Medical Coverage Policy

Effective Date.....**10/15/2021**
Next Review Date.....**10/15/2022**
Coverage Policy Number **0209**

Orthognathic Surgery

Table of Contents

Related Coverage Resources

Distraction Osteogenesis (DO) for Craniofacial Deformities
Head Imaging Guidelines
Redundant Skin Surgery
Rhinoplasty, Vestibular Stenosis Repair and Septoplasty
Surgical Treatments for Obstructive Sleep Apnea

INSTRUCTIONS FOR USE
The following Coverage Policy applies to health benefit plans administered by Cigna Companies. Certain Cigna Companies and/or lines of business only provide utilization review services to clients and do not make coverage determinations. References to standard benefit plan language and coverage determinations do not apply to those clients. Coverage Policies are intended to provide guidance in interpreting certain standard benefit plans administered by Cigna Companies. Please note, the terms of a customer's particular benefit plan document [Group Service Agreement, Evidence of Coverage, Certificate of Coverage, Summary Plan Description (SPD) or similar plan document] may differ significantly from the standard benefit plans upon which these Coverage Policies are based. For example, a customer's benefit plan document may contain a specific exclusion related to a topic addressed in a Coverage Policy. In the event of a conflict, a customer's benefit plan document always supersedes the information in the Coverage Policies. In the absence of a controlling federal or state coverage mandate, benefits are ultimately determined by the terms of the applicable benefit plan document. Coverage determinations in each specific instance require consideration of 1) the terms of the applicable benefit plan document in effect on the date of service; 2) any applicable laws/regulations; 3) any relevant collateral source materials including Coverage Policies and; 4) the specific facts of the particular situation. Each coverage request should be reviewed on its own merits. Medical directors are expected to exercise clinical judgment and have discretion in making individual coverage determinations. Coverage Policies relate exclusively to the administration of health benefit plans. Coverage Policies are not recommendations for treatment and should never be used as treatment guidelines. In certain markets, delegated vendor guidelines may be used to support medical necessity and other coverage determinations.

Overview

This Coverage Policy addresses orthognathic surgery. Orthognathic surgery is a subset of craniofacial surgery involving the surgical correction of abnormalities of the mandible, maxilla or both.

Coverage Policy

Coverage for orthognathic surgery varies across plans. Refer to the customer's benefit plan document for coverage details.

The following clinical documentation is required to support medical necessity for orthognathic surgery:

- medical history and physical examination with reference to symptoms related to the orthognathic deformity
- description of specific anatomic deformity present
- lateral and anterior-posterior cephalometric radiographs
- cephalometric tracings

- copy of medical records from treating physician documenting evaluation, diagnosis and previous management of the functional medical impairment(s)
- diagnostic quality (clear) photographs that fully demonstrate the dental occlusion

Molds may also be requested depending on the individual circumstances of the case.

Orthognathic surgery is considered medically necessary when BOTH of the following criteria are met:

- **ANY of the following facial skeletal deformities is present:**

  - anteroposterior discrepancies:
    - maxillary/mandibular incisor relationship: overjet of 5 millimeters (mm) or more, or a zero to negative value (norm = 2 mm)
    - maxillary/mandibular anteroposterior molar relationship discrepancy of 4 mm or more (norm = 0-1 mm)
  - vertical discrepancies:
    - presence of a vertical facial skeletal deformity which is two or more standard deviations from published norms for accepted skeletal landmarks
    - open bite with no vertical overlap of anterior teeth or unilateral or bilateral posterior open bite greater than 2 mm
    - deep overbite with impingement of palatal soft tissue
    - supraeruption of a dentoalveolar segment resulting from lack of occlusion when dentition in segment is intact
  - transverse discrepancies:
    - presence of a transverse skeletal discrepancy which is two or more standard deviations from published norms
    - total bilateral maxillary palatal cusp to mandibular fossa discrepancy of 4 mm or greater, or a unilateral discrepancy of 3 mm or greater, given normal axial inclination of the posterior teeth
  - asymmetries:
    - anteroposterior, transverse or lateral asymmetries greater than 3 mm, with concomitant occlusal asymmetry

