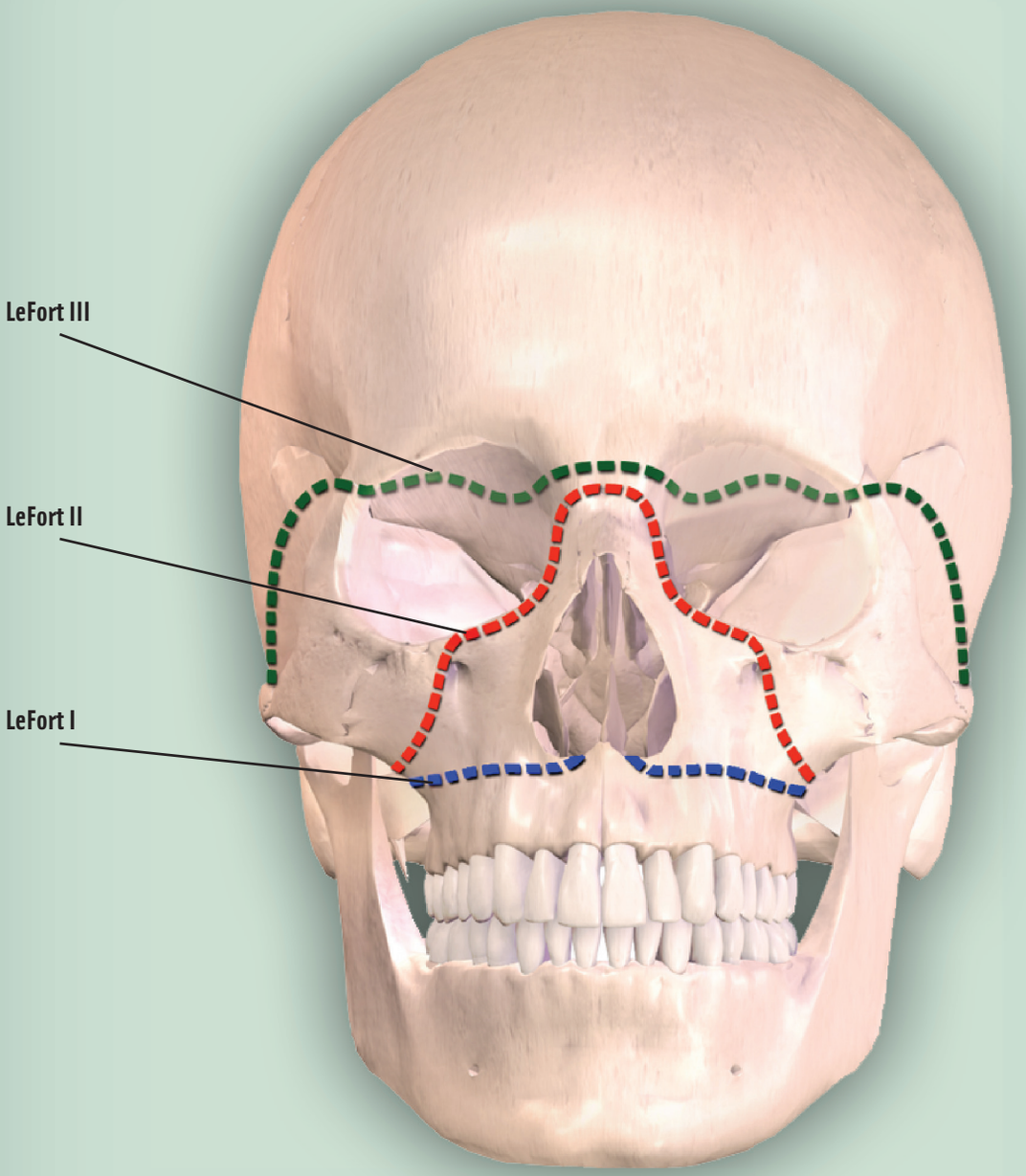


Three Types of LeFort Osteotomy

LeFort Osteotomy

Anna Moorhead[1]; Ryan Winters[2]; Marc Serra[3]

The LeFort I osteotomy is a procedure utilized extensively within the field of oral and maxillofacial surgery when maxilla repositioning is required to connect dentofacial abnormalities or facilitate surgical access. This procedure facilitates horizontal and vertical movement and allows for transverse expansion when performed as a segmental osteotomy.

