INTRODUCTION

Multiple anatomic characteristics contribute to create an aesthetically pleasing and youthful appearing face. These include skin (texture, color, and thickness), soft tissue (symmetry, composition and location), and facial bony contours (size, shape, location, and symmetry). The major architectural promontories of the facial skeleton, including the malar-midface region, nose, and chin provide the base upon which the soft tissues of the face drape. By altering these promontories dramatic changes can be made in the aesthetic appearance of the face – much more so than by changing soft tissue and skin alone.

The creation or restoration of an aesthetically pleasing facial contour can encompass many surgical approaches. Rhinoplasty is probably the most frequently performed procedure that has a marked effect on the facial appearance, but rhinoplasty alone is sometimes inadequate. Successful facial plastic surgery requires the surgeon to achieve a "balanced" facial appearance that takes into account more than the nasal profile. Chin and malar augmentation can play a major role in achieving this balanced look.

As an adjunct to rhinoplasty, chin implantation has long been a valuable technique. It can be especially important in creating an aesthetic profile when combined with rhinoplasty, as a poorly developed or proportioned chin frequently accentuates nasal deformities. The malar prominence areas dominate the lateral midface and their importance is paramount in the "social profile" or oblique view. Augmentation of this area can provide a more youthful appearance and softens the more angulated face that may appear drawn or harsh, especially when performed in conjunction with rhytidectomy, blepharoplasty, and lateral canthopexy.

The submalar area deserves special mention as this area is not emphasized in most of the literature reviewed that discusses malar augmentation. Malar flattening and submalar hypoplasia is most common in Caucasians and is particularly pronounced in certain craniofacial disorders such as Treacher Collins. Underdevelopment of the submalar area gives rise to the emaciated "hollow" facial appearance. The decrease in submalar soft tissue that occurs with subcutaneous
fat atrophy and decent as the face ages can exacerbate the problem. The deficiency here can be subtle and camouflaged by sagging of facial skin, but post-rhytidectomy results can appear tense and "stretched" over the inadequate submalar area. Further, augmentation of the malar area can exaggerate this deformity, so preoperative assessment is the key to success. A slight fullness of the submalar area imparts a youthful look, effaces prominent melolabial folds and softens the overall appearance. Submalar augmentation can be intuitively included in the discussion of malar augmentation that follows.

Aside from purely cosmetic surgery, both the malar and chin augmentation principles and techniques are valuable in restoring post traumatic and congenital facial disfigurement. Facial contour modification can be performed through craniofacial or orthognathic surgical rearrangement of the facial skeleton, or through the use of implanted material. For the purposes of this review, only implantation will be addressed. Orthognathic problems and malocclusion should be addressed before mentoplasty is proposed, but the great majority of patients are usually reluctant to undergo orthognathic surgery. Most just want cosmetic augmentation, but they should at least be counseled prior to proceeding.

HISTORY

Rubin et al. mentioned the first alloplastic prosthetic materials for chin augmentation in 1948. Prior to the introduction of alloplastic implants, autogenous materials were used. For example, some surgeons utilized the excised bone and cartilage from the dorsum of the nose during reduction rhinoplasties for autogenous grafting of the chin. Such materials placed as onlay grafts were generally unsuccessful and unsightly, since they were absorbed readily but unevenly. Their placement and positioning also were not part of a thorough understanding of the elements of "profileplasty."

In the 1950s several varieties of chin implants composed of different materials were developed." Since their initial use, alloplastic chin implants have been made of a variety of materials (eg, silicone, Proplast I & II [synthetic porous composite of Teflon polymer and alumina], Mersilene, Teflon, Dacron, Gore-Tex, acrylic, polyethylene, methylmethacrylate, hydroxyapatite) and in numerous shapes. Some of the earliest implants were short and shaped like an extended oval. They were designed for placement on the central chin, a concept that was flawed. Except in a limited number of circumstances, these implants produced an odd pointed chin shape.

More recently, Ed Terino developed a more anatomic shape to chin implants. These more closely resemble the shape and dimensions of the chin and extend from just beyond the mental nerve on each side. Initial placement of the implant extraperiosteally evolved to the more satisfactory subperiosteal placement.

Tessier (1971) was the first to describe malar augmentation in craniofacial reconstruction. He used split calvarium, rib, and iliac crest harvested as autogenous bone grafts. Osteotomies were sometimes necessary to achieve appropriate contouring. These methods posed potential risks of donor site morbidity, limitations on shaping the grafts, and unpredictable resorption. Gonzalez-Ulloa (1974) was among the first surgeons to describe malar augmentation with alloplastic materials. Shortly thereafter, Hinderer developed malar augmentation as an important
aesthetic procedure. He noted that prominent malar eminences enhance facial shape and are especially noticeable when seen on an oblique view. Binder and Terino (1994) have written extensively about midfacial anatomy, deficiencies, and augmentation. The current literature profiles alloplastic implants in malar-submalar augmentation as providing consistent and durable results.