- **ANY of the following functional impairments is present:**

  - persistent difficulties with mastication and swallowing after causes such as neurological or metabolic diseases have been excluded
  - malnutrition, significant weight loss, or failure-to-thrive secondary to facial skeletal deformity
  - speech dysfunction directly related to a jaw deformity as determined by a speech and language pathologist
  - myofascial pain secondary to facial skeletal deformity that has persisted for at least six months, despite conservative treatment such as physical therapy and splints

  Please note: Computer-assisted technologies, including computerized tomography guided planning procedures and three-dimensional virtual treatment planning, are considered integral to the primary procedure when performed as part of orthognathic surgery.

Note: Please reference Cigna Medical Coverage policy "Surgical Treatments for Obstructive Sleep Apnea" for conditions of coverage related to maxillomandibular advancement for the treatment of obstructive sleep apnea (OSA).

Not Covered

Surgical procedures such as rhinoplasty, genioplasty or rhytidectomy performed in conjunction with orthognathic surgery for the sole purpose of improving individual appearance and profile are considered cosmetic in nature and not medically necessary.

General Background

Orthognathic surgery is performed to correct abnormalities of the mandible, maxilla or both. Dentofacial abnormalities may be congenital resulting from genetic and/or environmental influences that impact fetal growth between the 20th and 50th day of gestation. Additionally, dentofacial anomalies may be evident at birth or they may emerge during growth and development. Jaw deformities may result from acquired defects, neoplastic processes, or degenerative diseases.

Jaw Deformities
Jaw deformities include abnormalities of jaw-to-jaw size and shape and may include excessive or deficient bone-to-bone or bone-to-soft-tissue relationships. Deformities may be present in any of the three planes: horizontal, vertical or transverse, or a combination of these.

In a position paper issued in 1988, the American Association of Oral and Maxillofacial Surgeons (AAOMS) classified dentofacial deformities as mid-face or mandibular, as follows:

- skeletal deformities of the mid-face
  - maxillary hyperplasia
  - maxillary hypoplasia
  - cleft deformities
  - other mid-face deformities, including nasal, zygomatic, orbital, ethmoidal, frontal or other cranial bones
- skeletal deformities of the mandible
  - mandibular hyperplasia
  - mandibular hypoplasia
  - mandibular asymmetry
  - condylar abnormalities, including hypoplasia, hyperplasia, neoplasia, ankylosis, post-traumatic conditions, and agenesis

The relationship between facial skeletal abnormalities and malocclusion is generally accepted. A strong correlation has been established between the state of a patient's occlusion and chewing efficiency, bite forces, and restricted mandibular excursions. Other signs of dysfunction related to facial skeletal abnormalities, such as obstructive sleep apnea, may also be present. Orthognathic surgery may be performed to improve function by correcting the underlying skeletal deformity when dental/orthodontic treatment alone is precluded due to the severity of deformities and related impairment.

Dental Occlusion/Malocclusion
The classification of dental occlusions is based on Edward Angle's early observations that the key to occlusion is the relationship of the mandibular first molar to the maxillary first molar. Angle's occlusal classifications are as follows (Liang and Naran, 2019; Patel, 2018):

- **Class I (neutro-occlusion):** The mesiobuccal cusp of the maxillary first molar articulates within the mesiobuccal groove of the mandibular first molar.
- **Class II (disto-occlusion):** The mandibular first molar articulates distal to the mesiobuccal cusp of the maxillary first molar. This may be due to a deficiency of the lower jaw or excess of the upper jaw, and is, therefore, categorized into two divisions. In Division I, the mandibular arch is behind the upper jaw with protrusion of the upper front teeth, while in Division II the mandibular teeth are behind the upper teeth, with a retrusion of the maxillary front teeth.
- **Class III (mesio-occlusion):** The mesiobuccal groove of the mandibular first molar is mesial to the mesiobuccal cusp of the maxillary first molar. This occlusion usually produces a strong protruding chin, due to either horizontal mandibular excess or horizontal maxillary deficiency.