This procedure has various applications. The LeFort I osteotomy improves facial harmony and aesthetics by addressing maxillary asymmetry and protrusion. The technique also enhances dental occlusion and chewing function by connecting malocclusion. The LeFort I osteotomy may also alleviate symptoms of obstructive sleep apnea by enlarging the upper airway. Proper technique helps optimize patient outcomes and reduce morbidity.

This activity for healthcare professionals is designed to enhance learners' proficiency in identifying patients with indications for the LeFort I osteotomy and performing the procedure with precision and care. Participants gain a deeper understanding of the procedure's origins, indications, limitations, contraindications, potential complications, and clinical significance. Greater competence equips learners to collaborate more effectively within an interprofessional team caring for patients with dentofacial abnormalities.

LEARNING OBJECTIVES

- Identify pertinent anatomical structures associated with LeFort I osteotomy.
- Describe the different indications for LeFort I osteotomy.
- Implement the proper surgical techniques for LeFort I osteotomy.
- Execute effective collaboration and communication practices among interprofessional team members to improve outcomes and treatment efficacy for patients who might benefit from a LeFort I osteotomy.

INTRODUCTION

The LeFort I osteotomy is a horizontal maxillary osteotomy utilized to connect midface deformities, allowing movement of the dentition-bearing portion of the maxilla anteroposteriorly, vertically, rotationally, and with segmentation or expansion. The procedure may also be used to facilitate surgical access for tumor removal and the reduction of complex midfacial fractures. This surgery is named after the LeFort I horizontal fracture pattern described by Rene LeFort in 1901.[1]

The earliest maxillary osteotomies were utilized to facilitate exposure during nasopharyngeal polyp removal. The first LeFort I osteotomy for dentofacial deformity correction was described by Wassmund in 1921, utilizing orthopedic traction rather than intraoperative mobilization. Auxhausen first described osteotomy with intraoperative mobilization in 1934 to close an open bite.[2] Schuchardt separated the pterygomaxillary junction, allowing anterior repositioning. Bell's research demonstrated the revascularization phenomenon, the ability to sacrifice the descending palatine arteries without compromising blood supply, and the ability for osseous healing from a complete maxillary osteotomy, thus providing the biological basis for a complete down-fracture. The technique has continued to evolve, incorporating and recognizing the roles of hypotensive anesthesia, orthodontics, tension-free stability, and virtual surgical planning. Consequently, the LeFort I osteotomy has become widely accepted as a reliable, predictable, and safe procedure.[3]

ANATOMY AND PHYSIOLOGY

The maxilla is comprised of paired maxillary bones fused at the midline. This bone articulates with the frontal bone superiorly, alveolar process inferiorly, zygomatic bone laterally, palatine bone posteriorly, and pterygoid plate of the sphenoid bone posterolaterally (see image Maxillary Bones.)

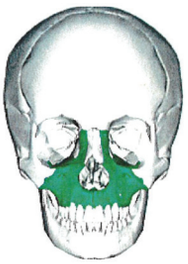
Blood supply to the LeFort I segment of the maxilla is provided by the ascending palatine artery, a branch of the facial artery, and the anterior branch of the ascending pharyngeal artery, which arises directly from the external carotid artery. The potential for significant bleeding during LeFort I osteotomy requires in-depth knowledge of the location of various blood vessels pertinent to the procedure. In particular, the descending palatine arteries are posterior to the pyramidal processes of the palatine bone. These blood vessels may be inadvertently damaged from overextension of the lateral nasal osteotomy part of the procedure. Inappropriate superior placement of the osteotome to separate the pterygomaxillary junction can interrupt the pterygopalatine fossa and damage the internal maxillary artery and its branches.[4]

> The LeFort I osteotomy improves facial harmony and aesthetics by addressing maxillary asymmetry and protrusion.

