REVIEW ARTICLE

The Art of Genioplasty: An Insight

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ABSTRACT

Approximately 20% of the population is affected by dentofacial deformities which may demonstrate myriad degrees of functional and aesthetic compromise. Moderate to severe occlusal discrepancies most often require combined orthodontic treatment and orthognathic surgery to attain the most stable results with optimal function and aesthetic outcomes. Orthognathic surgery is said to be the art and science of diagnosis, treatment planning and execution of treatment by combining orthodontic and oral and maxillofacial surgery to correct dentoosseous, musculoskeletal and soft tissue defects of maxilla and mandible, and the structures associated to them. Among the various orthognathic surgical procedures, genioplasty is one of the most widely performed surgical procedures used for correcting chin deformities. The term genioplasty is used to describe miscellaneous facial profile concerns starting from orthognathic surgery in conjunction to a facial symmetrical balancing procedure assisting with soft tissue contours and chin enhancement for those undergoing elective facial surgery.

KEYWORDS: Genioplasty, Orthodontics Treatment, Orthognathic Surgery, Osteotomy.

INTRODUCTION

We, human tend to acquire an appearance that is pleasing for self and also to the society. Stereotyping of personality characteristics is quite often based on facial features. Variations in facial proportions within normal limits make a human face interesting. It is the harmony and symmetry of each segment which contributes towards the total beauty of the face. Any deviation from the normal facial development brings about an unpleasant facial appearance with a disturbance in both aesthetics as well as function. Egyptians and Greek statues which have been the basis of the study by Guyuron, proves that man, from ancient times, were concerned about aesthetical beauty. Both depicted facial features with variations i.e. the former depict a round face with prominent eyes, thick lips, a straight nose and a positive appearing chin while latter with an oval face which tapers to the chin and blends geometrically with the lower face.[1] An article, "The Study of the Human Face" published back in 1869 by Woolnoth used the basic description for facial features which are still used in contemporary facial analysis namely straight, convex and concave which he further describes them as most attractive, youthful and as older appearing respectively.[1,2] The chin is often subconsciously associated with "character" or "personality". A retruded oval shaped chin is generally regarded as a sign associated with femininity, while a strong, square chin with masculinity.[3,4] Approximately 20% of the population is affected by dentofacial deformities which may demonstrate myriad degrees of functional and aesthetic compromise. Moderate to severe occlusal discrepancies most often require combined orthodontic treatment and orthognathic surgery to attain the most stable results with optimal function and aesthetic outcomes. Orthognathic surgery is said to be the art and science of diagnosis, treatment planning and execution of treatment by combining orthodontic and oral and maxillofacial surgery to correct dentoosseous, musculo-skeletal and soft tissue defects of maxilla and mandible, and the structures in relation to them. Among the various orthognathic surgical procedures, genioplasty is one of the most widely performed surgical procedures used for correcting chin deformities.[5]

EVALUATION OF FACE

The correct method of evaluating the face should always be with the teeth in occlusion and the lips in repose.[6]

Frontal analysis

The mandible should have a smooth and well defined inferior border, from angle to chin, along with a definite separation of the lower third of the face from the neck region. The size, shape, and form of the chin should be in harmony with the gender and the particular facial type of the patient.

Transverse dimensions: People with leptoprosopic (narrow and long) facial features also usually have "pointed" chins, transversely deficient chins that seem separate from the mandible on the other hand, dolicoprosopic (broad and wide) faces usually have strong broad chins.

Vertical dimensions: The height of the labiomental fold to soft tissue menton (Me) should be equal to the distance from the lower lip stomion (Stms) to the labiomental fold.

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Two thirds of the lower facial height should be comprised of the lower lip and chin with a length of 80 ± 2 for females and 44 ± 2 for males measured from lower lip stomion (Stm) to soft tissue menton (Me).

Symmetry: The symmetry of the chin is evaluated in relation to both the dental and the facial midline of the mandible.

Profile analysis [6]

The chief contributing factors that are responsible for the chin contour or shape is the anteroposterior position of the lower lip, the height and depth of the labio-mental fold, and the shape of the chin button. The harmonious combination of the above three structures in the combination of the cervico-mental area, will help in achieving an esthetically appealing and an attractive chin. The head should be in natural posture when the profile is evaluated.

Labiomental fold: The labiomental fold forms an angle between a line tangent to the superior convexity of the chin and and the lower lip should be ±130. This angle formed, is usually obtuse in Class III cases and acute in Class II cases.

Lip-chin-submental angle: This angle is formed by the lip-chin line (labrale inferius and pogonion) and submental tangent and should be approximately ±121 degrees for females and ±126 degrees for males. The angle is obtuse in deficient chins and acute in anteroposterior excessive chins. Excessive submental fat, lower lip procumbence, and increased submental bulk will increase the lip-chin-submental angle.