ANATOMY

The chin is defined as the region inferior to the labiomental fold, the groove that separates the lower lip from the chin. Several muscles cover the bony mandibular symphysis or chin. These include the mentalis, quadratus labii inferioris, triangularis, orbicularis oris, and some platysma fibers. Branches of the facial nerve innervate these muscles. The geniohyoid, genioglossus, and anterior bellies of the digastric muscle attach along the posterior and inferior surfaces of the mandibular symphysis (chin).

The sensory innervation of the chin area is from the mental nerve on either side, which is a branch of the inferior alveolar nerve, itself a branch of the mandibular nerve. All of these originate from the trigeminal (fifth cranial) nerve. The motor innervation is from the marginal mandibular branch of the facial (seventh cranial) nerve.

CONTRAINDICATIONS

Although malar-submalar augmentation with implants is a safe and simple technique, surgeons should exercise caution when considering implants in certain patients. These include patients with excessively thin skin, significant facial asymmetry, or extremely prominent bone structure. In addition, patients with a history of irradiation or malar fractures with exposed sinus mucosa generally are not candidates for midfacial contouring.

It is generally agreed that it is not appropriate to use implantation alone for correction of severe micognathia or retrognathia (3rd degree retraction - see below). Additional "relative" contraindications to routine mentoplasty include the patient with a very short mandible or a disproportionately short maxilla Schoenrock outlines several contraindications to malar augmentation. In addition to avoiding augmentation of the malar area of patients who really have submalar deficiency, he advises against this procedure in patients with small nasal and mental features, those who have prominent noses with small chins (unless chin augmentation is also planned), and patients with "deep-set" orbits in whom augmentation may exaggerate the appearance.

PREOPERATIVE EVALUATION

The surgeon often suggests the need for chin implantation to a patient during the preoperative planning for a different procedure, such as rhinoplasty, rhytidectomy, and/or blepharoplasty. Generally, a decision to correct a small or retrusive chin contour usually is made by the surgeon on the basis of physical examination, photographic evaluation, and the surgeon’s artistic impression. The chin-to-nose relationship is well known to plastic surgeons. A small chin has the affect of making the nose look larger. It is important for the surgeon to educate the patient about this relationship. It is also necessary to describe the affect the chin implantation
will achieve not only with respect to the nose, but also with respect to the rest of the jaw line and chin contour. Chin implants primarily address anterior projection of the chin at the pogonion in a sagittal dimension. To a lesser degree they also can address lateral width of the chin in the parasymphseal area. They do not significantly address the vertical height of the chin or change the width of the mandible.

**Facial analysis**

Attractiveness is a subjective quality, and many people who are considered "beautiful" have less than classic facial features in some aspects. In order to lend more objectivity to the process, the surgical community has established certain characteristics that are considered aesthetically pleasing. Many authors have proposed methods of facial analysis to allow surgeons to objectively evaluate their patients and thus plan surgical alteration of their appearance. Typically, detailed analysis of the facial features of people considered to be highly attractive have been used as the basis for these methods.

Multiple methods of facial analysis have been proposed by aesthetic surgeons are mostly based on one form or another of cephalometrics. This is nothing more than the formulation of geometric analysis of anatomic relationships of the face and head. Cephalometrics can be determined for "hard tissue" (skeletal) or "soft tissue". Soft tissue cephalometrics is the most commonly described in the aesthetic surgery literature, while skeletal cephalometrics is probably most useful for planning maxillofacial orthognathic or reconstructive surgery. To illustrate, if chin implantation is planned, soft tissue landmarks could be used to determine the amount of augmentation and therefore the size and shape of the implant, whereas if sliding genioplasty were planned, skeletal cephalometric analysis would be desirable.

**Chin Analysis**

Analysis of the soft tissue profile of the chin is the primary tool. Several authors have described methods of determining ideal chin position and will be described. No one method is "best", but some are simpler than others.

**Rish technique** - A line perpendicular to the Frankfort Horizontal line is projected tangential to the most anterior edge of the lower lip vermilion border. This perpendicular line is the meridian that marks the desired chin projection.

**Legan's angle** - One line is projected through the glabella and the subnasale, and a second line is projected through the subnasale and the pogonion. The ideal angle created between these two lines is $12^\circ \pm 4^\circ$.

