Standard and Customized Alloplastic Facial Implants Refining Orthognathic Surgery: Outcome Evaluation

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Purpose: Conventional orthognathic osteotomies provide appropriate functional outcomes but might be unable to correct midface deficiency, achieve a satisfactory outcome in asymmetrical cases, or allow sufficient chin advancement. We evaluated the outcome of both standard and customized facial high-density porous polyethylene implants used to refine the cosmetic outcome of orthognathic surgery.

Patients and Methods: We implemented a retrospective study. The sample was composed of all patients who underwent facial alloplastic augmentation between June 2011 and October 2018 in our department. The complication rate was recorded after a mean follow-up period of 41 months postoperatively, and patient satisfaction was assessed through a qualitative evaluation based on an 11-item questionnaire.

Results: The sample was composed of 24 implants placed in 14 patients: 13 mandibular angle implants, among which 4 were customized; 8 malar implants; and 3 chin implants. No physical complications such as hematoma, infection, migration, or hypoesthesia were observed. Two implants had to be removed because of early unsatisfactory esthetic outcomes. Of 14 patients, 11 answered our questionnaire. Eighty-two percent strongly agreed that the overall outcome was satisfactory.

Conclusions: The results of this study confirm the low physical complication rate described in the literature, and the esthetic complication rate remains lower than the rates observed in previous reports. A high satisfaction rate was found among patients. The lowest mean satisfaction score was noted for appropriate implant symmetry (3.5), whereas the highest mean satisfaction score (3.8) was achieved when using...
customized implants. If standard high-density porous polyethylene implants appear to be relevant adjuncts to orthognathic surgery, customized implants seem to achieve higher satisfaction, although their prohibitive cost should be considered.

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Restoring proper dental occlusion was initially the primary goal of orthognathic surgery. In modern practice, achieving optimal esthetics has become a major concern. Conventional osteotomies, such as the Le Fort I and bilateral sagittal split osteotomy, are suited to provide an appropriate functional outcome. However, they might be unable to achieve a satisfactory outcome in asymmetrical cases. Besides, the upper midface deficiency often encountered in patients with Class III deformity is not always corrected by Le Fort I maxillary advancement. Although modified maxillary osteotomy lines, such as those in Le Fort II or III osteotomy, can be used, they imply higher morbidity and are therefore usually reserved for severe deformities in syndromic patients. As a result, they do not seem appropriate for patients with common Class III deformity. Correcting severe retrogenia (receding chin) using a sliding genioplasty is also challenging, as adequate contact between bone segments, mandatory for bone healing, restricts the amount of chin advancement.

In all the aforementioned cases, skeletal augmentation is required. If autogenous bone onlay grafting appears to be a solution, it is available in limited quantity and requires time-consuming and complex graft modeling. This is particularly critical when symmetry is sought in bilateral structures, such as the zygoma and mandibular angle. Moreover, there is unpredictable postoperative resorption of up to 50% and increased donor-site morbidity. Prolonged surgical and hospitalization time increases procedure costs.

Alloplastic augmentation appears to be the solution to optimize the skeletal facial contour. Numerous alloplastic materials have been used, but they are known to induce various complications such as infection, displacement, foreign body reaction, and underlying bone resorption.

High-density porous polyethylene (HDPE) (Medpor, Stryker, Kalamazoo, MI) has been widely used for more than 40 years, particularly for esthetic indications. HDPE seems to offer many advantages compared with other biomaterials. Our aim was to evaluate the tolerance for and satisfaction with both standard and customized facial HDPE implants used especially to refine the cosmetic result of orthognathic surgery.

Patients and Methods

All patients who underwent facial alloplastic augmentation in our department between June 2011 and October 2018 were included in the study. All presented with a Class II or III dentofacial deformity and requested facial skeletal refinement. Most of the included patients were treated in the context of orthognathic surgical procedures. The patients comprised 2 groups: The first group had a history of orthognathic surgery, and these patients requested postoperative alloplastic morphologic refinement simultaneously with osteosynthesis plate removal, thereby allowing them to be considered their own controls. The second group consisted of patients who underwent alloplastic augmentation simultaneously with orthognathic surgery (Table 1).

