FACIAL PLASTIC SURGERY CLINICS OF NORTH AMERICA

Facial Plast Surg Clin N Am 10 (2002) 265–277

Aesthetic malar recontouring: the zygomatic sandwich osteotomy

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The malar prominence has a profound influence on facial form and aesthetics. Therefore, malar augmentation is a popular procedure in Western culture. Most often, alloplastic materials are used for malar augmentation. Even for experienced surgeons, malar implants are not without complications. The technique of malar augmentation through zygomatic osteotomies is a valuable alternative. We have used the zygomatic sandwich osteotomy (ZSO) for more than 10 years and are quite satisfied with the results and the low complication rate.

Preoperative assessment

The evaluation of the malar area is somewhat hindered by a lack of anthropometric or cephalometric landmarks along its complex three dimensional curvature. The point zygion (Fig. 1A, point zy), which defines the maximum interzygomatic distance (zygion-zygion) [1] does not correspond to the area of maximum malar prominence (Fig. 1A, area x).

Malar recontouring involves not only the zygomatic region, but also the infraorbital, paranasal, and buccal regions. Furthermore, imperfections of other facial areas may reflect negatively on the malar region. Pitfalls can be avoided if one is conscious about these relationships. Evaluation should include the four basic photographic views: frontal, lateral, three-quarter oblique, and basal.

Frontal evaluation

The frontal evaluation can be simplified by visualizing an anterior and posterior facial plane [2]. The anterior facial plane is defined by the superior temporal line, lateral border of the lateral orbital rim, malar prominence, midface, and mentum (Fig 1A, line a). The posterior facial plane is circumscribed by the contour-line of the head (Fig. 1A, line b). This plane represents the frontal projection of the lateral side of the head. A combination of variable forms of these two planes defines a variety of facial shapes, including the round, oval, square, triangular, long, and short. Among the different facial contours, the oval form is considered to be the most aesthetic in both Caucasian and Oriental cultures.

In general, Caucasians are characterized by dolichocephaly, a long and narrow face. A pronounced malar eminence gives the Caucasian face an oval form. Oriental skulls are mesocephalic with laterally protruding malar eminences and pronounced mandibular angles, resulting in a square (wide and short) face. As the anteroposterior diameter of the skull is small, the face shows less perspective and is perceived as flat. This facial type needs malar and/or mandibular angle reduction to create an oval shape.

Chubby faces show a preponderance of the posterior over the anterior plane. Lateral soft tissues such

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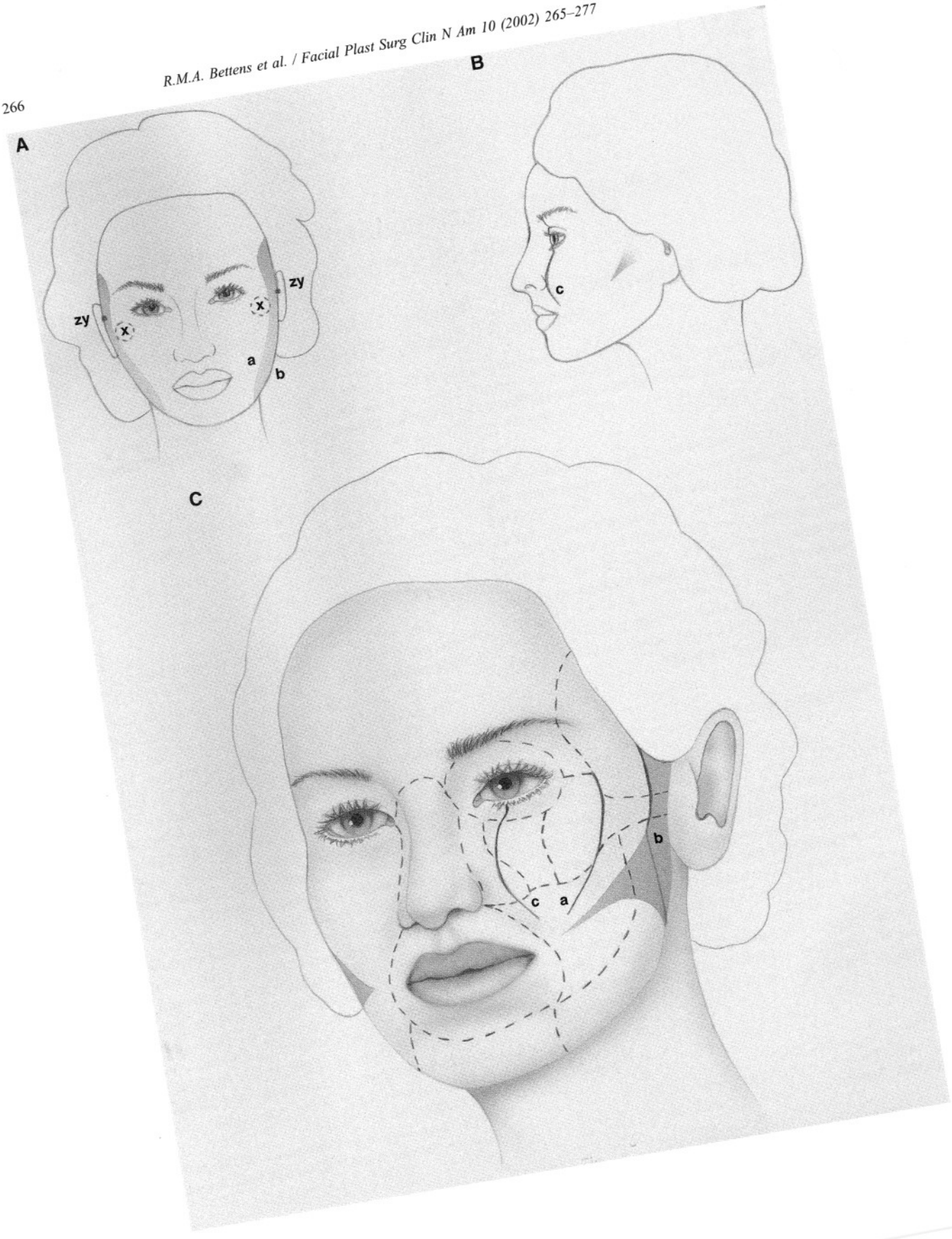
PII: S1064-7406(02)00012-3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as in the temporal and buccal area show increased convexity and dominate the facial appearance. The buccal region should be slightly concave or flat in adults, within the confines of a tangent from the cheekbone to the mandibular angle. Fullness in the buccal region can give the illusion of a poorly developed malar eminence. In these patients, partial excision of the buccal fat pad may be indicated [3]. Shadowing in the concavity of the buccal area highlights the malar eminence, giving it a sculptured, well-defined look. Caucasian women tend to accentuate this effect by using makeup, whereas Asians prefer much softer contours. But excessive buccal hollowness results in an emaciated, gaunt appearance with exaggerated malar definition.