Innervation to the maxilla is via the maxillary division of the trigeminal nerve (2nd division of the 5th cranial nerve or CN V2), which originates from the trigeminal ganglion and exits through the foramen rotundum to enter the pterygopalatine fossa, where it gives off multiple branches. The infraorbital nerve, a terminal extension of CN V2, exits through the infraorbital foramen and provides sensory innervation to the soft tissue of the midface, including the lower lid, cheek or malar region, nose, upper lip, and anterior maxillary dentition. The infraorbital nerve is encountered during dissection for the LeFort I osteotomy and should be identified and protected.[5]

PREPARATION

A comprehensive preoperative workup should include a detailed history and physical examination, facial analysis, and meticulous surgical planning via virtual or traditional model surgery. Occlusal splints may be fashioned, depending on the indication for LeFort osteotomy. Orthodontics may be performed before surgery to level, align, and decompensate the dentition if applicable and are frequently required postoperatively to finalize occlusion.[12]



Maxillary Bones. The green-shaded area marks the paired maxillary bones.

Anatomography, Public Domain, via Wikimedia Commons.

TECHNIQUE OR TREATMENT

The procedure is performed under general anesthesia in the supine position. Nasotracheal intubation facilitates intraoperative assessment of occlusion and placement in maxillomandibular fixation. The endotracheal tube should be placed passively but securely. Landmarks are established preoperatively to provide reference points, which can be checked throughout surgery to confirm the intended maxillary movements. This step may be accomplished utilizing a K-wire or marking pen at the nasion or nasofrontal junction. Preoperative measurements are recorded from the wire to the level of the orthodontic brackets or another stable and reproducible landmark bilaterally. Local anesthetic containing epinephrine is injected along the anticipated surgical incision to assist with hemostasis and postoperative analgesia.

A throat pack is placed. Plastic lip and cheek retractors, "toe-out" Obwegeser, or similar retractors can be utilized to provide better surgical access to the maxillary vestibule.

Careful planning of the surgical incision is necessary to provide an adequate cuff of gingival tissue for soft tissue closure. A minimum of 5 mm above the mucogingival junction should be maintained. The initial mucosal surgical incision is made from the 1st molar to the first molar utilizing either a #15 blade or electrocautery perpendicular to the maxilla. The incision is extended down to the bone. The periosteum is scored to facilitate subperiosteal dissection, performed with a periosteal elevator medially to the piriform rims. Care is taken to dissect the nasal mucosa around the nasal aperture. A curved freer elevator or the blunt end of a Woodson elevator may assist with the dissection of the nasal mucosa.

The nasal mucosal dissection then proceeds posteriorly to the palatine bone. The subperiosteal dissection proceeds superiorly to the infraorbital nerves, which should be identified and protected. The dissection laterally extends to and around the lateral maxillary buttress. Maintaining a subperiosteal plane is of particular importance at this curvature, as failure to do so may inadvertently expose the buccal fat pad, which will compromise and interfere with surgical access. A curved freer elevator may be useful in completing this part of the dissection. The lateral dissection terminates at the pterygomaxillary junction. A raytex sponge or neuro-patties may be placed in the lateral subperiosteal pocket to allow further blunt dissection and assist with hemostasis. Meanwhile, osteotomy is performed on the opposite side.

The planned osteotomy may be marked with a Bovie

INDICATIONS

LeFort I osteotomy is used to reposition the dentition-bearing maxilla and is indicated for the following conditions:

- Maxillomandibular deformities
  - o Maxillary hypoplasia or mandibular hyperplasia
  - o Vertical maxillary excess
  - o Angle's class II and class III malocclusions
  - o Midline discrepancies or asymmetries
  - o Apertognathia or open bite
  - o Absolute transverse arch discrepancy*
  - o Dual or multiplanar occlusion*
  - o Severe maxillary atrophy, in conjunction with bone grafting
- Obstructive sleep apnea
- Access for skull base tumors
- Facilitation of reduction of nonreducible fractures[6, 7, 8]

* May require segmental or multipiece LeFort osteotomy, which is not covered in this article.