After clinical examination and photography (frontal-view facial photographs with the face at rest and when smiling, as well as lateral and submental vertex views) by the first author (J.-C.L.), standard frontal and profile cephalometric radiographs and a 3-dimensional cone-beam computed tomography (CT) scan or CT scan (when considering customized implants) were obtained. The surgical staff of the department, involving 6 senior surgeons and 10 residents, then conducted the esthetic evaluation using the photographs to confirm the indication for implant placement. Treatment planning and the actual surgical procedures were performed by the first author.

The customized implants were initiated using the Stryker patient-specific solution Web application (CMF Customized Implants; Stryker Orthopaedics, Mahwah, NJ). A CT scan was performed with a slice thickness of 1 mm. Anonymized DICOM (Digital Imaging and Communications in Medicine) data were electronically uploaded to the Stryker Platform from which engineers achieved 3-dimensional reconstruction, using Mimics Medical (version 20; Materialise, Leuven, Belgium) and 3Matic (version 12; Materialise), and design with Freeform Plus (version 2016; Geomagic/3D Systems, Rock Hill, SC). The customized implants were designed using the mirroring technique during a Web session.
involving the first author and a Stryker engineer. A design proposal was uploaded for surgeon review and approval before manufacturing. The sterile customized implant was then delivered to the maxillofacial surgery department.

The patients were involved in the planning process. We presented the catalog of alloplastic implants to them to help choose the size of the implant according to their expectations, as well as a slideshow summarizing the surgical procedure. When customized implants were designed, the graphic rendering of the virtual surgical planning also was presented. This study was approved by the Strasbourg University Hospital Institutional Review Board (No. FC/dossier 2017-68), and all participants signed an informed consent agreement.

SURGICAL PROCEDURE

All procedures were performed by the first author. HDPE implants were placed simultaneously either with orthognathic surgery or with plate removal, which is often scheduled at 1 year postoperatively in our department.

Standard implants were chosen when bilateral implantation was indicated, whereas customized implants were preferred at a later stage, when addressing the correction of obvious asymmetry through a single implant (Fig 1). Initial subperiosteal infiltration of the operative site was performed using a solution with lidocaine (10 mg/mL) and epinephrine (0.005 mg/mL). Intravenous perioperative antibiotic prophylaxis (amoxicillin-clavulanate, 2 g) was administered.

All implants were placed through an intraoral incision, except in 1 case of a unilateral mandibular angle implant, in which a transcutaneous approach was performed using a scar left in the skin by a previous orthognathic procedure (Figs 1C, E). Sterile silicone sizing sets were used intraoperatively to help choose the appropriate size. Before placement, the chosen implants were immersed in hot saline solution to ease fitting. Minor individual implant contouring was performed, when needed, using a large scalpel blade (No. 23) or a round bur. The edges were feathered to obtain a smooth contour and to prevent any ‘step’ deformity.

Care was taken not to damage or compress any nerve adjacent to the implant. Once positioned in its subperiosteal pouch, each implant was fixed to the underlying bone using two 2.0 mm self-tapping titanium screws (Modus; Medartis Holding, Basel, Switzerland) placed intraorally to prevent migration. Only for mandibular angle implants were the screws inserted through a transbuccal approach using a drill guide or cannula.

Before suturing, the implantation site was rinsed with 100 mL of saline solution. A transcutaneous silicone drain was placed for the mandibular angle and chin implants. Submucosal and mucosal suture placement was performed with polyglactin sutures (No. 4-0 and 3-0).

A systematic compression bandage and a cooling facial mask (Allegre, Saint-Etienne, France) were applied. Methylprednisolone (2 mg/kg per day) was administered intravenously intraoperatively and then orally on postoperative day 1. Postoperative amoxicillin-clavulanate (3 g/day) was administered for 7 days.

POSTOPERATIVE FOLLOW-UP AND ASSESSMENT OF IMPLANT TOLERANCE

The drain was removed, radiographs were obtained, and patients were discharged on postoperative day 1. Chlorhexidine mouthwash and a liquid diet were prescribed for 10 days postoperatively.