Excessive width and prominence of the mandibular angle and masseter muscles make the malar eminence look small and give the face a square or triangular shape. Reduction of the mandibular angle and masseter muscles might be more adequate than malar augmentation. Surgical masseter reduction has been used succesfully for several decades [4]. Recently, Botulinum Toxin type A has been proposed to treat masseter muscle hypertrophy [5,6].

Besides general facial form, the surgeon should also look for facial asymmetries.

The malar eminence is also examined relative to the periorbital region. A high and prominent malar eminence enhances the appearance of the beautiful eye: the superolateral orientation of the brow and the mongoloid slant of the palpebral fissure are accentuated. In general, the more superiorly and laterally the malar prominence is located in the Caucasian patient, the more youthful and appealing the face will appear. Fullness of the area 10 mm lateral and 15–20 mm inferior to the lateral canthus should be obvious.

Lateral evaluation

The lateral view is best suited to evaluate anterior malar projection. The anterior malar projection is described by the anterior cheek contour (Fig. 1B, line c). Ideally, the anterior cheek contour forms one convex line, indicating youth, fullness, and harmony in the areas involved. The line starts at the inferior border of the tarsus of the lower eyelid, travels over the orbital fat compartment, and then follows the projection of the inferior orbital rim, the medial malar region, and paranasal region to end over the inferior part of the malar fat pad [7].

Also of importance is the position of this convexity in respect to the globe. When malar augmentation creates an excessively prominent cheek relative to the globe, it may produce a sunken orbital appearance [8].

The facial profile is assessed in order to detect abnormal maxillomandibular relations, as these can influence the relative appearance of the malar eminence. Attention should be paid to detect sagittal maxillary deficiency or vertical maxillary excess, as malar hypoplasia and central midface deformity may go hand in hand [9,10].

Three-quarter oblique evaluation

This view enables integration of the findings already made in the frontal and lateral views. It shows the entire malar area as a three-dimensional structure (Fig. 1C). The disadvantage is that no reference plane is available.

Basal evaluation

The basal view helps in evaluating symmetry. This view also facilitates evaluation of the zygomatic arch.

Philosophy

The vast majority of malar augmentations are done with alloplasts, probably because putting in a facial implant seems like an easy procedure. Achieving a satisfactory and symmetric result in malar augmentation is difficult, however, for even the most experienced surgeon [11]. In an American Society of Plastic and Reconstructive Surgery (ASPRS) survey [12] evaluating malar implants, a high incidence of complications was reported. Thirty five percent of the surgeons reported malpositioning of malar implants, 25% asymmetries, 15% hematoma/seroma/infections, 15% extrusion, 3% sensory deficit, and as high as 5% motor nerve dysfunction. Nearly 30% of the surgeons reported patients' disappointment with the size, shape, or contour of their malar implants, and 20–25% reported patient dissatisfaction as a result of asymmetry. Although being regarded as a reversible pro-

Fig. 1. Preoperative assessment. (A) Frontal view: zy = zygion; x = maximum malar prominence; line a delineates the anterior facial plane, which contains x; line b delineates the posterior facial plane containing zy. (B) Lateral view: line c = anterior cheek contour. (C) Three-quarter oblique view: three-dimensional contour of the malar area and its relationship to other facial regions.

cedure, over 30% and perhaps closer to 40% of secondary procedures were associated with some manifestation of nerve and/or muscle symptoms. Furthermore, capsule formation, implant migration, and the patients' awareness of implant presence are reported [13].

Onlay procedures of autologous, homologous, or heterografts also are associated with problems including irregularities, malpositioning, asymmetries, unpredictable resorption, and morbidity at the donor site.

Powell advocated malarplasty via osteotomy through an intraoral approach [14] (Fig. 2A). The osteotomy is made parallel to the lateral orbital rim. The lateral segment is separated and a graft of the surgeon's choice interposed. The result is an increase in interarch width (zygion-zygion) and, thereby, a transformation of a square or pear-shaped face to the more aesthetic oval contour. The disadvantages with the technique have to do with the lack of anteroposterior augmentation of the malar bone [15] and the morbidity at the donor site. In an effort to overcome this problem, some authors suggest making the inferior part of the osteotomy more medially [16,17]. This may add slightly to the lateral as well as the anterior component of the augmentation. The projection is more point shaped and more inferiorly located, however.

To solve these problems, Mommaerts et al [18] modified Powell's technique by connecting a vertical with a semihorizontal osteotomy which both transect the maxillary sinus, thereby maximizing anterior as well as lateral augmentation. Anterior malar projection is twice that achieved with Powell's technique (Fig. 2B). Moreover, the area of augmentation is increased (the area of maximum malar prominence is included) while avoiding any inferior movement of the osteotomized segment.