**Merrifield Z-angle** - A line is projected through the pogonion and the most anterior point of the upper lip vermilion border. The angle this creates with the Frankfort horizontal line should be $80^\circ \pm 5^\circ$.

**Zero meridian of Gonzales-Ulloa** (1966)- A line perpendicular to the Frankfort Horizontal line projected through the nasion. The pogonion is supposed to be within 5 mm of this line. Slight (up to the quoted 5 mm) retraction of the pogonion from this line is more acceptable in women as this creates a softer more feminine profile. Retraction of the chin up to 1
cm is deemed 1st degree retraction, from 1 to 2 cm is 2nd degree retraction, and greater than 2 cm is classified as 3rd degree retraction. The significance of this is that 1st and 2nd degree retractions are treatable with implants, but 3rd degree retraction is best treated with maxillofacial surgery.

**Goode's method** - A perpendicular line is projected from the Frankfort horizontal through the alar-facial cease. The ideal chin position is said to be at or just anterior to this line.

**Lower facial triangle** - Drs. Calhoun and Gibson (1992) created the lower facial triangle method of analysis, wherein a triangle is defined by the tragion (consistent with the superior margin of the EAC), the subnasale, and the chin defining point (determined by centering an arc at the tragion with a radius that allows the arc to be tangent to the chin). The points T, S, and C are used, and based on comparative data, the ideal facial profile was determined to have a TC/TS ratio of 1.15 to 1.19, and an angle "S" of 88 to 93°. Interestingly, the algorithm provided by the authors proposes that this analysis be utilized only if the lower facial profile was subjectively not well balanced. In other words, if the facial features were subjectively appropriate, no further analysis was recommended. The reported advantage of this method better correlates with perceived adequacy of chin projection. The authors state that perceived adequate chin projection is affected by subnasal contour, relative lower-facial-third height, and relative facial mass, shape, and size. The lower facial triangle method incorporates all three of these facets.

**Peck and Peck** - This method also takes into account facial height in addition to anterior projections of facial profile features. The nasal angle is defined by lines from the tragion to the nasion and the nasal tip. The maxillary angle is defined by lines from the tragion through the nasal tip and through the labrale superius. The mandibular angle is defined by lines from the tragion through the labrale superius and the pogion. The ideal values for these three angles is 23.3, 14.1, and 17.1° respectively. The facial angle is then defined as the angle created by the intersection of a line from the tragion through the midpoint of a line from the nasion through the pogion. Dropping another line from the nasion to labrale superius, through the aforementioned line from the tragion, creates another angle, the maxillofacial angle. Finally, the nasal maxillary angle is created by the intersection of the projection from the tragion with a line drawn between the nasal tip and the labrale superius. The ideal facial, maxillofacial, and nasal maxillary angles are said to be 102.5, 5.9, and 106.1° respectively.

**Holdaway** - The "harmony" line or "H-line" is a projection from the pogion through the most prominent portion of the upper lip. The angle between this projection and a line between the pogion and the nasion is called the "H angle". The ideal H angle is 10 degrees and the higher the angle, the more retrusive the chin.

**Powell and Humphreys** - This method uses "aesthetic triangle" and is based on the ideal profile having a nasofrontal angle of 115/120° (male/female), a nasofacial angle of 36/36°, a nasomental angle of 130/130°, and a mentocervical angle of 80/85°. The interrelationship of these angles can be appreciated by constructing them on a facial profile and noting how changes in any one reference point can affect the other angles.

**Stambaugh** - A straight line is projected tangential to the most anterior point of the vermillion of the upper and lower lips with the lips when they are in contact over the teeth. The
chin should meet this line in males (+/- 2 mm), and be 2 to 3 mm behind this line in females (+/- 2 mm). As stressed by Gibson and Calhoun, Stambaugh emphasizes that the vertical height of the maxilla and mandible be considered when evaluating the patient for chin augmentation. If the mandible itself is short relative to the rest of the face, augmentation may accentuate lower lip eversion. If the maxillary height is disproportionately small, augmentation of the mentum can accentuate a deep sublabial crease.