Follow-up clinical and radiologic examinations of all patients were carried out at intervals of 1 week, 2 weeks, 1 month, 3 months, and 1 year, as well as once a year thereafter. Implant tolerance was assessed by the physical complication rate: infection, hematoma, seroma, implant displacement, and exposure were recorded at all follow-up intervals. Neurosensory disturbance was assessed using the light-touch test with Semmes-Weinstein monofilaments before implant placement and during follow-up. Anesthetic complication was considered when obvious residual asymmetry was observed at 1 month postoperatively by both the surgeon and the patient (Table 2). This timing was chosen to avoid deterioration of the patient’s experience with an obvious unsatisfactory cosmetic outcome and to proceed swiftly with revision surgery.

QUALITATIVE EVALUATION

Qualitative evaluation was performed based on a standard questionnaire sent electronically between November 2017 and October 2018 to all patients to assess their satisfaction regarding the esthetic outcome. The questionnaire consisted of 11 items. A 4-entry Likert scale was used for answers, scoring 4 of 4 for ‘strongly agree,’ 3 of 4 for ‘agree,’ 2 of 4 for ‘disagree,’ and 1 of 4 for ‘strongly disagree’ (Table 3). In the case of early implant removal because of esthetic complications, the patient only answered the questionnaire once revision surgery had been performed. Descriptive statistics were computed. The follow-up period between surgery and the time of qualitative evaluation was recorded.
<table>
<thead>
<tr>
<th>Procedures</th>
<th>Patients</th>
<th>Gender Ratio (M/F)</th>
<th>Mean Age at Surgery, yr</th>
<th>Mean Follow-up Period (Until October 1, 2018), mo</th>
<th>Implants</th>
<th>Standard Mandibular Angle</th>
<th>Customized Mandibular Angle</th>
<th>Malar</th>
<th>Chin</th>
<th>Side</th>
<th>Patients With Orthognathic Surgery Context</th>
<th>Procedures per Type of Skeletal Refinement</th>
</tr>
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<tbody>
<tr>
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<td></td>
<td></td>
<td></td>
<td>Group 1: Implantation After Orthognathic Surgery Simultaneously With Plate Removal</td>
<td>Group 2: Implantation Simultaneously With Orthognathic Surgery</td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Achievement of Symmetry</td>
<td>Correction of Mid/Third Face Deficiency</td>
</tr>
<tr>
<td>n</td>
<td>16</td>
<td>14:13</td>
<td>30.9</td>
<td>41:24</td>
<td>9</td>
<td>4</td>
<td>8</td>
<td>3</td>
<td></td>
<td>Bilateral in 8, right in 2, left in 3, centered in 3</td>
<td>10:3</td>
<td>5:4</td>
</tr>
<tr>
<td>%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>71:4</td>
<td>21:4</td>
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<tr>
<td>SD</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>9.9</td>
<td>22</td>
</tr>
</tbody>
</table>
FIGURE 1. Customized implant in treatment of severe asymmetry in patient with hemifacial microsomia (Goldenhar syndrome) affecting right side. The patient underwent multiple procedures during childhood, including mandibular distraction osteogenesis and bimaxillary osteotomy after growth. Together with agenesis of the left ear, obvious asymmetry of the mandibular angle was still present. Before reconstruction of the ear and for determination of its appropriate position, a customized right mandibular angle implant allowed satisfactory symmetry. A, Submental vertex preoperative clinical photograph. B, Submental vertex view of preoperative 3-dimensional (3D) computed tomography (CT) scan. C, Three-quarter preoperative clinical photograph. D, Three-quarter view of preoperative 3D CT scan. E, Intraoperative photograph of customized right mandibular angle implant placed through cutaneous approach (because of existing scar). The 2 screws fixating the implant should be noted. F, Submental vertex clinical photograph at 6 months postoperatively. G, Submental vertex view of preoperative 3D CT scan displaying virtual surgical planning of customized right mandibular angle implant (arrow). H, Three-quarter clinical photograph at 6 months postoperatively. I, Three-quarter view of preoperative 3D CT scan displaying virtual surgical planning of customized right mandibular angle implant (arrow). J, Intraoperative photograph of stock mandibular implant placed through intraoral approach in a different patient. One of the two screws fixating the implant is marked (arrow).

Results

SAMPLE AND IMPLANT FEATURES

A total of 24 consecutive facial implants were placed through 16 procedures performed with patients under general anesthesia by the first author. The sample consisted of 14 patients, with a gender (male-female) ratio of 1.3 and a mean age of 30.9 years (standard deviation, 9.9 years) at the time of surgery (Table 1).