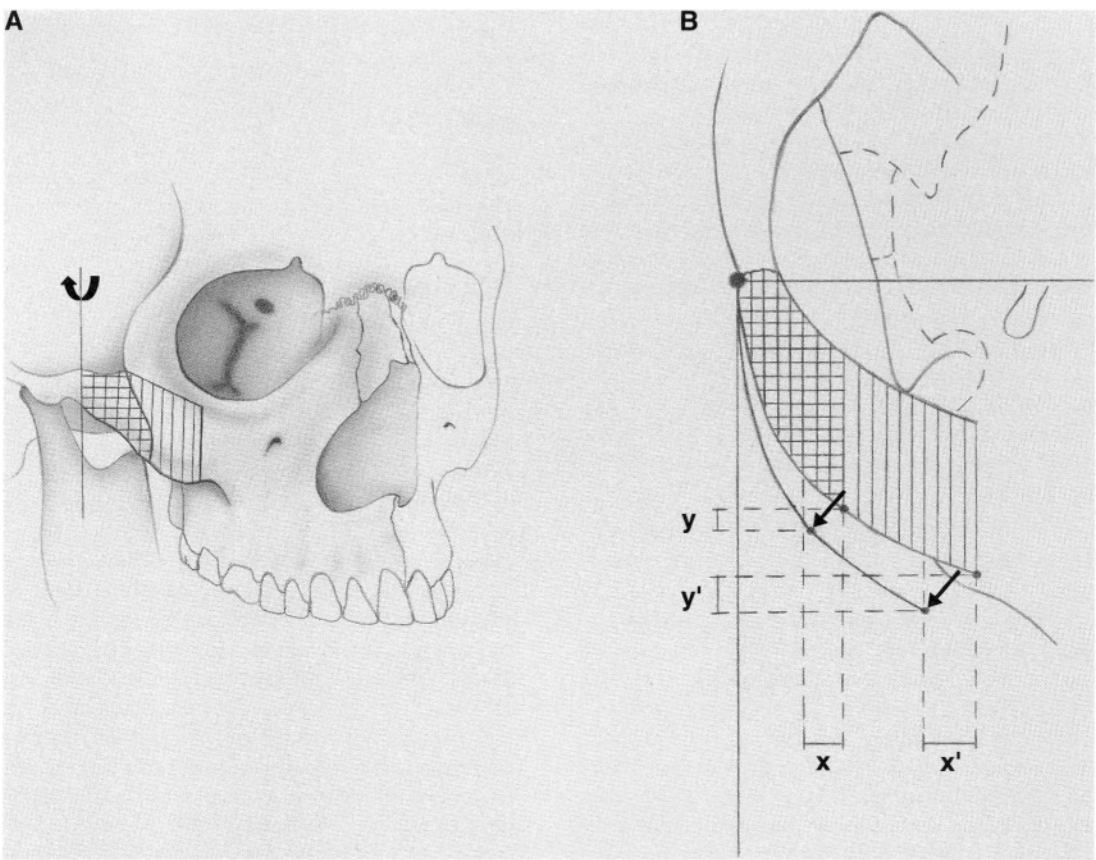

Fig. 2. Comparison of zygomatic arch osteotomy (Powell et al) and zygomatic sandwich osteotomy (Mommaerts et al). (A) difference in design (zygomatic arch osteotomy [ZAO] = horizontal lines; zygomatic sandwich osteotomy [ZSO] = vertical lines). (B) amount of augmentation, caudal view (x = lateral displacement with ZAO; x' = lateral displacement with ZSO; y = anterior displacement with ZAO; y' = anterior displacement with ZSO).

Indications for the ZSO

The ZSO is indicated when an anterolateral deficiency of the malar area is present, inferior and lateral to the lateral canthus. The ZSO can be performed as an isolated, purely aesthetic procedure in patients asking for malar augmentation [16], or it can be combined with simultaneous Le Fort I osteotomy in cases of vertical maxillary excess or sagittal maxillary hypoplasia [10]. Patients with cleft lip and palate or Treacher Collins syndrome with mild to moderate zygomatic hypoplasia are also excellent candidates for this procedure.

If reduction instead of augmentation of the malar prominence is the goal, such as in Oriental patients, a second vertical cut can be made, bone removed, and the zygoma infractured, retruded, and rigidly fixated.

In general, post-traumatic malar deformities cannot be treated by the ZSO because enophtalmus, displacement of the infraorbital rim, and canthal dystopia cannot be corrected. If excess or deficient anterolateral projection of the malar eminence is the only deformity, however, this can easily be corrected using the ZSO.

Technique of ZSO

A horizontal incision, parallel to and at least 5 mm cranial to the mucogingival margin, is made. When the ZSO is performed as an isolated procedure, the incision measures about 15 mm in length and is located in the premolar-first molar region. If the ZSO is to be combined with another midface osteotomy, the standard maxillary vestibular approach provides ample access. A vertical subperiosteal tunnel is made over the zygomaticomaxillary suture line. The cephalic border of the mucoperiosteal elevation is just cephalad to the "innominate" semihorizontal groove below the infraorbital rim, thereby avoiding detachment of the arcus marginalis. By not disturbing