The terms Class I, II, and III are also used to define the maxillary and mandibular canine relation. The above classification relates only to maxillary/mandibular dentition. Although it is often assumed that a similar skeletal

relationship of Class I, II, and III follows, this is not always the case. A Class I molar relationship is possible with a Class II skeletal relationship by dental extractions and orthodontic alignment regardless of skeletal status (Liang and Naran, 2019; Patel, 2018).

Surgical Procedures
In orthognathic surgery, an osteotomy is made in the affected jaw, and the bones are repositioned in a more normal alignment. The bones are held in position with plates, screws and/or wires. Intermaxillary fixation, a procedure in which arch bars are placed on both jaws, may also be needed to provide added stability. Simultaneous osteotomies may be performed when deformities must be corrected in both jaws. Grafts from the ribs, hip or skull may be performed for patients with deficient bone tissue; alloplastic bone replacement may also be required. Orthognathic surgery is generally performed under general anesthesia on an inpatient basis. Although sometimes performed for cosmetic purposes, orthognathic surgery is generally considered to be medically necessary when performed to treat a significant abnormality that is causing considerable functional impairment. Functional impairments include (AAOMS, 2020; Brooks and Boyd, 2018):

- persistent inability to masticate and swallow food adequately when other causes such as neurological or metabolic diseases have been ruled out by physical exam and/or appropriate diagnostic testing
- malnutrition, significant weight loss, or failure to thrive
- speech and articulation disorders directly related to jaw deformity, as determined by a speech and language pathologist
- myofascial pain that has persisted for at least six months, despite conservative treatment, such as physical therapy
- airway obstruction, such as obstructive sleep apnea, when documented by sleep study when:
  - conservative treatment (e.g., continuous positive airway pressure [CPAP], oral appliance) has been attempted and failed despite patient compliance
  - the patient has failed prior less invasive surgical procedures or has craniofacial skeletal abnormalities that are associated with a narrowed posterior airway space and tongue-base obstruction

Patients with bone or soft tissue deficiency of the face may require distraction osteogenesis. In this procedure, a distraction device is applied to the bone, and a controlled fracture is created and gradually separated, allowing new bone formation in the distracted segments. This allows the facial bone and adjacent soft tissue to elongate.

Orthognathic surgery involves complex three-dimensional movements of the maxilla and mandible, and thus the preoperative workup is extensive. Along with a complete history and physical exam, thorough skeletal, soft tissue, and dental analyses are also undertaken. High-quality standardized photographs may be necessary for documentation and treatment planning. Ideally these include intraoral views, frontal views at rest and at full smile, left and right lateral views, and left and right three-quarter views. Additional views such as bird's eye or worm's eye views may be indicated in select patients (e.g. an individual with cleft lip or palate) (Oh and Oishi, 2018). Preoperative imaging may include a panorex, posteroanterior cephalometric, and lateral cephalometric radiographs; cone beam computed tomography (CT) may also be performed. All key anatomical landmarks, measurements, and cephalometric tracings are documented to facilitate diagnosis and treatment planning. Dental models (molds/casts) are created. Typically, if a single jaw surgery is planned, only one set of impressions for the maxilla and mandible is necessary. If a double jaw and/or more complex surgery is planned, additional impressions may be required (Oh and Oishi, 2018). Model surgery is then performed on the casts to simulate the cuts and repositioning to be performed in the actual surgery. Once repositioned, the dental casts are then secured in their new position and an occlusal splint is created that will be used intraoperatively to place the maxilla and the mandible into the planned final occlusion prior to the application of rigid fixation (Liang and Naran, 2019).