Twenty-one implants (13 patients, 92.8%) were placed in patients in the context of orthognathic surgical procedures: 71.4% of patients in the first group (implants placed simultaneously with osteosynthesis plate removal 1 year after orthognathic surgery) and 21.4% of those in the second group (implants placed simultaneously with orthognathic surgery) (Table 1). The remaining 3 implants were placed for purely cosmetic purposes in a single patient with Class II deformity who did not consider orthognathic surgery.

There were 13 mandibular angle implants (among which 4 were customized) (Fig 1), 8 malar implants (Fig 2), and 3 chin implants (Fig 3, Table 1). Among the 13 mandibular angle implants, 8 references were RZ design reference: 4 medium and 4 large size. In the 5 asymmetry cases, 1 “contoured mandibular angle” and 4 custom-made implants were used. Seven implants were placed simultaneously with orthognathic plate removal, 3 were placed without any additional procedure, 2 were placed together with chin wing genioplasty, and 1 replaced a mandibular angle implant removed from the same position.

The 8 malar implants were all RZ design reference: 6 petite and 2 super-petite size. Four implants were placed simultaneously with Le Fort I maxillary advancement and advancement genioplasty; 4 implants were placed simultaneously with maxillary plate removal. The 3 chin implants were “contoured two-piece chin” implants. Two implants were placed simultaneously with chin plate removal; 1 was associated with no other procedure.

TOLERANCE

The mean follow-up period was 41 months (range, 3 to 88 months; standard deviation, 22 months). Complications are presented in Table 2.

PATIENT SATISFACTION

Of 14 patients, 11 (79%) replied to the questionnaire. Overall patient satisfaction, regardless of implant type, reached a high mean score (3.8 of 4), as did satisfaction with the profile esthetic outcome (3.8 of 4) (Table 3). The highest mean satisfaction scores were obtained for chin implant centering (4 of 4). The lowest mean satisfaction scores were noted for discomfort related to implant surgery (3.5 of 4) and implant symmetry (3.5 of 4) (Table 3).

Discussion

Our aim was to evaluate the outcome of both standard and customized facial HDPE implants. This study found no physical complications during a mean follow-up period of 41 months and an 8% esthetic complication rate, returning to 0% after revision surgery. The rate of patients who strongly agreed that the overall outcome was satisfactory was 82%.
HDPE facial implants were chosen when addressing facial skeletal alloplastic implantation cases. Indeed, many complications of silicone implants, such as exposure, infection, and major bone erosion, have been treated in our department. In numerous studies, HDPE facial implants, unlike silicone (Silastic, Dow Corning, Midland, MI), polytef (Gore-Tex, Gore and associate, Flagstaff, AZ), or polyester mesh implants (Mersilene, Ethicon, Sommerville, NJ), have been reported to provide very good tolerance and satisfactory esthetic results.

The most frequently reported complication was "patient dissatisfaction with appearance," ranging from 10.3% to 26.3%. The infection rate varied from 0.9% to 12.5% mainly depending on implant location (orbit and nose locations were particularly vulnerable to infections). As opposed to implants composed of other materials, HDPE implants allow fixation to the underlying bone. The rate of extrusion, implant removal, underlying bone resorption, hematoma, and seroma was lower than 1%. Tolerance in our study is consistent with these findings, given that no case of infection, hematoma, extrusion, displacement, or bone resorption was reported.

Residual asymmetry was observed in 2 patients (8% of all implants) at 1 month postoperatively (Table 2).