Despite the existence of all of these mathematical methods of determining adequacy of chin projection, the majority surgeons do not sit with their patients drawing lines and calculating angles. Rather, they rely on gross visualization of the patient in multiple plains to get an overall feeling of the facial balance. Cohen writes, “A variety of authors have proposed aesthetic and cephalometric systems to evaluate the relative size and shape of the chin. None of these systems is absolute, and surgical decisions should be based on aesthetic relations and not cephalometric values.” Zide (1999) suggested the Quick Analysis of the Chin (QUAC) which is based on anatomic observations and not mathematical calculations. In this analysis Zide describes and stresses the importance the following: (1) lip eversion, (2) the anterior teeth, (3) chin pad thickness, (4) labiomental fold depth and height, and (5) dynamic chin pad motion with smile. He relates these anatomic points to potential unsatisfactory results which can occur after chin implantation if they are not taken into account in the preoperative period.

Malar Analysis

Despite the relative availability of literature about malar implantation augmentation, there does not appear to be a very widely accepted standard method of facial analysis to optimize preoperative planning. Rather, the definition of anatomic landmarks and methods of delineating the malar prominence and boundaries is accompanied by a caveat that malar augmentation should be offered when it will affect a greater harmony and balance of facial proportions. Perhaps the reason that standard facial analysis is difficult to apply to malar areas is that two dimensional projection analysis does not take into account the more important three dimensional aesthetics of the malar mound. In fact, the aesthetics of a particular individual may supersede algorithmic analysis. Nevertheless, a summary of some methods that can assist in evaluating the malar area follows.

**Hinderer** - In a frontal view, draw a line from the lateral commissure of the lip to the lateral canthus of the ipsilateral eye. Another line projects from the tragus to the inferior edge of the nasal ala. The area posterior and superior to the junction of these two projections should be the most prominent area of the malar eminence.

**Powell et al.** - A vertical line is drawn through the middle of the face and then the segment between the nasi and the nasal tip is bisected by a line that curves gently upward to the tragus on both sides. This line demarcates the . A line is drawn from the inferior ala to the lateral canthus and another one, parallel to this one, is drawn from the lateral oral commissure toward the ear. The intersection of the curvilinear horizontal line and the line from the oral commissure marks the point where the malar area should be most prominent.

**Silver and Guilden** - As general rule these authors suggest that if the malar prominence in the true lateral projection is greater than 5 mm posterior to the nasolabial groove then there is
deficiency in the malar area. As a more formal method of analysis Silver describes the malar prominence triangle. To construct this triangle draw a Frankfort horizontal line across the face in frontal projection, and a parallel line that bisects the upper lip. Then drop a perpendicular line through both of these lines and through the lateral canthus. The intersection of the vertical line and the line through the upper lip defines "point A". Project a line from point A though the medial canthus and then a second line from point A towards the temporal area but at the same angle from the vertical that was created by the projection from point A through the medial canthus. This creates the malar prominence triangle with the base the Frankfort line and the apex point A. Silver advises that the implant should be placed several millimeters below the Frankfort line.

Schoenrock - On an oblique view (27 to 35 degrees of rotation from the frontal view) with the patient in a position to keep the Frankfort line truly horizontal, a line drawn through lateral canthus and the mentum should reveal the "width" of the malar eminence. This is said to be about 3 to 7 mm in the average person, and therefore this gives the target for augmentation purposes in the under developed malar area. In evaluating this area it appears that the author intends for the 3 to 7 mm dimension to refer to the perpendicular distance from the projected line, and that he is describing the width of the skeletal component excluding the soft tissue covering.

Some authors confess that the best way to plan malar augmentation is to use computer graphics software that allow the surgeon to directly visualize the overall effect of malar augmentation on the video monitor. One method is to use a prototype implant of the proposed size, taped to the skin, and photograph the patient. Then using the software capabilities to shade the implant to match the surrounding skin, the postoperative appearance can be simulated so that the patient can be involved in the selection of the amount of augmentation. Whatever method is used, careful scrutiny of the submalar area should be performed. Flattening of the submalar area is sometimes more causative of midfacial disharmony than is malar flattening, and as noted previously, augmenting the malar area in these instances will only enhance the deformity.

IMPLANT SELECTION

There are a variety of implantable materials available. Implant materials have been the subject of a great deal of scrutiny in the past few years particularly silicone based products, which is important as this has historically been one of the more popular materials for chin and malar implants. The jury is literally and figuratively still out on this topic so any surgeon should familiarize himself with the available options. Autogenous implant materials do circumvent the problem of biocompatibility but also carry the price of donor site morbidity, absorption in some cases, and prolonged surgical procedures (harvest and donor site closure time in addition to normal implant time).

The key factor in implant behavior is the tissue/implant interface and this interface may change in reaction to the forces of the biologic environment. As originally proposed by Scales, the ideal implant material should behave according to the following criteria:

- it should not be physically modified by soft tissue
- it should not incite foreign body reaction
• it should not incite an allergic response or induce hypersensitivity
• it should be non-reactive chemically
• it should be noncarcinogenic
• it should resist deformation secondary to strain (it should be "elastic"
• not "plastic") it should be sterilizable it should be capable of being fabricated or modified
to the desired form easily.