CONTRAINDICATIONS

Contraindications to LeFort I osteotomy include the following:

- Incomplete skeletal growth (skeletal immaturity)
- Severe or uncontrolled periodontal disease
- Progressive dentofacial deformities (e.g., condylar hyperplasia and idiopathic condylar resorption)
- Bone or joint diseases (e.g., osteoporosis and osteopenia)
- Medical comorbidities (e.g., uncontrolled diabetes and immunocompromised status)
- Poor nutritional status (e.g., in cases of hypoalbuminemia)[9, 10]

Contraindications should be considered relative in nature and, in certain scenarios, may become indications for surgery. Thus, the surgeon must perform a thorough preoperative evaluation and obtain informed consent from the patient, parent, or legal guardian, explaining the risks, benefits, and potential complications before proceeding with surgery.

EQUIPMENT

The following equipment and materials are needed for LeFort osteotomy:

- 15 blade
- Monopolar or bipolar electrocautery
- Assorted retractors
- Marking pen
- Local anesthetic with epinephrine
- Kirschner or K-wire
- Gauge or caliper
- Assorted periosteal elevators
- Reciprocating saw
- Straight tapered fissure bur (701 or 702)
- U-shaped or double-guarded straight osteotome
- Single guarded osteotome
- Cruciform or large curved osteotome
- Turvey spreaders
- Rowe disimpaction forceps
- Rongeur
- Bone-eating bur or reciprocating rasp
- Small single-pronged skin hook
- Sutures
- Assorted 24- to 28-gauge wires [11]

PERSONNEL

The following personnel are needed:

- Surgeon(s)
- Surgical assistant
- Surgical technologist
- Perioperative nurse
- Anesthesiologist or nurse anesthetist
- Postanesthesia care unit nurse

electrocautery, a bur, or another implement once fully exposed. The osteotomy should proceed apically to the roots of the teeth while terminating below the inferior turbinate. An instrument, such as a Sayre elevator or freer, may be inserted on the nasal aperture's medial aspect to protect the previously dissected nasal mucosa while completing the osteotomy if desired.

The osteotomy is initiated at the lateral maxillary buttress and extended through the piriform rim utilizing a reciprocating saw, straight tapered fissure bur, or bone scalpel under continuous irrigation. The osteotomy is then mirrored on the contralateral side. Care should be taken not to apply force to the cutting implement as the initial bone in the buttress is dense. However, the anterior maxillary sinus wall is very thin once through the buttress, and excessive force can result in loss of control of the implement, iatrogenic damage to the sinus wall, and potentially compromised fixation areas.

Once bilateral osteotomies are completed, the lateral maxillary buttress can be "backcut" by reinserting the cutting implement into the lateral portion of the osteotomy and passing it in a medial-to-lateral direction. Alternatively, small straight osteotomes can recapitulate the cut at the lateral buttresses.

Lateral nasal osteotomies are then completed with a small straight chisel or Neivert-Anderson single-guarded osteotomes with the curved end of the osteotome in contact with the floor. Note that the lateral nasal wall diverges from anterior to posterior. Thus, the osteotome must be oriented accordingly. A hard stop occurs when the osteotome contacts the palatine bone's pyramidal process. The nasal septum is then separated from the maxilla utilizing a thin U shaped or double-guarded V-shaped osteotome seated on either side of the septum with the curved end of the osteotome against the nasal floor. Care should be taken to avoid extending this osteotomy to more than 30 mm in female patients and 35 mm in male patients to avoid damage to the descending palatine arteries.[13]

Afterward, the pterygomaxillary junction is separated utilizing a large curved or Tessier cruciform osteotome directed at the junction in an anterior, inferior, and medial direction. A finger is placed intraorally against the pterygoid hamulus to ensure that the osteotomy is completed at the appropriate level.

Alerting the anesthesia team that the surgical team is preparing to down-fracture the maxilla is prudent before the pterygomaxillary osteotomy. Anesthesia may wish to

maintain mean arterial pressure at around 60 mm Hg to limit excessive bleeding if a hypotensive anesthetic is preferred. Damage to the maxillary artery and its branches, the descending palatine artery, and the sphenopalatine artery can result in significant bleeding during this step if the osteotome is inappropriately positioned. Thus, some authors advocate for separating the maxilla at the tuberosity or achieving down-fracture with digital pressure alone and forgoing an osteotome at the pterygomaxillary junction.[14]

Ultimately, the surgeon's experience, skill, and clinical judgment determine the method for separating the maxilla. Some surgeons prefer to separate the pterygomaxillary junction before completing the nasal osteotomies to expedite visualization and access in the event of vessel damage and brisk bleeding.