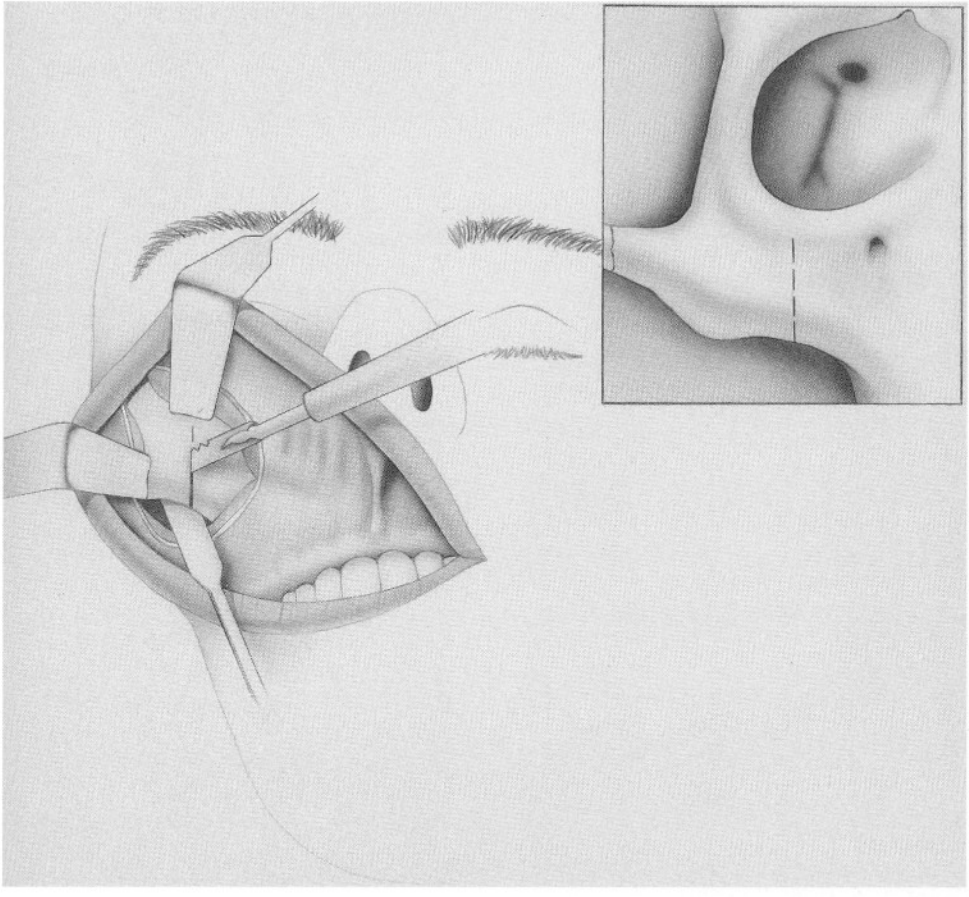

Fig. 3. Vertical osteotomy.

the orbital septum, ecchymosis is avoided. The periosteum is then tunnelled laterally up to the junction between the frontal and temporal processes, using a nasal elevator. By limiting the amount of dissection to this L-shaped zone, unnecessary edema is avoided and the vascularization of the osteotomized segment is preserved. Care is taken not to damage the periosteum in order to promote good bony healing. Another subperiosteal tunnel (approximately 20 mm in length) is made over the posterior aspect of the maxillary process of the zygoma.

While protecting the buccal fat pad and the temporalis muscle with a curved periosteal elevator, the vertical osteotomy is then made by using a thin reciprocating saw blade (disposable Aesculap-Werke AG, Tuttlingen, Germany) (Fig. 3). This vertical osteotomy transects both the anterior and posterior maxillary sinus walls. The bony cut stops at the semihorizontal groove, approximately 4 mm below the infraorbital rim.

An elevator is then positioned at the junction of the frontal and temporal processes to protect the soft-tissue envelope, while the oblique horizontal osteotomy is performed (Fig. 4). The osteotomy starts at this junction and proceeds in an anterior, medial, and slightly inferior direction, traveling through the semihorizontal groove 4 mm under the orbital rim to meet the cranial end of the vertical osteotomy. The reciprocating saw is angulated so that the anterior and posterior sinus walls are transected while leaving the orbital floor intact. The osteotomy lines are completed with chisels.

A 10-mm–wide osteotome (Leibinger GmbH, Tuttlingen, Germany) or a superior ramus separator (Leibinger GmbH, Tuttlingen, Germany) is then placed in the vertical bone cut, and outward pressure is exerted on the lateral segment in order to open the bony gap (Fig. 5). The zygomatic segment is rotated anterolaterally with the center of rotation located in the temporozygomatic suture line. It is important that