No man-made material has been found that meets all the criteria, but some come reasonably
close.

**Metals**: All metals corrode to some degree in the human body. The implant/tissue
interface is the site of this action and with the initial reaction, there is the formation of an oxide
film which actually changes the characteristics of the interface and thus the process is retarded to
some extent. Stainless steel was the first metal to be used extensively, but it does corrode.
Vitallium was introduced in the 1920's and is an alloy of cobalt and chromium. Like all
chromium alloys, it has more corrosion resistance than stainless steel but is not corrosion proof.
Titanium is a bit more corrosion resistant than Vitallium. In general metals are used to restore or
change skeletal framework and are not often used to support soft tissue augmentation.

**Polymers**: are carbon chain based molecules with varying degrees of crosslinking,
which is the origin of their varied mechanical properties. This category includes the
dimethylsiloxanes (or "silicone" based molecules), polytetrafluoroethylene (PTFE) (eg. Teflon),
expanded polytetrafluoroethylene (Gore-tex), nylon, polyethylene, polyamide (Supramid),
polyethylene terephthalate (Mersilene). These are the most widely
used synthetic implant materials in facial contour surgery. All of the materials when used in
bulk induce a fibrous capsule formation around the implant. However, because these materials
can have textured surfaces and can be woven they can be "incorporated" into the implant site by
fibrous "ingrowth" which is a nice way of saying they promote a dense scarifying reaction that
can hold them in position. Composite polymeric implants, such as a silastic chin implant with a
Dacron (polyester fiber - polyethylene terephthalate) backing, promote tissue ingrowth and help
secure the implant and avoid migration are also available.

**Silicone based products**: silicon is a natural occurring substance in the body, found in
mucopolysaccharide. Depending on the degree of crosslinking, it can be formulated as anything
from an injectable liquid to a dense rubber like consistency. It is relatively inexpensive and can
be carved, or purchased in pre-molded implant shapes. It has been the most popular chin implant
material but some question its use due to erosion of the mentum after years of pressure when
implanted in its more firm form. An alternative to the solid form is the use of prefabricated
silastic bags filled with silicone gel, which according to some has not shown any evidence of the
tendency to cause erosion of underlying bone. The drawback of this approach is the limitation in
the size and shape of the implant commercially available. Despite this it is widely used.

**Polyamide**: Supramid is a commercially available mesh that is related to Nylon and
Dacron. It promotes a fairly intense foreign body reaction that causes a dense scarifying
reaction, making it very difficult to remove once healed in place, but also provides stability. It
has not been reported to be associated with bone resorption, and can be custom shaped through
folding or stacking pieces of the material together.
Polyethylene and Polyethylene terephthalate: Mersilene (polyester fiber sheeting) is a mesh similar to Supramid, but made of polyethylene terephthalate (also known as Dacron), and touted to be a good material for facial contouring. McCollough is a proponent of rolled Mersilene implants in facial augmentation. It promotes a less intense tissue reaction than Supramid. Medpor is the trade name for a relatively new polyethylene polymer that is porous. It has a pore size of between 135 and 250 micrometers. Theoretically a pore size of greater than 100 micrometers will allow osseointegration and soft tissue ingrowth into the implant, which would be ideal for facial implants. There are however some conflicting data concerning osseointegration of this material. However, it has minimal disadvantages and is available in preshaped implants or as a block form that can be carved to custom sizes.

Expanded Polytetrafluoroethylene (Gore-Tex): Gore-Tex is a widely used surgical implant material which was first used for vascular grafting. Its safety has been proven in animals (Neel, 1983) and humans. Two formulations of expanded PTFE are typically used in facial reconstruction today. Pure e-PTFE is an expanded, strongly hydrophobic, fibrillated polymer that can be produced in sheets, three-dimensional strands, and suture material. It is composed of nodules of PTFE interconnected through a fibrous mesh network, creating a three-dimensionally amorphous structure. Fluorinated e-PTFE is based on the standard architecture of e-PTFE with the addition of reinforcing fluorinated ethylene propylene bonds. This allows for sturdier sheets of e-PTFE and the ability to create three-dimensionally shaped implants. Ideally, a substance used for an implant with enough porosity to allow some ingrowth of tissue for stability but balanced with ability for easy removal. Newer formulations of e-PTFE have pore sizes up to 100 um which has been considered the ideal pore size for achieving stability and providing easy removal. The manufacturer of Gore-Tex have now begun to incorporate silver and chlorhexidine (MycroMesh Plus) which prevent bacterial adhesion. Advanta produces dual-porosity e-PTFE implants with an outer core porosity of 40 um and an inner core porosity of 100 um. Preliminary data suggest that these implants decrease the rate of migration, show reduced shrinkage of the construct, and are softer. Currently, Gore-Tex provides pre-made subcutaneous facial implants for nasal, malar, and chin augmentation.