Chin-neck length: This measurement is made from the submental neck point to soft tissue menton (Me) and it should be 42 ±4. Usually this measurement will be increased in Class III cases and decreased in Class II cases.

Chin throat angle (cevico-mental angle): The chin-neck angle is formed by a submental tangent and a neck tangent (±121 degrees for females and ±126 degrees for males). Individuals with macrogenia or mandibular excess will have an acute angle while individuals with microgenia or mandibular deficiency will have an obtuse angle.

Radiographic evaluation[6]

Lateral cephalometric analysis: Relationships between various hard and soft tissue structures of the craniofacial complex are measured by analysis of the lateral cephalometric radiograph. It is a helpful guide for diagnosis and treatment planning, predicting treatment results and to assess soft tissue and hard tissue changes resulting from treatment.

Facial angle: This angle is formed by the Frankfort horizontal plane and a line drawn from Pogonion and Nasale (mean 82 to 95 degrees).

Facial contour angle: The facial convexity angle is between a line connecting Sn and Pogonion (Pog) (lower facial plane - LFP) and lines drawn from G¥ to Sn (upper facial plane - UFP). The mean angle for females is -12 to -14 degrees and males is -11 to -13 degrees.

E-line: From the tip of the nose (Pronasale) to Pogonion (Pog) the esthetic plane is drawn. The the lower lip should be 2mm behind it, while upper lip should be 4mm behind the line. The profile behind the esthetic plane should form an almost symmetric Cupid's bow.

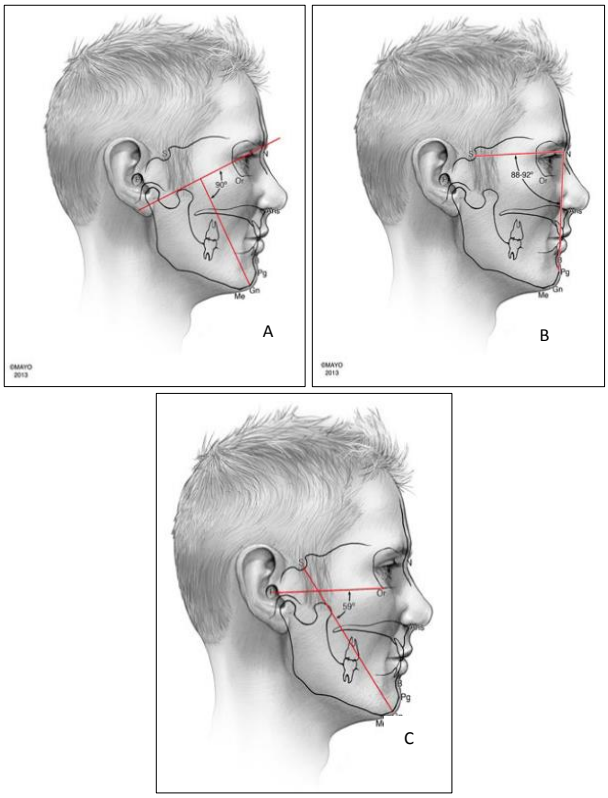
Postero-anterior cephalometric analysis: This radiograph will assist in differentiating between asymmetry of the chin, the dentition, the maxilla and the mandible. Occlusal cants and its role, due to which, facial asymmetry can be caused is also seen on this radiograph.

Cephalometric Analyses

Selected Cephalometric Analyses is stated in Table – 1.

Selected Cephalometric Analyses[7]
Facial Axis: Represents the intersection of a line from Nasion to Basion and PT point to Gnathion (Fig. A) and has a normative value of 90.˚
Facial Angle: Represents the internal angle from Sella-Nasion an Nasion-Pogonion (Fig. B) and has a normative value of 88 to 92.˚
Y-axis: Represents the intersection of Frankfort Horizontal (P-O) with a line from Sella-Gnathion (Fig. C) and has a normative value of 59.˚
Holdaway Ratio: Represents the intersection of lines from the lone axis of the mandibular incisor teeth and a true vertical line through point B. It has a normative value of 4 mm or 25.˚ Pogonion should lie 4 mm anterior to the vertical line and the lower incisor tip 4 mm posterior to the line

Table 1



A. Facial Axis: This has a normative value of 90° and represents the intersection of a line from Nasion to Basion and PT point to Gnathion; B. Facial Angle: This has a normative value of 88-92° and represents the internal angle from Sella-Nasion and Nasion-Pogonion; C. Y Axis: This has a normative value of 59° and represents the intersection of Frankfort Horizontal (P-O) with a line from Sella-Gnathion.