**Table 3. SATISFACTION QUESTIONNAIRE REGARDING ESTHETIC OUTCOMES**

<table>
<thead>
<tr>
<th>Statement</th>
<th>Total No. of Responses</th>
<th>1: Strongly Disagree</th>
<th>2: Disagree</th>
<th>3: Agree</th>
<th>4: Strongly Agree</th>
<th>Mean Score (of 4)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Altogether</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. I am satisfied with the overall result.</td>
<td>11</td>
<td>—</td>
<td>—</td>
<td>2 (18)</td>
<td>9 (82)</td>
<td>3.8</td>
<td>0.4</td>
</tr>
<tr>
<td>2. I am satisfied with the front aesthetic result.</td>
<td>11</td>
<td>—</td>
<td>—</td>
<td>4 (36)</td>
<td>7 (64)</td>
<td>3.6</td>
<td>0.5</td>
</tr>
<tr>
<td>3. I am satisfied with the profile aesthetic result.</td>
<td>11</td>
<td>—</td>
<td>—</td>
<td>2 (18)</td>
<td>9 (82)</td>
<td>3.8</td>
<td>0.4</td>
</tr>
<tr>
<td>4. I cannot see any step deformity.</td>
<td>11</td>
<td>—</td>
<td>—</td>
<td>2 (18)</td>
<td>9 (82)</td>
<td>3.6</td>
<td>0.8</td>
</tr>
<tr>
<td>5. I do not feel any discomfort related to the implant surgery.</td>
<td>11</td>
<td>1 (9)</td>
<td>1 (9)</td>
<td>—</td>
<td>9 (82)</td>
<td>3.5</td>
<td>1.0</td>
</tr>
<tr>
<td>B. Chin implant</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. The middle part of the chin is centered.</td>
<td>2</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>2 (100)</td>
<td>4.0</td>
<td>0.0</td>
</tr>
<tr>
<td>C. Bilateral implants</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. The implants are symmetrical.</td>
<td>8</td>
<td>—</td>
<td>—</td>
<td>4 (50)</td>
<td>4 (50)</td>
<td>3.5</td>
<td>0.5</td>
</tr>
<tr>
<td>D. Mandibular angle implants</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. The scar on the skin is inconspicuous.</td>
<td>6</td>
<td>—</td>
<td>—</td>
<td>1 (17)</td>
<td>5 (83)</td>
<td>3.8</td>
<td>0.4</td>
</tr>
<tr>
<td>E. Malar implants</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. The implants do not interfere with my lateral eyesight.</td>
<td>4</td>
<td>—</td>
<td>—</td>
<td>1 (25)</td>
<td>3 (75)</td>
<td>3.8</td>
<td>0.5</td>
</tr>
<tr>
<td>2. The implants do not interfere with my forward eyesight.</td>
<td>4</td>
<td>—</td>
<td>—</td>
<td>1 (25)</td>
<td>3 (75)</td>
<td>3.8</td>
<td>0.5</td>
</tr>
<tr>
<td>3. The implants do not interfere with my downward eyesight.</td>
<td>4</td>
<td>—</td>
<td>—</td>
<td>1 (25)</td>
<td>3 (75)</td>
<td>3.8</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Abbreviation: SD, standard deviation.

Both were treated with mandibular angle implants (as discussed later).

Qualitative evaluation found a high satisfaction rate because 100% of patients strongly agreed (82%) or agreed (18%) with the statement ‘I am satisfied with the overall result.’ The main negative feedback was related to step deformity and the discomfort experienced once the implant had been placed (Table 3). Such an outcome could be explained by the perfectible fitting of HDPE implants, which are often perceived as hard and rigid. We believe that the use of customized implants can help improve these results.

HDPE implants have a convenient versatility in facial augmentation. Their use to restore facial harmony after accidental trauma, radiotherapy, or cancer surgery has achieved a consensus. They also are used in the correction of congenital deformities and in esthetic contouring surgery. However, the use of HDPE implants to refine the outcome of

Orthognathic surgery has been scarcely described in the literature. In this study, 93% of patients (13 of 14) presented with an orthognathic surgery context, meaning they underwent either plate removal (71.5%) or orthognathic surgery (21.5%) simultaneously with implant placement. In our department, plate removal is often recommended at 1 year postoperatively, as the literature has shown a complication or discomfort rate due to orthognathic fixation plates ranging from 10 to 30%.23-26

Our results have shown that placing HDPE implants in an orthognathic context does not entail any increased risk of complications. Specific features can be emphasized depending on implant site (Tables 1, 4).

**MANDIBULAR ANGLE: STANDARD AND CUSTOMIZED IMPLANTS**

*Increasing Mandibular Angle Projection*

Preoperative assessment of mandibular symmetry is crucial, using especially a low-angle frontal facial photograph, with the patient’s head being placed in extension. Indeed, a pre-existing asymmetry can be unveiled or worsened when bilateral implants of the same size are used to increase the mandibular angle...
Correcting Asymmetry

An alternative to alloplastic implantation is "chin wing mentoplasty" consisting of a mandibular basal osteotomy that can simultaneously correct the position of the mandibular angles and the chin.27-30 However, it is not appropriate in cases of severe asymmetry as bone healing requires contact between bone segments. Subsequent bone grafting makes this technique more invasive than alloplastic implantation.