Polytetrafluoroethylene (PTFE or Teflon): Proplast I was the first biosynthetic material specifically designed for implantation, and is a black solid composed of carbon fibers and Teflon. Proplast II (which is white), is mixture of Teflon and aluminum oxide (instead of carbon fibers). Both versions of Proplast are porous, allowing for some tissue ingrowth, and can incite fairly aggressive inflammatory reactions that last for months. They are not however noted to have a high infection or extrusion rate. Proplast material is available in commercially preshaped implant sizes, but can be carved with some difficulty. Although the Proplast II was developed to allow its use in areas covered by thinner skin because it is less likely to show through, it is a harder material and more difficult to carve than Proplast I.

Polymethylmethacrylate (PMMA): PMMA is a hard polymer that is frequently used in bony reconstruction of skull defects, it can be used as a facial contour implant. Gonzales-Ulloa, who was one of the pioneers of chin implants, uses it by choice and claims to have never experienced an extrusion or even a significant complication in 38 years. It can be purchased in preformed implant form, or fashioned intraoperatively in a cold-curing form. The cold-curing form comes as two components, a liquid monomer and a methylmethacrylate powder. These are mixed together and a polymerizing reaction takes place creating a temporarily malleable mixture
that is then custom shaped and trimmed to fit the needs of the surgeon. This form is not especially useful for implantation when the introducing incision is small, as in most malar and chin implant cases. There is also the risk of side effects sometimes seen due to the toxicity of the monomeric component, although this is rare. Nevertheless it has some excellent qualities such as superior biocompatibility and tissue ingrowth promoted by drilling multiple holes in the implant. The preformed version can be cut and shaped with rotary burrs.

**HTR:** "Hard Tissue Replacement" and is a trademark of the company that developed this composite material. It consists of a core of PMMA, surrounded by a coating of polyhydroxyethylmethacrylate (PHEMA) and calcium hydroxide. The intention is to create a hydrophilic outer layer that is capable of being osseointegrated. The absorption of water in the outer layer is accompanied by the presence of calcium ions carrying a negative charge. It has been shown that negative surface charge at the interface of healing bone enhances new bone growth, by mechanisms that are not clear. HTR has been used successfully in humans, but whether it delivers on the aspect of osseointegration is not agreed upon. There does appear in some studies to be a bilaminar fibrous capsule intimately associated with the implant with bone growth surrounding it in some cases (osseoconduction), but actual bone growth into the outer layer of the implant has only been reported in one animal study. HTR comes in block form, granule form (can be used to fill defects and irregular surfaces), or in preshaped implants. It is more difficult to custom shape and drill than most other polymers.

**Bioplastique:** Dr. Robert Ersek has reported the only use of this material in human subjects. Bioplastique is a biphasic mixture of textured 100 and 600 micrometer particles of vulcanized methylpolysiloxane in a gelatinous carrier vehicle. The gel is a "plasdone" and is readily absorbed by the body and excreted unchanged by the kidney. Dr. Ersek has used the material for chin augmentation to in 13 patients. A "pocar" is used to create an array of subcutaneous tunnels above the layer of the periosteum. The pocar is introduced through a puncture made on the opposite side of the mentum, and the tunnels are created in a radial fashion through this puncture. The procedure is performed bilaterally and a special injection gun and cannula system is used to deliver the Bioplastique mixture through the puncture into the subcutaneous tunnels. The amount of material is based on the judgement at the time of injection, and irregularities are "digitally" manipulated into smooth contour during the first postoperative week. There have been no reported adverse effects and no loss of augmentation in follow up, although the longest period is reported as five years. The augmentative effect is not thought to be due to the material itself, but rather to the development of multitudes of fibrous capsules around the minute particles.

**Synthetic bone graft materials:** Synthetic bone graft materials are intended to be incorporated into the host bone structure either through osseointegration or osseoconduction. The principle is that no intervening fibrous layer is supposed to exist between the implant and the host bone. There is some question.