CHIN CLASSIFICATION

Classification of the chin is stated in Table – 2:

Table 2: Chin Classification [8]

Class
I: Macrogenia: horizontal, vertical, combined
II: Microgenia: horizontal, vertical, combined
III: Combined: horizontal macro/ vertical microgenia, horizontal microgenia/vertical macrogenia
IV: Asymmetric: a) short, b) normal, c) long anterior facial height
V: Witch's Chin: soft tissue ptosis
VI: Pseudomacrogenia: normal bony volume with excess soft tissue volume
VII: Pseudomicrogenia: normal bone volume with retrogenia secondary to excessive maxillary growth and clockwise rotation of mandible
VIII: Iatrogenic malposition

SURGICAL TECHNIQUE[7]

An intraoral incision made in a number of ways, for osseous genioplasty including scalpel, electrocautery, radiowaves or laser. The incision is to be kept toward the labial surface instead of at the vestibular depth or toward the dentition. Initially care is needed with the lateral aspects of the incision so as to not transect the terminal branches of the mental nerves. Retraction of the mucosa allows the nerves to be visualized just deep to the surface, helping in their avoidance. Then the mentalis muscles are transacted, and a full thickness subperiosteal flap is elevated in order to completely expose the anterior mandible. The mental foramina and nerves are identified and exposed bilaterally.

Once appropriate exposure is achieved, the midline and para-midline areas are marked with a pencil then go over the lines with the Piezosurgical saw or sagittal saw to leave a lasting reference for the procedure. Precise measurements are made to mark out the location for the osteotomy. Marking this line, in a manner similar to that mentioned above, aids in the actual procedure. Importantly, the osteotomy should stay a minimum of 4.5 mm below the mental foramen and ideally should be closer to 6 mm below so as to not injure the mental nerves.[7] Highlight these surgical aspects of marking, exposure, nerve identification and fixation.

The osteotomy is completed with reciprocating, sagittal oscillating, or Piezosurgical devices. Angulation of the osteotomy variations are possible and are adjusted based on the desired result of the procedure. Avoid a steep oblique osteotomy as it contributes to significant notching and palpable defects at the inferior border of the mandible following healing. The vertical enhancement can be done by augmenting the chin with some type of interpositional graft material using a variety of common grafting techniques. Vertical reduction is accomplished by removing a wedge of bone correlating to the desired change. Utilize copious amounts of irrigation in order to cool the bone and assist with visualization during the osteotomy procedure. Try to keep the saw in a one plane to assist with symmetry and enable a uniform platform for repositioning. Once the osteotomized segment is down fractured we have to carefully inspect the lingual pedicle and floor of mouth soft tissues. If there is any bleeding, it must be controlled before progressing. Then we must position the inferior border segment to the desired location and secure it in place. In most cases, appropriate symmetry can be maintained by utilizing the reference lines that were placed at the time of the surgery, but in cases of pre-existing asymmetry or cases combined with other procedures can be more difficult.[27,28]

Horizontal advancement:

Anteroposterior chin deficiency (microgenia)- Anteroposterior augmentation of the chin by sliding genioplasty is the most common operation to correct an anteroposterior deficient chin. Individuals with a mandibular antero-posterior deficiency commonly have Class II malocclusions and will require mandibular advancements. The sliding genioplasty for chin augmentation has pronounced advantages above the use of alloplastic materials. The inferior segment is brought forwards, and wires are used to fix the lingual cortex to the buccal cortex of the main body of the mandible. Or it can also be done by placing bent mini plates. The advancement, in this procedure, is limited to the overall thickness of the symphysis. Sometimes, the chin is so deficient that a double sliding horizontal osteotomy must be used. This technique involves the creation of a stepped intermediate wafer of bone between the inferior fragment and the mandible, which is also advanced so that bony contact is provided between the upper and lower fragments. Or a sandwich bone graft also can be effectively used to get the good interface and also to ensure a predictable contour. [9-11]

Horizontal set-back:

Anteroposterior excess (macrogenia) is mainly caused due to the skeletal prominence of the symphysis, however, excessive soft tissue thickness can also lead to an unesthetic chin projection. When the chin is reduced anteroposteriorly, the clinician should take care not to reduce or flatten the labiomental fold resulting in unesthetic chin shape. We need to keep in mind that chin shape is more important than chin position. The proximal tips of the mobilised fragment are reduced in order to ensure a smooth transition along the inferior border. Also, we must be aware of the possible loss of vertical dimension of the chin.[6]

The tenon technique:

In 1974, Michelet et al described the 'tenon' technique of genioplasty. A 'U' shaped monocortical osteotomy cut is created centrally in the symphysis. Below the mental nerves lateral extensions are developed, which connect to the superior limbs of the 'U'. Full thickness osteotomies are completed on the lateral extensions only through the lingual cortex on the superior aspect of the 'U'. The resultant full thickness of bone behind the tenon allows for a better positioning and lag screw fixation. In case posterior movement is desired, the 'U' is inverted and the tenon is in the inferior fragment.[6]

Vertical reduction:
Vertical chin excess- When the lower facial height has increased we should differentiate between vertical mandibular excess and vertical maxillary excess. In cases where the maxilla is vertically excessive: the interlabial gap has to be increased; the upper incisor exposure under the upper lip is increased and patient often has a gummy smile. The height of the chin will be excessive when: the lower two thirds (Stm-Me) of the lower facial half (Sn-Me) is more than the normal ratio of 1:2 = Sn-Stm: Stm-Me, while the lower half of the facial (Sn-Me) will be excessive corresponding to the upper half (N-Sn < Sn-Me).[12]

The vertical height changes are effected by altering the angle of the osteotomy. The magnitude of vertical dimensional change is proportional to the direction and amount of the horizontal movement. If we want to shorten the chin without horizontal changes, a wedge reduction is usually indicated, which can be performed using horizontal osteotomy or tenon technique. It is easier to do the wedge ostectomy from the superior stable fragment.[12]

Vertical augmentation:
Vertical chin deficiency - Decrease in the lower facial height relative to the midface height is caused due to a vertical deficiency of the anterior mandible. Vertical chin deficiency should be differentiated from deep bite cases and vertical maxillary deficiency. In all three dentofacial deformities will be clinically and cephalometrically as a diminutive or "squashed" lower facial third, vertically shorter than the middle third. The lower two thirds (Stm - Me) of the lower facial height (Sn - Me) is shorter in relation to the upper third (Sn - Stm). This is indicated when the deficit is in the mandibular alveolus or the symphysis, the lower facial height is to be increased. Vertical augmentation is achieved by alloplastic implant placement between the osteotomised segments or by interpositional grafting or altering the angle of the horizontal cut.[13]

Transverse chin deformities[6]:
There are only few guidelines to help the clinician in evaluating the width of the chin. The transverse dimension of the chin is related to the patient's bigonial and bizygomatic widths, the general shape of the face (europrosopic and leptoprosopic) and head (brachicephalic and dolicocephalic). The face can also be described as square, narrow, round, oval, tapering or a combination of the above shapes and the chin outline should be in synchronization with the facial shape.

Transverse deficiency: The chin can be widened in the posterior area by cutting the chin segment in the midline and rotating the segments outward, while the anterior part of the chin can be widened by lateral repositioning of the segments and also by placement of a bone graft in the defect in the midline.

Transverse excess: The chin may be made narrow or made more tapered by sectioning the chin segment in the midline and removing a triangular section of the bone from the lingual aspect. Placing a bone plate on the anterior surface of the segment before mobilization will allow the segment to be "bent" narrower. A very broad, square, chin can be narrowed by removing a rectangular section of bone in the middle of the chin segment. The segments are finally moved medially and fixated.[6]

Chin asymmetry[6]:
Asymmetry of the chin is rarely an isolated entity and it is most often a part of mandibular asymmetry. Facial asymmetry is a challenging defect to assess and to correct as the defect, generally, results from a truly three dimensional skeletal abnormality. The chin may be asymmetric to the facial or dental midline. Correction, in such cases, requires a horizontal osteotomy of the chin sliding the chin to the right or left until the facial midline and chin midline match. The cant of the lower border of the chin may differ from the inter-pupillary plane or the cant of the occlusal plane. Correction of the lower border cant is influenced by the relative height of the chin and can involve unilateral vertical augmentation or reduction or a combination of the above performed on the left and right side.[6]

Submental liposuction:
The submental area plays an important role in the overall aesthetics of the chin e.g. the submental- neck angle, lip-chin-submental angle, chin-neck length, etc. Excessive fat add to poor chin aesthetics and submental liposuction or lipectomy is considered as an adjuvant procedure to enhance chin esthetics.[14]

Diagnosis-based treatment:
Prior to embarking on attempts to correct dentofacial defects, it is important to have an accurate diagnosis of the existing problem. Cephalometric measurements, clinical examinations and model analysis are useful to this count. A treatment plan can be decided on the basis of this diagnosis and should include the osteotomy planned, amount and direction, the segments are to be moved and movement of teeth using post-surgical or pre-surgical orthodontics. Often there will be a particular treatment that provides the best outcome, but ideally, the treatment plan of each patient should be individualized as two deformities are never alike.[15]