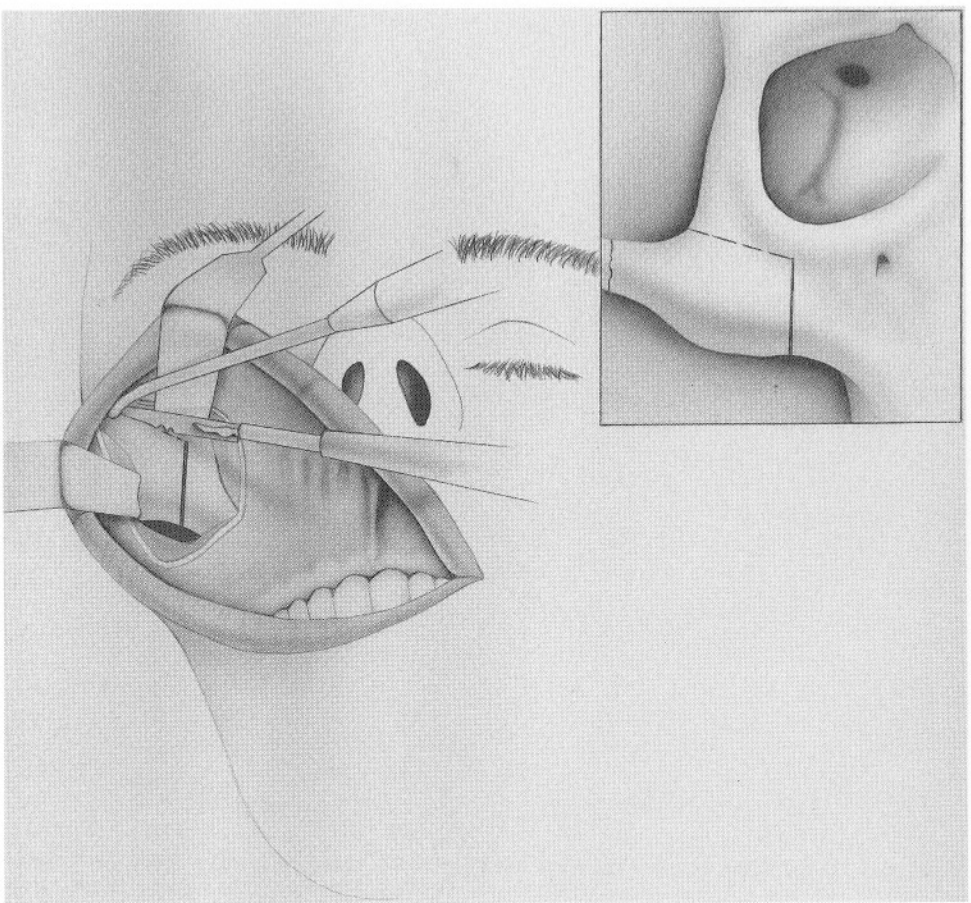

Fig. 4. Semihorizontal osteotomy.

the osteotomies are complete and that the fulcrum is at the inferior part of the vertical bone cut, where the bone is thick and dense (lateral maxillary buttress). If the lateral maxillary buttress is cut (eg, when a Le Fort I osteotomy is performed), it is advisable to pull laterally with the osteotome without applying pressure on the bone of the canine fossa. In some patients, the zygomatic arch will bend elastically, whereas in others a greenstick fracture occurs at the temporozygomatic suture. A wedge of hydroxyapatite or other material is carved to the exact width and wedged in the vertical osteotomy space. The wedge can be soaked in antibiotic solution prior to placement. The greenstick fracture will allow anterolateral displacement of the zygomatic bone, while exerting sufficient medially directed pressure on the rough surface of the wedge to secure it in position by friction. Alternatively, rigid fixation can be performed.

Results and complications of ZSO: a 10-year experience

During the past 10 years, 55 patients have been treated with the ZSO in the General Hospital of St John, Brugge, Belgium. A total of 105 osteotomies (50 bilateral and 5 unilateral) have been performed. Patient and surgeon satisfaction levels are high. The ZSO provides a distinct anterolateral malar prominence (Figs. 6–9) with smooth transitions in all directions, except cephalad where it leaves an invisible horizontal step-off located in the innominate groove between orbital rim and malar prominence. After bony healing, the step-off converts to a palpable groove just as in unoperated individuals. Augmentation of the infraorbital area is hardly ever necessary when a ZSO is performed. The undamaged periosteum will be tented off the bone medial to the vertical osteotomy

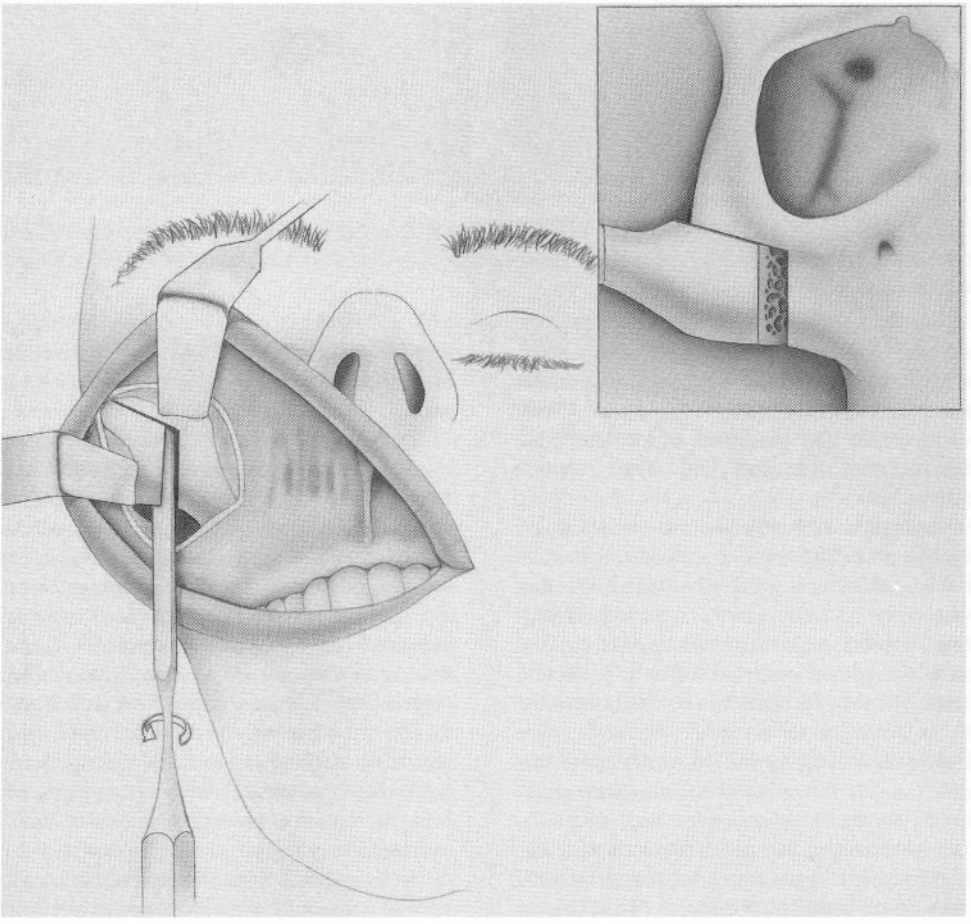

Fig. 5. Opening of the vertical osteotomy and insertion of spacer material.