Intraoperative complications of orthognathic surgery, while relatively rare, may include bleeding, bad splits/segment fractures, and dental injuries. The prevalence of postoperative complications is also relatively low, and may include infection, neurologic injury, bad splits, relapse of the condition, and temporomandibular disorder (Olate, et al., 2018; Kim, 2017). In a retrospective analysis of 16,515 orthognathic surgery patients, Metalwala et al. (2018) noted that patients with more severe presentations (i.e., clefts or craniofacial anomalies) were at

higher risk for postoperative infection (7.4% compared to 0.6% of patients without a craniofacial anomaly), as well as increased length of hospital stay, and higher hospital charges.

Computer-assisted techniques associated with orthognathic surgery, which includes surgical planning, simulation, and intraoperative translation of virtual surgery, have been reported on in the literature (Huang, et al., 2019; Zhang, et al., 2016; Lin, et al., 2015; Swennen, et al., 2009). Most recently, three-dimensional virtual surgical planning of orthognathic surgery, which includes three-dimensional printing of surgical templates and models which are then transferred into the actual operative setting, has been recommended to increase efficiency and accuracy of the surgical reconstruction. However, when performed as part of orthognathic surgery computer-assisted technologies including virtual surgical planning, three-dimensional imaging, and/or computerized tomography scans, are considered integral to the primary surgical procedure.

Peck et al. (2021) observed that, compared to white patients, orthognathic surgery complications were increased among Hispanic patients treated for malocclusion (2.1% versus 1.3%, p=0.037), and for other (non-Black/white/Hispanic/Asian/Pacific Islander) patients treated for apnea (8.7% vs 0.83%, p=0.002). Hospital length of stay was increased in both Black patients (3.3 versus 2.1 days, p<0.001) and Hispanic patients (2.9 days, p<0.001). Hospital costs were higher than whites ($35,633.47) among Hispanic patients ($48,029.15, p<0.001), Black patients ($47,034.41, p<0.001), and Asian/Pacific Islander patients ($44,192.49, p<0.001). The authors hypothesized that lower utilization of preoperative dental and orthodontic care (potentially related to systemic and financial factors) may predispose more complex surgeries among non-white patients, requiring larger sagittal advancements and increasing both costs and hospital length of stay. Additionally, those same systemic factors may influence comorbidity, the type and quality of hospital care, and various elements of recovery and discharge. The authors concluded that the observed disparities are likely due to nuanced and complex relationships of a combination of factors both prior to and during hospitalization.

Other Procedures: Procedures such as rhinoplasty, genioplasty or rhytidectomy may be performed in conjunction with orthognathic surgery. Procedures performed with the primary purpose of improving physical appearance or to treat psychological symptomatology or psychosocial complaints are cosmetic in nature and not medically necessary.

U.S. Food and Drug Administration (FDA)
The FDA has granted 510(k) (Class II) approval to several implantable bone plate systems used in orthognathic surgery, such as the CranioMaxillofacial Fixation (CMF) System (Visionare LLC, San Diego, CA, 2018); the Frontier Devices Maxillofacial, Orthognathic, Mandible Reconstruction and Mesh Systems (Frontier Devices, Pelham, AL, 2010); and the Ortrautek Orthognathic System (Tekka, Bethesda, MD, 2003).