Mandibular prognathism:
Prior to attempting correction of mandibular prognathism, it is important to assess if the condition is a true mandibular excess or a case of midface retrusion. Most individuals with mandibular prognathism presents with a long lower jaw, high FM angle, Class III malocclusion, and an excessive facial height. Mandibular prognathism can be corrected using a variety of surgical maneuvers. Previously famous procedures included subcondylar osteotomy, condylotomy, Obwegeser sagittal split and mandibular body osteotomies. Now, most individuals are treated by some form of ramus osteotomy like the vertical ramus osteotomy, BSSO, or inverted 'L' osteotomies. As needed, a reduction or advancement genioplasty in horizontal or vertical dimension may be performed as an adjuvant procedure.[1]

Mandibular retrognathism / micrognathia:
The treat-men of mandibular retrognathism is difficult owing to the tendency to relapse and problems with bone grafting. The BSSO and vertical ramus osteotomies are useful only for moderate cases. The inverted 'L' osteotomy can be a better procedure in such cases. In some instances, a longer genioplasty is required to correct chin retrusion. Rigid fixation and bone grafting has solved the problems of relapse to a great extent. The distraction osteogenesis technique is proven to be valuable tool in the correcting mandibular retrognathism.[15]

Bimaxillary protrusion:
A condition in which the maxilla and mandible both are so severely protruded that the lips cannot be closed without strain is termed bimaxillary dento-alveolar protrusion. The relative protrusion of the jaws in this condition may or may not be accompanied. The patient's problems are primarily aesthetic, since bimaxillary protrusion is compatible with a good occlusal relationship.In both growing children and non-growing adults, orthodontic correction of bimaxillary protrusion can be carried out quite successfully. The main disadvantage of orthodontic correction is that due to anchorage loss, for retraction, the space available cannot be used to its full extent. The surgical treatment of bimaxillary protrusion involves maxillary and mandibular segmental osteotomies following extraction of first or second premolars, as required to retract and frequently to intrude protruding maxillary and mandibular incisors. In many instances, an adjuvant augmentation genioplasty is also needed to achieve a good facial profile. LeFort I osteotomy and mandibular body/ramus osteotomies are the other procedures often required for the correction of severe bimaxillary protrusion.[15]

In adjunct to osseous genioplasty, a numerous other options are available to utilize alloplastic implants in order to achieve specific patient and surgeon demands. Several characteristics of ideal alloplastic implants should be considered when selecting one for facial augmentation of the chin or other areas of the face. The most common materials in use today for facial augmentation are solid silicone, porous polyethylene and PTFE (polytetrafluoro-ethylene).[7]

Advantages & Disadvantages of Chin Osteotomy[72]:

Advantages and disadvantages of chin osteotomy is stated in Table – 3.

ADVANTAGES	DISADVANTAGES
Very versatile procedure	Requires osteotomy, adding risk from surgery and anesthesia
Corrects vertical problems	Significant surgical armamentarium
Corrects AP excess and asymmetry	Significant microdroplet blood aerosol
Stable over time	Vascular injury risk
Increases submental length and cervicomental angle	Airway emarrassment risk
Advances genial-tongue-hyoid position, of benefit in sleep apnea	Not easily reversible
	Increased expense for anesthesia, OR time and fixation materials when compared to implants.

Table 3: Advantages and Disadvantages

Postoperative Complications[7]:
The post operative complications that can be encountered after genioplasty is stated in Table - 4:

Complications of Genioplasty
Tooth devitalization
Neurosensory loss
Soft tissue chin ptosis
Dental root exposure
Asymmetry
Irregularities and step deformities
Lower lip lag
Over and under correction
Patient or surgeon dissatisfaction

Table 4: Postoperative Complications

DISCUSSION

Genioplasty is used to address numerous facial concerns from a facial balancing procedure in adjunction with orthognathic surgery to assisting with soft tissue contours and chin-neck enhancement for patients undergoing elective facial surgery. Over the years many authors have proposed different studies leading to various advances in the method of genioplasty in order to treat numerous types of chin augmentation. In 1934, Aufricht described the use of nasal cartilage as a means for chin augmentation.[16] Trauner and Obwegeser in 1957, published the first article on intraoral sliding osseous genioplasty,[17] which is still used throughout the world today.[18] In 1942, Hofer first described advancement genioplasty through an external approach[16], later in the late 1950s Trauner & Obwegeser described an intraoral approach [19], Converse & Wood-Smith.[20] In the 1960s Converse and Wood-Smith, as well as Hinds and Kent, described the versatility of the sliding genioplasty.[1,21,22] In the 1970s Gonzales-Ulloa, Loeb and Field described various methods to address "witch's chin" and deep submental folds.[23,24,19] 1980s the introduction of the use of hydroxyapatite as an inlay or onlay graft to augment the lower facial height in the osteotomized chin.[25] In the late 1990s to 2007, Zide and his colleagues wrote a series of articles stating numerous contemporary aspects of genioplasty approaches, evaluation, complications, and refinements that serve as a strong foundation for surgeons undertaking this procedure.[26-28]