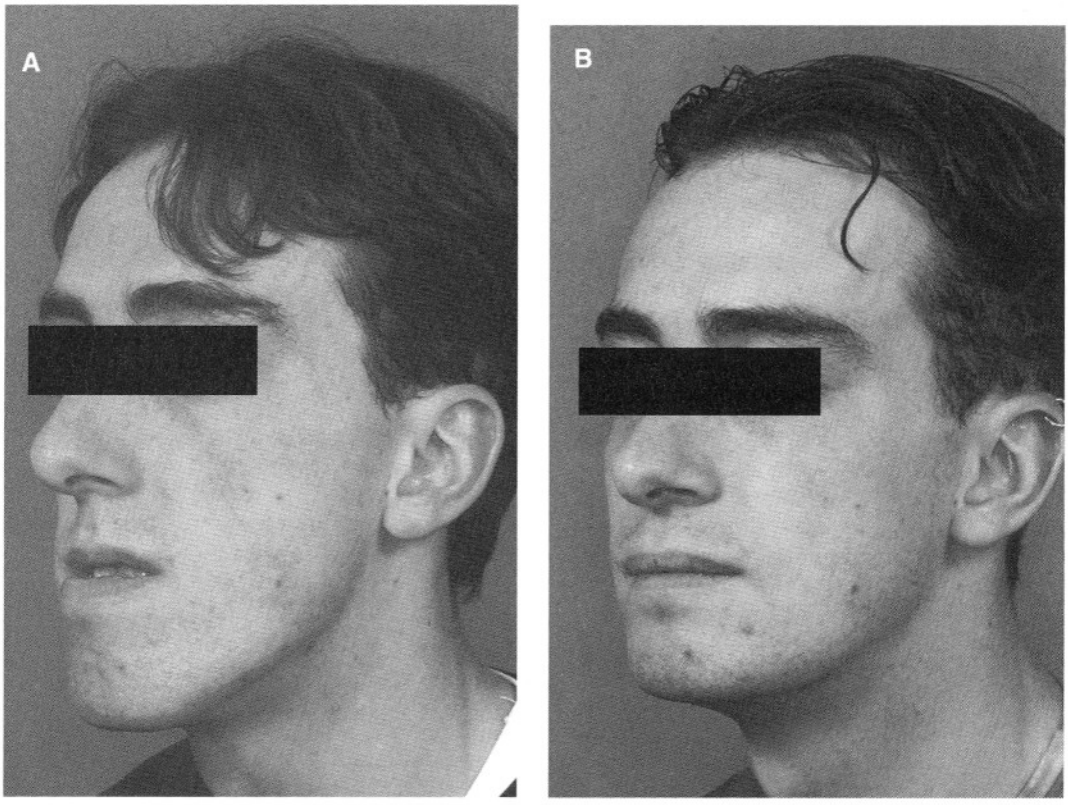

Fig. 6. (A) Before treatment and (B) 9 months after treatment, including advancement and vertical shortening of the maxilla, setback of the mandible, vertical shortening and advancement of the chin, rhinoseptoplasty, and bilateral ZSO for malar augmentation. (See also Color Plates 1 and 2.)

line, and bony apposition will occur to some extent. Clinically, we have found no evidence of relapse, not even when all facial buttresses were transected such as when the ZSO was combined with a Le Fort I osteotomy (with or without midline split) and lateral nasal osteotomies.

It is a safe procedure with minimal complications and minimal morbidity. Asymmetries or irregularities do not occur, and this is a big advantage over other malar augmentation techniques. The amount of augmentation is predictable and reproducible for the surgeon. If the patient desires a different projection postoperatively, the procedure can be easily repeated without any danger to sensory or motor nerve branches, as there is no capsule formation with this technique. Capsule formation often complicates revision surgery for malar augmentation with alloplasts. Facial nerve weakness has never occurred with this technique.Transient hypoesthesia of the infraorbital nerve can occur because of traction or inadequate positioning of retractor instruments. One patient complained of loss of sensation in the area supplied by the zygomaticofacial nerve. The lateral displacement of masseter and zygomaticus muscles has not caused any masticatory or mimetic problems.

Fracture lines in the orbital rim have occasionally been noted during mobilization with the 1-cm osteotome placed in the semihorizontal osteotomy. This problem can be avoided by checking whether this semihorizontal osteotomy has been fully completed in its posterior part, thereby avoiding pressure building up during mobilization. Instead of bending or greenstick fracturing of the zygomatic arch, a true fracture of the arch may occur. Osteosynthesis will help in these circumstances to prevent the masseter muscle from pulling the segment downward. Postoperative swelling is minimal when unnecessary degloving is avoided. Hematoma formation has not been an issue, as drainage is provided through the open maxillary sinus.

Sinus-related complications have occurred. These are not caused by maxillary sinus opening. Transsecting the walls of a healthy maxillary sinus in Le Fort-type osteotomies does not cause problems [19].