Digital pressure should be utilized to down-fracture the maxilla. Excessive force is not required in this step if all osteotomies are properly completed. Using excessive force can result in an unfavorable fracture and other complications and is thus discouraged. If the maxilla does not down-fracture at this point, each previous osteotomy should be carefully examined and revised as necessary until the maxilla down-fractures easily.

Once down-fractured, additional nasal mucosal dissection or repair of torn nasal mucosa may be more easily performed due to improved access. Repair is best performed with a fine, resorbable suture, such as a 5-0 fast absorbing gut.

Down-fracture completion should be followed by careful inspection for any active bleeding, which needs to be controlled at this point before proceeding. Bleeding may be controlled by packing or applying pressure. However, pulsatile bleeds are best controlled with bipolar electrocautery or ligation of identifiable vessels. Depending upon surgeon preference, the descending palatine arteries may be identified, exposed, maintained, or conversely ligated and sacrificed at this stage. Sacrificing the descending palatine arteries generally does not compromise maxillary perfusion.

Depending on the planned surgery, the soft tissue may require stretching at this point to allow for mobilization and tension-free maxillary repositioning to the predetermined postoperative position. This step may be accomplished with digital pressure or Rowe disimpaction forceps. Care should be taken when placing and manipulating the maxilla with the forceps, as improper use may damage the teeth or maxillary bone.

The preoperative surgical plan and osteotomy indications dictate the procedure's next steps. A planned impaction, such as for vertical maxillary excess, usually requires reducing the bone and the nasal septum to enable proper repositioning and prevent nasal septal deviation. Large advancements or down-grafts may require bone grafting for added stability and success. Autogenous and allograft sources are acceptable.

Fabricated surgical splints should be fitted to the dentition. The maxilla should be manipulated into position, and the patient should be placed into maxillomandibular fixation utilizing stainless steel wires. The entire maxillomandibular complex should be rotated, ensuring the mandibular condyles are seated in their respective fossae. Failure to seat the condyles may result in postoperative malocclusion.

> Although oral and maxillofacial surgeons or head and neck surgeons typically perform the LeFort I osteotomy, the crucial role of an interdisciplinary team throughout all stages … cannot be overstated.

Rechecking the preoperatively determined landmarks and anticipated moves against the actual maxillary position is crucial at this point to confirm appropriate positioning, making adjustments as needed. Fixation is then accomplished by utilizing plates and screws. Plates are bent and adapted to the contours of the maxilla's position and secured to the piriform rims and the zygomaticomaxillary buttresses bilaterally, using 4 plates in total. Alternatively, Lindorf-style pre-bent plates may be utilized on each piriform rim, requiring 2 plates in total.

The patient should then be released from maxillomandibular fixation. The mandible should be rotated in and out of the splint, if present, to confirm passive rotation in and out of centric occlusion. Centric relation should also be assessed at this stage, as any occlusal discrepancy may indicate improper condylar seating and necessitate hardware removal and replacement. Dental and skeletal midlines should also be checked to ensure the predetermined positions are achieved.

The surgical site is then irrigated. The mucosa is closed in a watertight fashion utilizing a resorbable suture such as 3-0 or 4-0 chromic gut in a continuous or continuous interlocking fashion.

Before closing the vestibular incision, a nasal or alar cinch suture may be considered to limit alar base widening, as seen with large maxillary advancements. This step is accomplished by everting the vestibular incision and passing a slowly resorbing or nonabsorbable 2-0 to 3-0 suture through the transverse nasalis muscle on either side of the alar base intraorally. The suture is then cinched down in a controlled fashion. Care is taken to ensure that the alar bases are narrowing symmetrically. A nasotracheal tube, which distorts this landmark, can make evaluating this maneuver more difficult.