Five patients were treated with unilateral mandibular angle implants to achieve symmetry (Table 1). In 2 patients, asymmetry of the mandibular angles occurred after bimaxillary procedures correcting Class II dentofacial deformity in 1 and Class III in 1. Such asymmetry probably resulted from the mechanical overload between bone segments after mandibular osteotomy and inadequate fixation.31,32 One patient underwent revision surgery in which one of the previously placed bilateral mandibular angle implants was replaced with a customized implant (the aforementioned pitfall). In the last 2 patients, asymmetry resulted from insufficient correction of mild (or severe) hemifacial microsomia (Goldenhar syndrome) (Figs 1A-I).

The use of a unilateral standard mandibular angle implant in the first patient (contoured mandibular angle) did not provide a satisfactory outcome. Consequently, it had to be removed, and no further procedure was performed because the patient preferred to retain his initial appearance. Standard catalog implants therefore seemed hardly appropriate for optimal correction of asymmetry. Subsequently, the 4 other mandibular asymmetry cases were successfully treated using customized implants. Mirroring was used through CT scan–based computer-assisted design and manufacturing, considering the larger side of the patient’s face as a reference.

Of the 5 patients treated with unilateral mandibular angle implants, 4 responded to the questionnaire; 3 strongly agreed and 1 agreed that the overall esthetic result was satisfactory. Interestingly, no esthetic complication was reported by the 4 patients treated with customized implants.

Throughout the literature, the rate of esthetic dissatisfaction with HDPE implants ranges from 10 to 20%. This could result from the uneasy intraoperative fine-tuning of standard HDPE implants sometimes requiring instrumental contouring (needed in 40% of our case series). The use of customized implants could improve these results. Despite cost-related concerns, we definitely recommend the use of customized implants for the correction of asymmetry.

<table>
<thead>
<tr>
<th>Type of skeletal refinement</th>
<th>Implants</th>
<th>Procedures, n</th>
<th>%</th>
<th>Indication</th>
</tr>
</thead>
<tbody>
<tr>
<td>Achieving symmetry</td>
<td>1 unilateral standard mandibular angle implant and 4 unilateral custom mandibular angle implants</td>
<td>5</td>
<td>31</td>
<td>Restoration of symmetry after initial bimaxillary surgery in 3, restoration of symmetry after an initial cosmetic procedure in 1, and completion of symmetry in a dysmorphic case after numerous orthognathic procedures in 1</td>
</tr>
<tr>
<td>Correcting mid-third face deficiency</td>
<td>4 bilateral malar implants</td>
<td>4</td>
<td>25</td>
<td>4 secondary procedures after initial orthognathic surgery</td>
</tr>
<tr>
<td>Increasing mandibular angle projection</td>
<td>4 bilateral mandibular angle implants</td>
<td>4</td>
<td>25</td>
<td>4 secondary procedures after initial orthognathic surgery</td>
</tr>
<tr>
<td>Increasing chin projection</td>
<td>3 chin implants</td>
<td>3</td>
<td>19</td>
<td>2 secondary procedures after initial orthognathic surgery and 1 isolated procedure</td>
</tr>
</tbody>
</table>

Total                                             | 24                                    | 16            | 100 |                                                               |

From the 14 patients operated on, one had an obvious residual asymmetry that required early implant replacement and one patient underwent two implant procedures (first, for bilateral mandibular angle implants, second for a chin implant). Therefore, a total of 16 procedures were performed.

MALAR IMPLANTS

Some studies have suggested that Le Fort I osteotomy alone achieves a marked subjective improvement in malar projection when advancement is performed,\(^\text{33}\) together with a more favorable relation among orbits, ocular globes, and lower eyelids (reduction of excessive inferior sclera show) when vertical shortening is combined.\(^\text{34}\) They have emphasized that the decision for concomitant malar augmentation and Le Fort I advancement should be made on a case-by-case basis in conjunction with the patient’s concerns and that it could be prudent to reassess any malar deficiency concern after Le Fort I advancement and after resolution of postsurgical edema.\(^\text{35}\) In our series, 8 malar implants were placed in 4 patients, all affected by midface deficiency in the context of a Class III malocclusion. Consistently with findings in the literature\(^\text{33, 34}\) the implants were placed simultaneously with orthognathic surgery in 2 patients who were considered to have severe midface hypoplasia, whereas malar alloplastic augmentation proceeded 1 year after Le Fort I osteotomy in the other 2 patients.