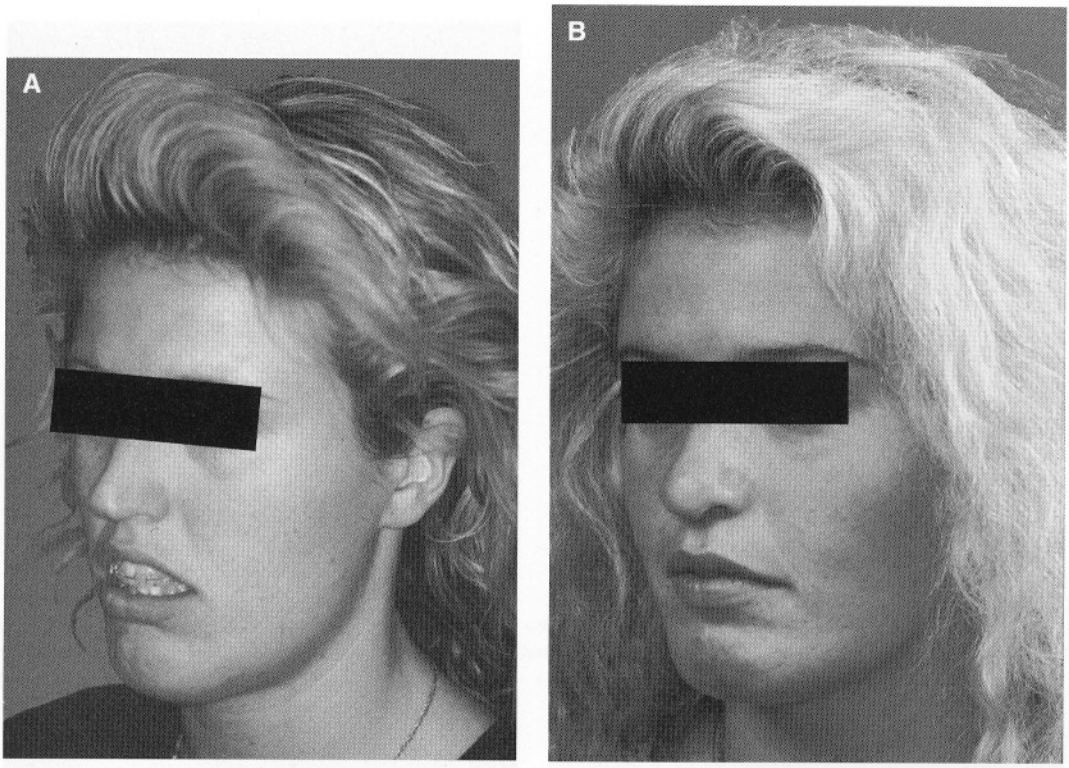

Fig. 7. (A) Before and (B) after treatment, including vertical shortening and surgical widening of the maxilla, vertical shortening and midline correction of the chin, septorhinoplasty, bilateral surgical masseterreduction, V-Y plasty of the upper lip, and bilateral ZSO for malar augmentation. (See also Color Plates 3 and 4.)

But exposing the inside of the maxillary sinus to a foreign body is different. We have used different methods and materials to maintain the anterolateral displacement. Autologous bone grafts may give way to the compressive forces if no osteosynthesis is used. Bone grafts also involve donor site morbidity and lengthen operation time if they are not harvested during a concomitant procedure (eg, reduction genioplasty). Another concern is the possibility that cortical blocks with smooth surfaces would slip into the maxillary antrum. In three osteotomies, cranial bone grafts were used. In seven osteotomies, bone harvested during reduction genioplasty was combined with osteosynthesis. No infections occurred in these patients. In 50 ZSO procedures, porous hydroxyapatite blocks (Interpore 200, Interpore International, Irvine, CA) were used, and calcium carbonate blocks (Biocoral, Biobloc 3, Inoteb, France) were used in 40 sites. Both of these spacer blocks have a rough surface, preventing them from slipping into the sinus. They are (partially) invaded/substituted by bone and provide mechanical resistance against the inward elastic forces generated by the zygomatic arch and soft tissues until the semihorizontal gap is ossified. Hydroxyapatite blocks have been used successfully in Le Fort I extrusion procedures [20] in a situation that generates similar conditions regarding exposure to the antrum and resistance to compressive forces. As these blocks are not completely substituted by bone, masticatory movements can lead to frictional forces and chipping of the material. Small fragments falling into the antrum may cause sinusitis. Sinus-related complications were noted in four patients. Chronic maxillary sinusitis was pre-existent in one patient. A subacute exacerbation in that case responded well to postoperative antibiotics. The three other patients (two with hydroxyapatite and one with calcium carbonate blocks) healed uneventfully after antibiotic treatment and rinsing or sneezing out a small fragment. The spacer blocks did not have to be removed.

Large hydroxyapatite blocks should be avoided. This is evidenced by one patient with Treacher Collins syndrome in whom a 10-mm–wide block was placed. A unilateral fistula developed in the buccal sulcus with periodic release of hydroxyapatite granules. Curettage had to be performed annually for