Professional Societies/Organizations
American Association of Oral and Maxillofacial Surgeons (AAOMS): The AAOMS Criteria for Orthognathic Surgery (2020) have become widely adopted as a tool to assist in determining whether orthognathic surgery is medically indicated. As listed below, these maxillary and/or mandibular facial skeletal deformities associated with masticatory malocclusion relate verifiable clinical measurements to significant facial skeletal deformities:

- anteroposterior discrepancies:
  - maxillary/mandibular incisor relationship: overjet of 5 mm or more*, or a zero to negative value* (norm = 2 mm)
  - maxillary/mandibular anteroposterior molar relationship discrepancy of 4 mm or more* (norm = 0–1 mm)

  *These values represent two or more standard deviations from published norms.
- vertical discrepancies:
  - presence of a vertical facial skeletal deformity which is two or more standard deviations from published norms for accepted skeletal landmarks
  - open bite:
    - no vertical overlap of anterior teeth
    - unilateral or bilateral posterior open bite greater than 2 mm
  - deep overbite with impingement or irritation of buccal or lingual soft tissues of the opposing arch
  - supraeruption of a dentoalveolar segment due to lack of occlusion

- transverse discrepancies:
  - presence of a transverse skeletal discrepancy which is two or more standard deviations from published norms
  - total bilateral maxillary palatal cusp to mandibular fossa discrepancy of 4 mm or greater, or a unilateral discrepancy of 3 mm or greater, given normal axial inclination of the posterior teeth
- asymmetries:
  - anteroposterior, transverse or lateral asymmetries greater than 3 mm, with concomitant occlusal asymmetry

In addition to the above conditions, the AAOMS states that orthognathic surgery may be indicated in cases where there are specific documented signs of dysfunction. These may include conditions involving:

- Facial skeletal discrepancies associated with documented sleep apnea, airway defects, and soft tissue discrepancies
  - Before surgery, such patients should be properly evaluated to determine the cause and site of their disorder with appropriate non-surgical treatment attempted when indicated.

- Facial skeletal discrepancies associated with documented temporomandibular joint pathology
  - Prior to performing an orthognathic procedure on such patients, non-surgical therapies should be attempted, including those procedures and treatments that mimic the effects of occlusal alteration.

- Facial skeletal discrepancies associated with documented psychological disorders
  - Prior to surgical treatment designed primarily to improve psychological conditions, appropriate consultation should be obtained and non-surgical therapy attempted when reasonable.

- Facial skeletal discrepancies associated with documented speech impairments
  - Prior to surgery, speech evaluation should be obtained to demonstrate the nature of the problem and to determine if improvement can be expected.

Use Outside of the US
No relevant information.

Medicare Coverage Determinations

	Contractor	Policy Name/Number	Revision Effective Date
NCD		No National Coverage Determination found	
LCD	Palmetto GBA	Cosmetic and Reconstructive Surgery (L33428)	7/29/2021
LCD	Wisconsin Physicians Service Insurance Corp.	Surgical Treatment of Obstructive Sleep Apnea (OSA) (L34526)	7/29/2021

Note: Please review the current Medicare Policy for the most up-to-date information.

Coding/Billing Information

Note: 1) This list of codes may not be all-inclusive.
2) Deleted codes and codes which are not effective at the time the service is rendered may not be eligible for reimbursement.

Considered Medically Necessary when criteria in the applicable policy statements listed above are met:

CPT®* Codes	Description
21110	Application of interdental fixation device for conditions other than fracture or dislocation, includes removal
21125	Augmentation, mandibular body or angle; prosthetic material
21127	Augmentation, mandibular body or angle; with bone graft, onlay or interpositional (includes obtaining autograft)
21141	Reconstruction midface, LeFort I; single piece, segment movement in any direction (eg, for Long Face Syndrome), without bone graft
21142	Reconstruction midface, LeFort I; 2 pieces, segment movement in any direction, without bone graft
21143	Reconstruction midface, LeFort I; 3 or more pieces, segment movement in any direction, without bone graft
21145	Reconstruction midface, LeFort I; single piece, segment movement in any direction, requiring bone grafts (includes obtaining autografts)
21146	Reconstruction midface, LeFort I; 2 pieces, segment movement in any direction, requiring bone grafts (includes obtaining autografts) (eg, ungrafted unilateral alveolar cleft)
21147	Reconstruction midface, LeFort I; 3 or more pieces, segment movement in any direction, requiring bone grafts (includes obtaining autografts) (eg, ungrafted bilateral alveolar cleft or multiple osteotomies)
21150	Reconstruction midface, LeFort II; anterior intrusion (eg, Treacher-Collins Syndrome)
21151	Reconstruction midface, LeFort II; any direction, requiring bone grafts (includes obtaining autografts)
21154	Reconstruction midface, LeFort III (extracranial), any type, requiring bone grafts (includes obtaining autografts); without LeFort I
21155	Reconstruction midface, LeFort III (extracranial), any type, requiring bone grafts (includes obtaining autografts); with LeFort I
21159	Reconstruction midface, LeFort III (extra and intracranial) with forehead advancement (eg, mono bloc), requiring bone grafts (includes obtaining autografts); without LeFort I
21160	Reconstruction midface, LeFort III (extra and intracranial) with forehead advancement (eg, mono bloc), requiring bone grafts (includes obtaining autografts); with LeFort I
21188	Reconstruction midface, osteotomies (other than LeFort type) and bone grafts (includes obtaining autografts)
21193	Reconstruction of mandible rami, horizontal, vertical, C, or L osteotomy; without bone graft
21194	Reconstruction of mandible rami, horizontal, vertical, C, or L osteotomy; with bone graft (includes obtaining graft)
21195	Reconstruction of mandibular rami and/or body, sagittal split; without internal rigid fixation
21196	Reconstruction of mandibular rami and/or body, sagittal split; with internal rigid fixation
21198	Osteotomy, mandible, segmental;
21206	Osteotomy, maxilla, segmental (eg, Wassmund or Schuchard)
21208	Osteoplasty, facial bones; augmentation (autograft, allograft, or prosthetic implant)
21209	Osteoplasty, facial bones; reduction
21210	Graft, bone; nasal, maxillary or malar areas (includes obtaining graft)
21215	Graft, bone; mandible (includes obtaining graft)
21247	Reconstruction of mandibular condyle with bone and cartilage autografts (includes obtaining grafts) (eg, for hemifacial microsomia)

References

1. American Association of Oral and Maxillofacial Surgeons (AAOMS). Criteria for orthognathic surgery. Published 1999. Updated 2020. The American Association of Oral and Maxillofacial Surgeons. Accessed August 19, 2021. Available at URL address: https://www.aaoms.org/

2. American Association of Oral and Maxillofacial Surgeons (AAOMS). Guidelines to the evaluation of impairment of the oral and maxillofacial region. 2018. The American Association of Oral and Maxillofacial Surgeons. Accessed August 19, 2021. Available at URL address: http://www.aaoms.org/

3. American Association of Oral and Maxillofacial Surgeons (AAOMS). Position Paper: Orthognathic Surgery. Rosemont, IL: AAOMS;1988 Aug.

4. Baur DA. Distraction osteogenesis of the mandible. Medscape. Updated Feb 2014, March 8, 2016. Accessed August 26, 2021. Available at URL address: https://emedicine.medscape.com/article/844837-overview

5. Brooks CD, Boyd SB. Orthognathic Surgery for Obstructive Sleep Apnea. Oral and Maxillofacial Surgery, edited by Fonseca, RJ, Elsevier, 2018, 264-277.

6. Centers for Medicare and Medicaid Services (CMS). Local Coverage Determinations (LCDs) alphabetical index. Accessed August 19, 2021. Available at URL address: https://www.cms.gov/medicare-coverage-database/indexes/lcd-alphabetical-index.aspx

7. Centers for Medicare and Medicaid Services (CMS). Local Coverage Determinations (LCD): Cosmetic and Reconstructive Surgery (L33428). Accessed August 19, 2021. Available at URL address: https://www.cms.gov/medicare-coverage-database/details/lcd-details.aspx?lcdid=33428