Various studies have been presented by different authors to help us understand and correct dentofacial deformities involving the chin using the process of genioplasty. Epker BN and Wessberg GA in 1981 stated dentoalveolar osteotomy, reduction cheiloplasty, and genioplasty could be used to correct functional deformities, while not detracting from existing aesthetics, of certain individuals with short face dentofacial characteristics. [29] Precious DS and Delaire J in 1985 stated that anterior mandible's functional genioplasty is an osteotomy-ostectomy which reduces the excessive lower anterior facial height to 55% of the total anterior facial height.[30] Epker BN and Fish LC in 1983 said that in augmentation genioplasty, augmenting the chin is determined by three basic criteria: NB : Pog ratio, the soft tissue thickness of the lower lip

and chin, and the type of genioplasty to be done. [31]

Different types of genioplasties have been mentioned earlier for treating various types of dentofacial disorders like the horizontal advancement, horizontal set back, the 'Tenon' technique, vertical reduction, vertical augmentation and rotational genioplasty. The horizontal sliding osteotomy is widely used for genioplasty throughout the world because it has several merits. First, it can be used to treat microgenia as well as macrogenia. Second, it is simple to perform. Third, the amount of bone resorption is small, and the aesthetic result is stable. Chang et al. in 2001 preferred the sliding genioplasty technique as it allowed for the correction of a vast range of abnormalities. They found surgeon and patient satisfaction scores to be high for this procedure and the operative times for experienced surgeons were around 15 minutes, results were stable, and neurologic complication was transient and infrequent.[32] Gui et al. in 2008 conducted a large retrospective study to compare sliding genioplasty with a Medpor chin implant, he found that both the techniques produced almost similar patient satisfaction, but in all 3 dimensions, sliding genioplasty was more versatile in correcting abnormalities.[33] Li and Cheney in 1996 advocated the use of sliding genioplasty for the treatment of failed chin implants in the setting of infection and/or extrusion. If an infected implant does not resolve with only antibiotics, the implant is usually removed, and a secondary procedure is required 3 to 6 months later for replacing the implant. However, Li and Cheney recommends an immediate sliding genioplasty at the time of implant removal. They found that the need for a second surgery was eliminated and it produced an excellent immediate result.[34] Reyneke J. P., and Sullivan S.M, in 2001 authors present a simplified technique in which the transverse dimension of the chin can be selectively changed. This is done by controlling the 2 symphyseal segments and predictably widening or narrowing the chin. [35] Fariña et al. in 2012 discussed a new technique of genioplasty with successful results, the M-shaped genioplasty. This new genioplasty technique makes it possible to increase the vertical dimension, as well as the mental sagittal projection, without placing a graft or interposition material. [36]

Advancement of the genioplasty segment using the sliding horizontal osteotomy also has its drawback. It will result in notching at the inferior border of the mandible behind the chin segment. This can result in an external esthetic deformity that is visible and will accentuate the soft tissue jowls. These unesthetic changes can be bothersome and frequent. Lindquist and Obeid in their study found this problem to occur in 72.5% of their patients.[37] Stephen A. Schendel in 2010 discussed a new technique called the sagittal split genioplasty.[38] Sagittal split of the lateral one-third to two-thirds of the inferior chin segment was done. The SS genioplasty technique has been devised to specifically avoid this complication and result in an improved, more predictable esthetic outcome. By sagittally splitting the anterior lateral border of the mandible, the inferior gap, is eliminated. The anterior lingual vascular pedicle is maintained because the osteotomy reverts to the typical horizontal cut mesial to the cuspid teeth. The area behind the advanced chin segment still has the normal vertical mandibular height because of the sagittal splitting and no through and through a gap is created. The inferior chin segment is then secured in the anterior region by rigid fixation using a chin plate and screws. Advancement of 6 to 12 mm could be achieved.[38] With the modification and standardization of the horizontal sliding osteotomy, 6-10 the incidence of complications has declined. The incidence of neurosensory deficiency, however, remains very high and has not decreased significantly. The cause of nerve injury suffered during the operation is mostly due to the restraint of the soft tissue around the mental nerve. Hence, a neurosensory involvement of genioplasty should always be taken into consideration in order to avoid any sensory disturbance following the procedure of genioplasty. To decrease the incidence of neurosensory disturbance of the chin, Jichang Wang, Lai Gui, Qiaoyan Xu, Jinglong Cai in 2007 developed a new type of osteotomy for advancement genioplasty. In case of a mild or moderate degree of microgenia and have normal bite function, the sagittal curving osteotomy is a safe, simple and effective technique for advancement genioplasty. It could effectively decrease the incidence of neurosensory disturbance of the chin. [39]