**IMPLANT SIZING**

When planning orthognathic and maxillofacial procedures that rearrange the facial skeleton, it is common to use a 1.0 : 1.0 dimensional ratio in predicting the post surgical effect of a change in bone structure on soft tissue facial contour. Kent has found that with implant
materials, a ratio of 1.0 : 0.7 more accurately predicts the final result (about two years post-op); that is if you select an implant that is 1 cm thick, you end up with a 0.7 cm increase in soft tissue projection eventually. The loss of dimension comes from position shifts with settling or shifting of the implant, bone resorption (although this occurs over an extended period of time), and soft tissue thinning as it is stretched over the implant.

The size of the implants is selected based on the preoperative facial analysis, although the malar implant sizing is more subjective than the chin implant size. For chin implants the method to determine the width of the implant is not set in stone, and the surgeon's judgment with respect to lateral "tails" is the deciding factor. The length of the lateral portion of the chin implant can be used to change the overall appearance of the jawline. There are commercially available computer morphing programs to create the desired surgical effect on patient photos. Some surgeons will photograph the patient with the implant taped to their skin. The photograph is then digitized and the implant is colored to match the patient’s skin. This is useful because it involves the patient in the decision making process.

There are a number of commercially available preformed implants available for facial contouring. They come in various sizes and materials, and a complete discussion of these is not necessary. However, some research by the surgeon into the available products might save a great deal of intraoperative implant modification time.

SURGICAL TECHNIQUES

CHIN IMPLANTS

There are two basic approaches to chin implantation – external and intraoral. The majority of authors reviewed prefer an extraoral submental approach. Their reasons are that this avoids contamination form oral flora, and is associated with less post-operative morbidity for the patient. Stabilization of the implant is also said to be more difficult when the intraoral approach is utilized. However, Gonzales-Ulloa uses the intraoral approach and reports no increased incidence of infection or extrusion. He places a PMMA implant in an intramuscular plane of dissection, and uses a periosteal "U" stitch to secure its location. This method seems attractive, but nevertheless, the majority of authors report the preference for an external procedure.

For the external approach, a small submental horizontal incision is made just posterior to the first submental skin crease. Placement in the crease leads to a depression and ultimately may produce a witch's chin deformity. This is carried down to periosteum, which is incised along the inferior surface of the mandible on both sides of the midline. The periosteum is then elevated carefully superiorly and a bit laterally, taking care to avoid damage to the mental nerves (remember that the mental nerves exit the mandible about 25 to 27 mm lateral to the midline and approximately 1cm above the lower border of the mandible). The periosteum is elevated to create a pocket slightly larger than the implant to allow easier insertion. The pocket's position, whether directly over the leading edge of the chin (as is most often the appropriate location) or slightly above toward the labiomental sulcus on the flat surface, is determined by the desired or needed improvement. Care must be taken to place the implant inferior to the mental nerves. Approximating the size and preferred position of the implant by employing sterile implant sizers is useful. Laying a sizer over the chin and outlining it on the skin allows the surgeon initially to
dissect a pocket that is not excessively large. Anatomically shaped sizers are meant to be re-sterilized for repeated use. With the pocket developed, the sizer then can be inserted into this space to obtain a general idea of the best implant size. The implant is placed in the subperiosteal pocket. Most authors recommend some method of stabilization or fixation of the implant to avoid superior migration which might lead to accelerated bone erosion of the anterior mandible. Various methods of implant fixation have been proposed. The most common involves permanently securing the implant to the periosteum or soft tissue at the lower border of the mandible in two places. An alternative method includes transpad fixation with either sutures or needles to temporarily secure the implant.

Supra- versus sub-periosteal implantation is an area of some controversy, with some claiming that subperiosteal implantation leads to more bone resorption. Supra-periosteal implantation is an acceptable method, and some even perform a composite type of technique wherein they incise the periosteum laterally and elevate small tunnels in which to insert the "tails" of the implant, leaving the central portion of the implant above periosteum. The wound bed is irrigated copiously with antiseptic solution. No drains are used. Absorbable sutures are used for deep layers and nonabsorbable suture is used for skin.

Postoperative care includes a soft diet, elevating the head of the bed or use 2-3 pillows, limit touching or manipulating chin area, good oral hygiene (for patients with intraoral approach), gentle irrigation with antiseptic mouthwash and lukewarm water 2-3 times daily, no use of toothbrush around lower central incisors, antibiotics for 1 week, pain medication as needed, and 2 weeks of avoidance of strenuous activity. Sutures should be removed 5-7 days post-surgery for external sutures and 7-10 days postsurgery for intraoral sutures.