No postoperative complications were encountered. All patients were very satisfied (3 of 4) or satisfied (1 of 4) with the esthetic outcome. The implants were placed simultaneously either with Le Fort I osteotomy and genioplasty (2 patients) (Fig 2) or with orthognathic plate removal (2 patients) (Fig 3). Although we did not identify any difference with the simultaneous procedure, we recommend implant placement 1 year after orthognathic surgery, together with plate removal. This allows more gradual facial changes compared with if implants were placed simultaneously through orthognathic surgery. Moreover, because plate removal is a quick procedure, the total operative time when combined with simultaneous implant placement remains short, and the risk of infection is therefore lower.

The mean age of malar implant patients was 32 years (range, 22 to 53 years), with 3 of them being younger than 30 years. If malar implants achieve optimal facial contouring in young patients (Figs 2B-H), they also provide strong support to the lower eyelid in older patients, therefore inducing a rejuvenating effect.

CHIN IMPLANTS

Regarding chin implants, 1 patient presented with a purely cosmetic indication with no orthognathic surgery context whereas the other 2 patients had indications of residual retrogenia and lip incompetence despite previous genioplasty. No postoperative complications occurred and a very satisfactory outcome was obtained in all 3 cases.

Genioplasty can be used either alone or combined with orthognathic surgery to refine functional and esthetic outcomes. However, appropriate bone healing requires contact between the chin segment after osteotomy and the superior mandibular segment. This anatomic constraint usually restricts chin advancement to a maximum of 10 mm, even if more were required for morphologic purposes. Our series shows that the placement of a chin implant to refine genioplasty, simultaneously with chin plate removal (after 1 year postoperatively in 2 cases) (Fig 3), is a promising solution, as has already been described in the literature.\(^\text{35}\)

An intraoral approach was used in our series, given the orthognathic surgery context and to avoid scarring, except in one case in which a previous cutaneous scar was used. The rigidity and size of the implants make their placement somewhat difficult and sometimes requires a large mucosal incision. Therefore, whenever possible, 2-piece implants such as chin implants were preferred.

Among all implant references, the RZ design, available for mandibular angle and malar implants, is presented as the result of anatomic studies. In our series, this reference has proved to be the most straightforward to place. According to the literature, both extraoral and intraoral approaches are efficient, and the risk of postoperative complications is equivalent, including infection and migration.\(^\text{20}\) We recommend implant placement simultaneously with plate removal whenever possible to allow progressive morphologic changes and lower the risk of infection.

Despite the sample size, our qualitative evaluation questionnaire is the first detailed questionnaire described in the literature. It might be useful to standardize the assessment of patient satisfaction.

Considering this series and the related literature, standard HDPE implants appear to be a relevant solution for the refinement of facial contour as an adjunct to orthognathic surgery. This is especially true when addressing upper midface deficiency in patients with Class III deformity, insufficient advancement genioplasty, and facial asymmetry.

The lowest mean satisfaction score was obtained for symmetry of standard implants (3.5 of 4), whereas the highest score was reached when customized implants were used (3.8 of 4). Custom-designed procedures are now performed in routine maxillofacial surgery.\(^\text{36, 37}\) Subsequently, customized implants are probably the future gold standard for alloplastic facial augmentation, although their current prohibitive cost can restrict their wider use.

Because HDPE implants cannot be visualized using conventional imaging techniques, interactive segmentation of the postoperative CT scan\(^\text{38}\) was conducted to render implant position in some cases in our series (Figs 2E, I). It might be interesting to develop an automated segmentation procedure\(^\text{39}\) to investigate the
long-term outcomes of HDPE implants regarding the surrounding facial tissues.

If implant customization can allow swift and accurate fitting, no convenient preoperative planning solution exists for standard implants. The development of a software program to allow the surgeon to plan the size and position of facial implants would be quite relevant. Different clinical scenarios could be simulated and presented to the patient to deliver optimal information and optimize decision making.

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References