The present era witnesses the growing popularity of Computer Assisted genioplasties. We feel it is a welcome change in performing the procedure as the surgical time is reduced drastically because the entire planning takes place virtually and predefines the plan for the actual surgery. It is obvious that reduced surgical time leads to a better post operative recovery. R. Olszewski et al. in 2010 present a procedure of computer-assisted genioplasty. Mimics (Materialize) software was used to carry out virtual planning of the osteotomy lines. A 3 dimensional rapid-prototyping multi-position model of the chin area as built. Virtual information transfer to the operating room in the form of a surgical guide used for the transfer of the osteotomy lines and the positions of the screws was used. This method had promising results. [40] Möhlhenrich et al in 2015 performed 4 different osteotomy techniques for genioplasty to conduct a study with the aim to compare the contact surface area (CSA) between bony segments. Virtual genioplasties were done in terms of sliding or chin-shield genioplasty and 1- or 2-tiered genioplasty on computed tomography (CT) data. The CSA of the lower 2-tiered genioplasty was larger than that of the corresponding 1-tiered genioplasty at a displacement distance of 8 mm.[41] Li et al. in 2016 conducted a study with the purpose to develop and validate a new chin template system for a two-piece narrowing genioplasty, by firstly superimposing the postoperative computed tomography model onto the planned model, the outcome evaluation was completed, and later measuring the differences between the planned and actual outcomes. Using this chin template system, all surgeries were completed successfully and no inferior alveolar nerve damage was seen in this study.[42]

Chin Implants for augmentation genioplasty is also very popularly used because of its less time consuming and hassle free procedure. Though different authors have a different opinion about whether osseous genioplasty or using chin implants are better for augmenting the chin, both have their own advantages as well as disadvantages; the former has a low risk of complications postoperatively while the latter being a less tedious procedure. Many facial plastic and plastic surgeons use alloplastic implants for augmentation genioplasty despite the benefits of advancement genioplasty, because it usually requires less operative time and is easier to accomplish. For modern implants the complication rates are low, but those complications that do occur tend to be more severe and require a prolonged treatment course.

The use of preformed dense, non-resorbable hydroxyl-apatite blocks as a grafting material was stated in 1986 by Zeller S Det al. for use in advancement and vertical lengthening of the bony chin associated with orthognathic surgical procedures. They concluded that dense hydroxyapatite is a biocompatible, synthetic, immune-logically inert material that can establish a chemical union with bone.[25] Harada K et al. in 1993 used one-block HA implantation for augmentation genioplasty can be used for vertical and horizontal augmentation can be performed simultaneously with greater augmentation possible than with osteotomy alone. [43] David HT et al. in 1999 stated that the fixed mandibular implant (FMI) and its prototype the staple implant were used to reconstruct an edentulous mandible and simultaneously stabilized a horizontal sliding genioplasty to correct a midline chin asymmetry. It helps in such instances by a simultaneous insertion of the FMI through the genioplasty segment, this in turn, secures the bony fragment in its new position and also provides the reconstruction of the edentulous mandible. This eliminates the need for two surgical procedures. [44] Strauss RA and Abubaker AO, in 2000 stated that despite personal preferences and training background that may influence the choice of which genioplasty technique to use, the osteoplastic technique has a better patient satisfaction rate, better soft tissue predictability, and less detrimental postoperative complications when compared with alloplastic augmentation.[45] Jones B.M., Vesely M.J.J. 2006 states that Osseous genioplasty is a more suitable technique for its long-term stability and versatility compared to alloplastic methods. It provides excellent results with a high degree of patient satisfaction and few long-term complications if performed correctly.[46] Whereas Park et al. in 2010 conducted a retrospective study to compare genioplasty using Medpor with osteotomy by measuring the amount of anteroposterior change in the hard and soft tissue. In their study, they found that the relapse rate of patients who underwent genioplasty with Medpor was lesser compared to patients who underwent genioplasty using osteotomy.[47]