8. Centers for Medicare and Medicaid Services (CMS). Local Coverage Determinations (LCD): Surgical Treatment of Obstructive Sleep Apnea (OSA) (L34526). Accessed August 19, 2021. Available at URL address: https://www.cms.gov/medicare-coverage-database/details/lcd-details.aspx?lcdid=34526

9. Centers for Medicare and Medicaid Services (CMS). National Coverage Determinations (NCDs) alphabetical index. Accessed August 19, 2021. Available at URL address: https://www.cms.gov/medicare-coverage-database/indexes/ncd-alphabetical-index.aspx

10. Costa F, Robiony M, Toro C, Sembronio S, Polini F, Politi M. Condylar positioning devices for orthognathic surgery: a literature review. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2008 Aug;106(2):179-90.

11. Haas Junior OL, Guijarro-Martínez R, de Sousa Gil AP, da Silva Meirelles L, de Oliveira RB, Hernández-Alfaro F. Stability and surgical complications in segmental Le Fort I osteotomy: a systematic review. Int J Oral Maxillofac Surg. 2017 Sep;46(9):1071-1087.

12. Huang MF, Alfi D, Alfi J, Huang AT. The Use of Patient-Specific Implants in Oral and Maxillofacial Surgery. Oral Maxillofac Surg Clin North Am. 2019 Aug 31.

13. Kim YK. Complications associated with orthognathic surgery. J Korean Assoc Oral Maxillofac Surg. 2017;43(1):3-15.

14. Liang F, Naran S. Essentials of Maxillofacial Surgery. 2nd edition. (2019). American Society of Maxillofacial Surgeons.

15. Lin HH, Chang HW, Wang CH, Kim SG, Lo LJ. Three-dimensional computer-assisted orthognathic surgery: experience of 37 patients. Ann Plast Surg. 2015 May;74 Suppl 2:S118-26.

16. Metalwala Z, Okunseri C, Fletcher S, Allareddy V. Orthognathic Surgical Outcomes in Patients With and Without Craniofacial Anomalies. J Oral Maxillofac Surg. 2018 Feb;76(2):436.e1-436.e8.

17. Oh ES, Oishi N. Orthognathic Model Surgery. Oral and Maxillofacial Surgery, edited by Fonseca, RJ, Elsevier, 2018, 44-61.

18. Olate S, Sigua E, Asprino L, de Moraes M. Complications in Orthognathic Surgery. J Craniofac Surg. 2018 Mar;29(2):e158-e161.

19. Peck CJ, Pourtaheri N, Shultz BN, Parsaei Y, Yang J, Park KE, Allam O, Steinbacher DM. Racial Disparities in Complications, Length of Stay, and Costs Among Patients Receiving Orthognathic Surgery in the United States. J Oral Maxillofac Surg. 2021 Feb;79(2):441-449.

20. Patel PK. Orthognathic surgery. Medscape. Updated December 27, 2018. Accessed August 26, 2021. Available at URL address: https://emedicine.medscape.com/article/1279747-overview

21. Steinbacher DM. Three-Dimensional Analysis and Surgical Planning in Craniomaxillofacial Surgery. J Oral Maxillofac Surg. 2015 Dec;73(12 Suppl):S40-56.

22. Swennen GR, Mollemans W, Schutyser F. Three-dimensional treatment planning of orthognathic surgery in the era of virtual imaging. J Oral Maxillofac Surg. 2009 Oct;67(10):2080-92.

23. Wood RJ, Jurkiewicz, MJ. Plastic and reconstructive surgery: head and neck. In: Schwartz SI, editor. Principles of surgery. New York, NY: McGraw-Hill Companies, Inc;1999. Chapter 43.

24. Zhang N, Liu S, Hu Z, Hu J, Zhu S, Li Y. Accuracy of virtual surgical planning in two-jaw orthognathic surgery: comparison of planned and actual results. Oral Surg Oral Med Oral Pathol Oral Radiol. 2016 Aug;122(2):143-51.