Consideration should be given to performing a V-to-Y closure if excessive thinning is a possible risk. This technique may also be performed at this point to avoid excessive lip shortening and thinning. A single-prong skin hook is placed in the labial mucosa at the midline and lifted approximately 1 cm to perform a V-to-Y closure. The same suture utilized for mucosal closure is then passed continuously to create a 1-cm vertical limb. Vestibular closure then proceeds on either side.[15]

The decision to perform either procedure should be based on the anticipated soft tissue changes associated with the planned surgery, surgeon experience, and preference. The oral cavity is suctioned free of debris. A nasogastric or orogastric tube may be passed at this point to suction the patient's stomach contents. The throat pack should be removed. Guiding elastics or maxillomandibular fixation is then placed if indicated.

COMPLICATIONS

While a technically simple and versatile procedure, rare but serious complications can occur during or after a LeFort I osteotomy. Complication rates vary, and the incidence has been reported in several studies to be between 6.7% and 8.77%. Complications can broadly be categorized as anatomic, septic, ischemic, vascular, neurologic, and otologic.

In a prospective study of 1,000 patients, Kramer et al found that patients with major anatomic irregularities, such as craniofacial anomalies, cleft palate, and vascular abnormalities, were at increased risk of complications and accounted for a disproportionate number of observed cases. Patients who underwent segmental osteotomies or large advancements were also shown to have an increased risk of complications.[16] A smaller study excluding segmental osteotomies and patients with major anatomic irregularities demonstrated increased complications associated with maxillary setbacks relative to other movements.

The most commonly encountered complications are anatomic and include nasal septal deviation resulting from an inadequate reduction of the cartilaginous septum when performing a maxillary impaction, nonunion of the osteotomy gap, and improper positioning of the maxilla.[17] Common septic complications include abscesses and maxillary sinusitis, both of which are readily controlled by conservative therapies.

The primary vascular complication of concern is hemorrhage, which typically results from damage to branches of the maxillary artery, most often due to an unfavorable fracture of the pterygoid plates.[18] This complication may be avoided by careful surgical technique and osteotome placement or consideration of alternatives to the traditional pterygomaxillary osteotomy. Tranexamic acid at 10 mg/kg 30 minutes before general anesthesia induction is also advocated to reduce blood loss.[19]

Ischemic complications, including avascular necrosis, are associated with large advancements, segmental osteotomies, and major anatomic irregularities. Consideration should be given to 2-jaw surgery if a significant advancement is anticipated, as it can help limit extensive anteroposterior movements within a single jaw.

Damage to teeth or root amputation is another complication that may be encountered but is related to the surgeon's experience and failure to initiate the osteotomy apical to the roots of the teeth. Neurosensory deficits in the infraorbital nerve are frequently seen after surgery secondary to compression or retraction, but symptoms typically resolve. Most patients regain full sensation within 2 months, and all regain sensation within 6 months. Other more serious neurologic complications have been reported, such as unilateral blindness and oculomotor nerve palsy.

However, these complications are exceedingly rare.

CLINICAL SIGNIFICANCE

The relative safety, versatility, and technical simplicity of the LeFort I osteotomy contribute to its position as a workhorse in maxillofacial surgery. With numerous applications, including but not limited to reconstruc-

tion, trauma, pathology, and sleep medicine, the LeFort I osteotomy is useful for surgeons of multiple disciplines. Advancement of the midface can improve the nasal airway and address maxillary hypoplasia while also improving occlusion and aesthetics. The LeFort I may also be used to impact or disimpact the maxilla for aesthetic reasons, managing the degree of incisoral show in the smile.

ENHANCING HEALTHCARE TEAM OUTCOMES

Although oral and maxillofacial surgeons or head and neck surgeons typically perform the LeFort I osteotomy, the crucial role of an interdisciplinary team throughout all stages-preoperatively, perioperatively, intraoperatively, and postoperatively, cannot be overstated. Successful outcomes are contingent upon comprehensive interprofessional care and support. Preoperatively and postoperatively, the orthodontist plays a critical role in preparing the patient for orthognathic surgery and providing input and expertise relative to the surgical treatment plan and the anticipated need for postsurgical orthodontics.