Soft and hard tissue influence of genioplasty has also been studied by various surgeons. The soft tissue attachment to the genial segment has been considered important for bone resorption after advancement genioplasty. This supposition has only been supported by observations in single cases but not by a long term follow-up study. In fact, the average resorption rate of 14.3 % after advancement genioplasty using the genial segment as a free graft that was reported by Wegener (1971) compares favourably with studies using pedicled grafts. [48] Ellis E, Dechow PC, et al in 1984, from their study indicated that during advancement genioplasty, soft tissue pedicles to the genial segments should be maintained to minimize the amount of bone resorption in the postoperative period.[49] Vedtofte P et al, in 1991 studied the influence of soft tissue attachment in augmentation genioplasty on the amount of postoperative bone remodelling in 29 patients. In their study the genial segments with a soft tissue pedicle underwent less resorption than the free grafts. [48] Strauss and Abubaker in 2000 found that osseous genioplasty yielded more predictable soft-tissue changes than did alloplastic implants.[45] Chaushu G et al. 2001 did a study, that compares vertical and horizontal profile changes of the lower lip and chin after genioplasty with or without precise reattachment of the mentalis muscle. Precise reattachment of the mentalis muscle during an intraoral surgical approach produces a superior result.[50] Kim et al. in 2010 conducted a study to investigate the 3-dimensional (3D) changes in the soft tissue after mandibular setback surgery. In the study it was found that there were significant decreases in the lower lip length and increases in the upper lip length in the large setback, hypodivergent, and genioplasty groups. The mento labial fold deepened less in the genioplasty group than in other groups. [51] Erbe et al. in 2011 conducted a retrospective study in Class I dental arch relationship patients, to calculate the skeletal and soft tissue facial profile changes and also the predictability and the short-term stability of the soft-tissue response to advancement genioplasty. In their study, all profile convexity angles increased significantly implying that the profile was straightened by the advancement of the chin. [52] J. Rustemeye and A. Lehmann conducted a study in 2013 in which they revealed that in a case of horizontal movement the soft tissue prediction is more accurate as compared to vertical movement. [53] Fritz et al. in 2015 investigated the influence of angular deviation and displacement distance on the overlying soft tissue during chin genioplasty and found out that advanced genioplasty leads to greater changes in the overlying soft tissue, whereas the affected area is larger after setback displacement, the ratio between soft and hard tissue movements largely depends on the displacement distance. [41]

Genioplasty can also be used to alleviate Obstructive Sleep Apnoea (OSA) either in isolation or in combination with other procedures. Hendler et al. found that genioplasty combined with uvulopalatopharyngoplasty improved the respiratory disturbance index for 86% of patients with moderate obstructive sleep apnea.[54] Kezirian and Goldberg found in their literature review that genioglossal advancement alleviated OSA in 67% of patients with severe OSA.[55] Santos et al. with

advancement genioplasty alone found an improvement in scores on the apnea-hypopnea index and recommended it as a treatment for OSA secondary to hypopharyngeal obstruction. The success of advancement genioplasty relies on capturing the geniohyoid, genioglossus, mylohyoid, and digastrics muscles for advancing the segment of the mandible for OSA. The superior bone cut should be made 5 or more below the tooth roots to prevent the devitalizing of teeth; but, some patients may have a genial tubercle above the level of this cut and can have outcomes that are worse-than-average.[56] Ferreira et al in 2007 presented in their study that Genioplasty for genioglossus advancement seemed to reduce with obstructive sleep apnea-hypopnea syndrome signs, thus, it can be considered as an option for the surgical treatment of patients with hypopharynx obstruction.[56] Heggie et al. in 2015 described genioplasty as a mode of treatment for obstructive sleep apnoe. A new method of genioplasty is designed to enable a rotational repositioning that allows for advancement of the genioglossus attachments but also avoids an excessive projection of pogonion, which would otherwise result in an unfavourable profile.[57] Jihua Li et al. in 2013 evaluated a staged treatment of TMJ ankylosis accompanied by micrognathia using arthroplasty, mandibular distraction osteogenesis, and advancement genioplasty. They suggested that genioplasty can be used to improve esthetic outcome in conjunction with either mandibular distraction or a staged and surgical orthodontic treatment might be a better approach to manage TMJ ankylosis accompanied by mandibular hypoplasia. They suggested that in addition to mandibular osteodistraction, advancement genioplasty should be considered for better improvement in facial esthetics and respiratory function.[58]

CONCLUSION

Osseous genioplasty is an extremely stable procedure associated with a relatively low risk of complications. It is also a particularly versatile procedure and can be used to correct a wide range of deformities related to the chin, including horizontal and vertical excess, horizontal and vertical deficiency, asymmetry, and abnormal contour. It is an excellent adjunct when combined with procedures such as rhinoplasty, cervical liposuction/lipectomy, and rhytidectomy. The use of customized implants has an important role in the multiply-operated or syndromic patient as they allow a method to correct unusual anatomical issues with not only one procedure and but also often with less morbidity. A variety of techniques exist for genioplasty, and all appear to produce various positive effects both aesthetically and functionally. Most of the methods' results are well received as well as the complication rates are low. Of all the various techniques mentioned, an individual surgeon should find a method that works best in that surgeon's hands for minimizing complications and maximizing benefit.

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