MALAR IMPLANTATION

Malar implantation can be performed through an intraoral "canine" type incision, a lateral subciliary skin/muscle flap approach, transconjunctivally, or via a rhytidectomy approach. The method used depends on the surgeon's skill, preference, and what other procedures are being performed at the same time. The intraoral approach probably provides the best exposure of the malar and the submalar areas and avoids an external scar. An incision is made in the soft tissue overlying the maxilla near the canine fossa similar to one used for a Caldwell-Luc procedure. The periosteum of the maxilla is elevated up to the malar area, taking care to avoid injury to the infraorbital nerve. The elevation is performed only as much as is necessary to introduce the implant as the subperiosteal pocket created will allow less movement of the implant if it is snug. Nevertheless, this approach has apparently allowed more mobility than others because it is the only approach where fixation of the implant stressed. One method of fixation is transfixion sutures, either through the overlying skin with the ends tied over a soft bolster or "external" splint, or suspension sutures triangulated through the superior/posterior aspect of the implant, passed blindly through the hairline and secured over a bolster. The transfixion or suspension sutures are removed after three or four days. Alternatively, in the case of a rigid implant, a screw can be used to directly fix the implant to the underlying bone.

The transconjunctival or subciliary approaches can be used independently or in combination with blepharoplasty. A standard transconjunctival approach allows access to the inferior and lateral orbital rims, and sharp dissection here followed by periosteal elevation allows
the creation of a pocket to accept the implant. The subciliary technique is similarly performed, but does create a minimal facial scar. Neither technique requires fixation of the implant, but both require (or at least it is recommended) a flexible implant material such as Silastic to be used because the incisions used are so small. Shoenrock uses this technique and recommends a textured Dacron backed Silastic implant (commercially available) to allow fibrous tissue ingrowth and adherence to maintain the position of the implant.

The rhytidectomy approach is advocated by those with experience in its use. It does put the frontal branch of the facial nerve at some risk, although proponents state that blunt dissection posterior to and parallel to the nerve is safe. This requires identification of the nerve and failure to do so would make this procedure less safe. If the nerve is found, the blunt dissection is carried down to bone, and the periosteum of the anterior zygomatic arch and malar prominence is elevated, creating a small pocket for the prosthesis. Again fixation is not possible, but a porous or predrilled implant is used by the advocates of this technique to encourage tissue ingrowth.

**COMPLICATIONS**

Complications after facial implantation can be classified as early or late. Early complications include bleeding, hematoma formation, nerve injury (mental or marginal mandibular n. – chin implants, infraorbital and zygomatic n. – malar implants), infection, and implant malposition. Late complications include implant migration (due to scarring) and or extrusion, bone resorption, post-infection deformity, and implant mobility. Infection is a particularly dreaded complication as it can lead to forced removal of the implant if antibiotics are not effective. Fortunately the incidence of postoperative wound infection ultimately requiring implant removal is very low. Studies have looked at the infection and extrusion rates for multiple implant materials and are all low ranging from 0.4-2.5% (Beekhuis, 1984, McCollough, 1990, Gross, 1999, Godin, 2003) To help prevent infection some authors advocate soaking the implant, especially the porous ones, in antibiotic solution such as gentamicin or bacitracin. Some commercially available implants come impregnated with antimicrobials. Most authors report preferring the external approach to the intraoral with the thought that saliva might contaminate the wound. Zide et al. reviewed 100 postoperative chin implant problems and stated, “almost all chin implant problems that the senior author has seen were caused by implants placed transorally.” They also favored external approach because it does not disrupt the insertion of the mentalis muscle which may change the location and appearance of the labiomental sulcus. Despite these assertions, no published studies have provided data to support the higher complication rate suggested with the intraoral approach.

Bone resorption under the implant is a controversial topic and there are conflicting reports concerning this occurrence. Implant characteristics do play a role in this with general agreement that the more firm the implant material the more likely there will be significant bone erosion. Some have suggested that subperiosteal implantation is more likely to lead to this complication. Supraperiosteal implantation may be more advantageous, but it also predisposes to increased implant mobility and this in itself is believed to be one of the causes of complications like infection, migration, and extrusion. As noted previously, a composite approach wherein part of the implant is subperiosteal and part is supraperiosteal may be useful and has been described for chin implants. Malar implants do not seem to be as subject to migration problems, probably due to less dynamic forces imparted on them as compared to chin
implants.

An additional complication, or at least the fear of this complication, has surfaced in recent times. This is the concern over the possibility of induced collagen-vascular illnesses secondary to silicone based implants. The most recent data does not support this, but fear over potential malpractice claims has not been quashed completely. Surgeons will have to make this choice based on their experience and the results of ongoing studies and litigation.

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