarding why change is needed.
2. I will work with management to change/implement a policy and procedure.
3. I will plan an informational meeting with physicians to seek their input and acceptance of the need for change.
4. I will implement change and evaluate the effect of the change at regular intervals until the change is incorporated as best practice.
5. Other: 

8B. If you will not change your practice as a result of reading this article, why? (Select all that apply)
1. The content of the article is not relevant to my practice.
2. I do not have enough time to teach others about the purpose of the needed change.
3. I do not have management support to make a change.
4. Other: 

9. Our accrediting body requires that we verify the time you needed to complete the 5.3 continuing education contact hour (318-minute) program: 

This program meets criteria for CNOR and CRNFA recertification, as well as other continuing education requirements.
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A score of 70% correct on the examination is required for credit. Participants receive feedback on incorrect answers. Each applicant who successfully completes this program can immediately print a certificate of completion.