Preoperative optimization is essential for patients with medical comorbidities to have safe and successful surgery. Depending upon the patient's medical conditions, preoperative optimization may involve care coordination and planning by physicians and caregivers from multiple disciplines. Intraoperatively, the anesthesia provider facilitates safe surgery and emergence from general anesthesia. The surgeon and anesthesia provider coordinate and discuss the preferred intubation technique and the risks, benefits, and timing of hypotensive anesthesia. The surgeon and anesthesia provider also plan for potential airway challenges due to maxillomandibular fixation and postoperative edema. Hypotensive anesthesia has been shown to reduce blood loss, provide better surgical field visualization, and shorten the length of hospital stay.[20, 21]

In the immediate postoperative period, the nursing team is vital in educating patients, providing psychosocial support, and ensuring that patients meet immediate postoperative milestones. The pharmacist and pharmacy team determine the appropriate postoperative medications for the patient, balancing adequate pain control with minimizing deleterious side effects. The pharmacist also devises appropriate and effective pain control regimens for patients at risk for over narcotization or respiratory depression, as is the case in patients with obstructive sleep apnea or morbid obesity. Proper nutrition is critical for wound healing. Thus, nutritionists and registered dieticians are pivotal in determining appropriate caloric needs, supporting and facilitating a dietary regimen, ultimately minimizing postoperative complications and decreasing patient morbidity.[22]

AFFILIATIONS

1 Madigan Army Medical Center
2 Ochsner Health System
3 Madigan Army Medical Center
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Disclosure: Anna Moorhead declares no relevant financial relationships with ineligible companies.
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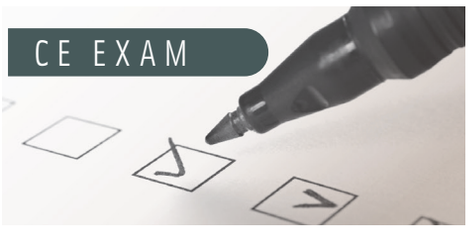
Disclosure: Marc Serra declares no relevant financial relationships with ineligible companies.



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CORRECTION:

There was a misprint on question #5 of the April 2025 edition of the Surgical Technologist CE exam #499 accompanying the article titled "The Economic Case for Implementing Automated Tissue Removal and Bone Milling Systems in Orthopedic Spine Procedures." The correct answer is A, 25 grams.

LeFort Osteotomy

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1. **Which of the following arteries provides blood to the LeFort I segment of the maxilla?**
a. Transverse facial
b. Ascending palatine
c. Inferior labial
d. Maxillary

2. **Which of the following is a contraindication for LeFort I osteotomy?**
a. Periodontal disease
b. Skull base tumors
c. Severe maxillary atrophy
d. Obstructive sleep apnea

3. **Which of the following nerves must be identified and preserved during dissection for a LeFort I osteotomy?**
a. Auriculotemporal
b. Zygomaticofacial
c. Supratrochlear
d. Infraorbital

4. **Which of the following instruments will a surgeon use to dissect the nasal mucosa?**
a. Freer elevator
b. #15 knife blade
c. Rongeur
d. Rasp

5. **What does the surgeon avoid exposing when extending the incision in a curved fashion around the lateral maxillary buttress?**
a. Inferior turbinate
b. Nasal vestibule
c. Buccal fat pad
d. Anterior maxillary sinus

6. **When separating the nasal septum from the maxilla, the surgeon avoids extending the osteotomy in male and females to avoid injuring the:**
a. maxillary artery.
b. superficial temporal artery.
c. ascending pharyngeal artery.
d. descending palantine artery.

7. **What postoperative complication can occur if the mandibular condyles are not properly seated when the maxillomandibular complex is rotated into position?**
a. Abscesses
b. Malocclusion
c. Hemorrhage
d. Nasal septal deviation

8. **What size and type of suture is used to close the mucosa?**
a. 4-0 polydioxanone
b. 2-0 polyglactin 910
c. 3-0 chromic gut
d. 2-0 polyglyconate

9. **Which of the following is the most commonly encountered category of complication?**
a. Anatomic
b. Vascular
c. Neurologic
d. Otologic

10. **What is the reason the surgeon communicates they are preparing to downfracture the maxilla so the anesthesia provider can maintain the mean arterial pressure at 60 mm Hg?**
a. Prevent damage to the nasotracheal tube
b. Prevent excessive hemorrhaging
c. Prevent the patient becoming hypoxic
d. Prevent neurosensory deficits in the patient

LEFORT OSTEOTOMY
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