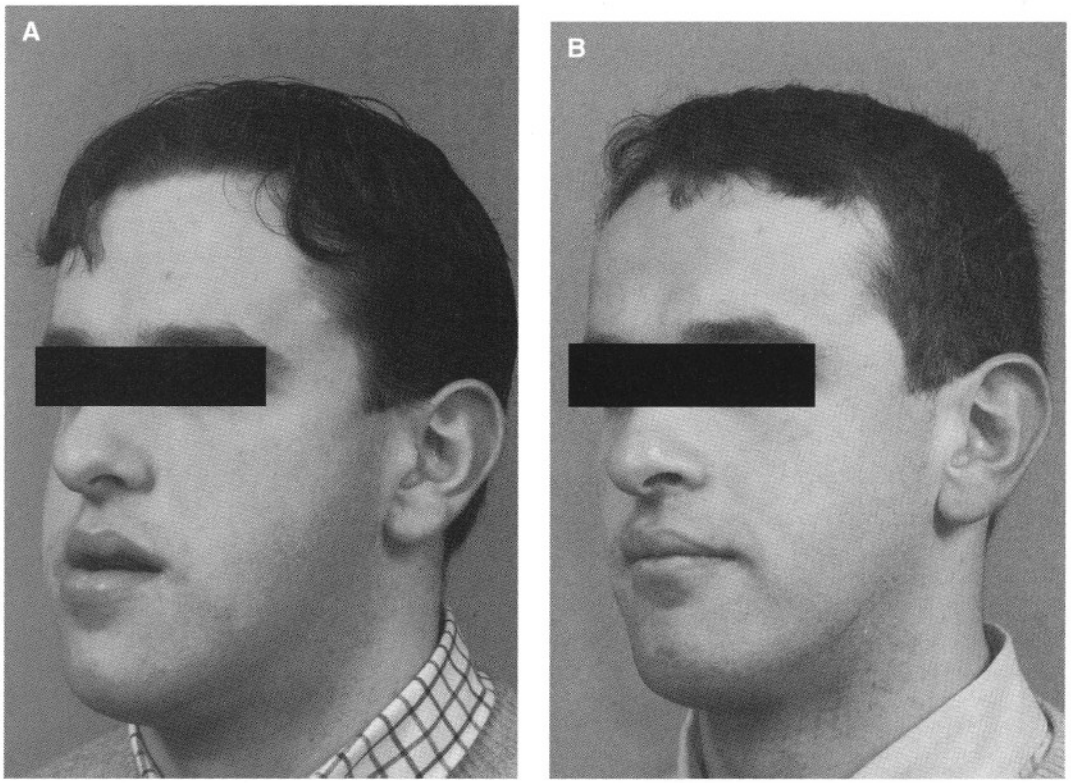

Fig. 8. (A) Before and (B) 2 years after treatment, including advancement and vertical shortening of the maxilla, set-back of the mandible and bilateral ZSO for malar augmentation. (See also Color Plates 5 and 6.)

5 years. The use of autologous bone grafts with osteosynthesis would have prevented this situation.

In one post-traumatic case, bovine cartilage was used for correction of enophtalmus and saddle nose deformity. In this patient, the cartilage was also used at the unilateral ZSO. Unfortunately, the cartilage block became displaced anteriorly and required secondary reshaping.

Recently, we have used merely osteosynthesis with or without bone grafts. For this purpose, special miniplates (Surgi-Tec n.v., Brugge, Belgium) have been designed that allow adjustment of the width of the vertical osteotomy gap without relocating the plate (Fig. 10). A third small hole in the middle of the plate allows for fixation of a bone graft by a microscrew [21].

Zygomatic osteotomies for malar reductions

Because of anthropometric as well as cultural differences, Oriental patients often ask for malar reduction instead of augmentation. Most often, the aesthetic complaint is the result of an increased bizygomatic arch distance as well as exaggerated anterolateral protrusion of the malar eminence.

In the past, this was corrected by using two separate approaches. These techniques depended on shaving, chiseling, or burring down the malar body [2,22]. A symmetrical and natural result was difficult to achieve through an intraoral approach as the existing curve had to be modified completely in a semiblind fashion. Furthermore, prominence of the posterior part of the arch still had to be addressed by resection or osteotomy of the zygomatic arch. As the zygomatic arch is a thin bone measuring only 3–5 mm in cross-section, trimming down the arch does not allow sufficient results.

Other surgeons have proposed treating the prominent zygoma in a different way. Instead of treating the body and arch as two separate entities, they performed osteotomies in which the zygomatic body and arch were moved in one piece after exposure through a coronal approach [23,24]. Some of these osteotomies involved the intraorbital space and were designed as if treating a malunited zygomatic tripod

Fig. 9. (A) Before and (B) 6 weeks after treatment, including vertical shortening of the maxilla, advancement of the mandible, vertical shortening and advancement of the chin, septorhinoplasty, and bilateral ZSO for malar augmentation. (See also Color Plates 7 and 8.)

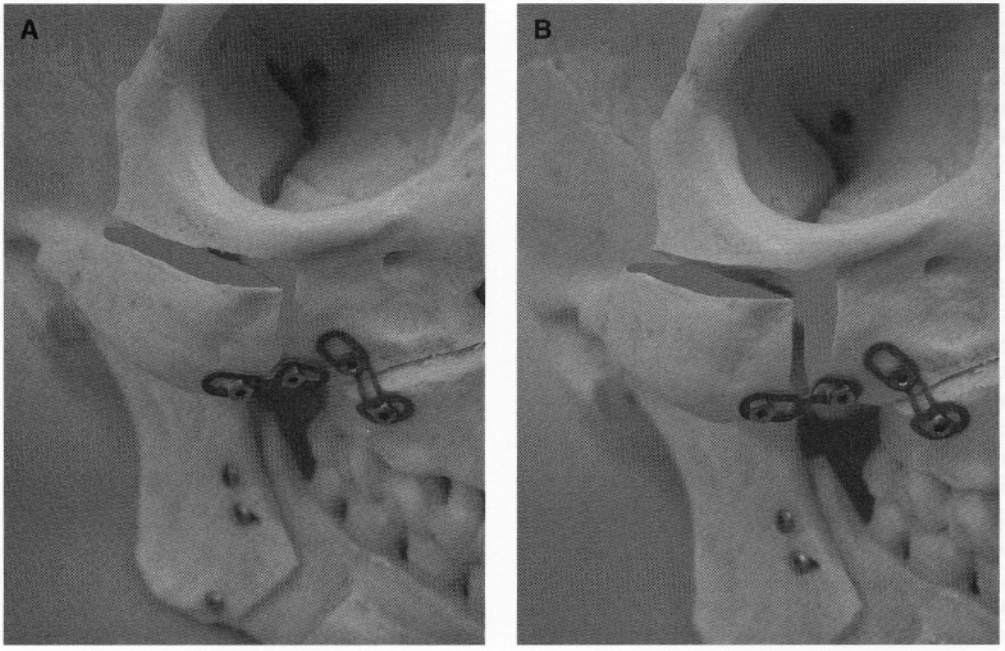

Fig. 10. Miniplate system that allows adjustment of the vertical osteotomy gap without relocating the miniplate: (A) less augmentation; (B) more augmentation. (See also Color Plates 9 and 10.)

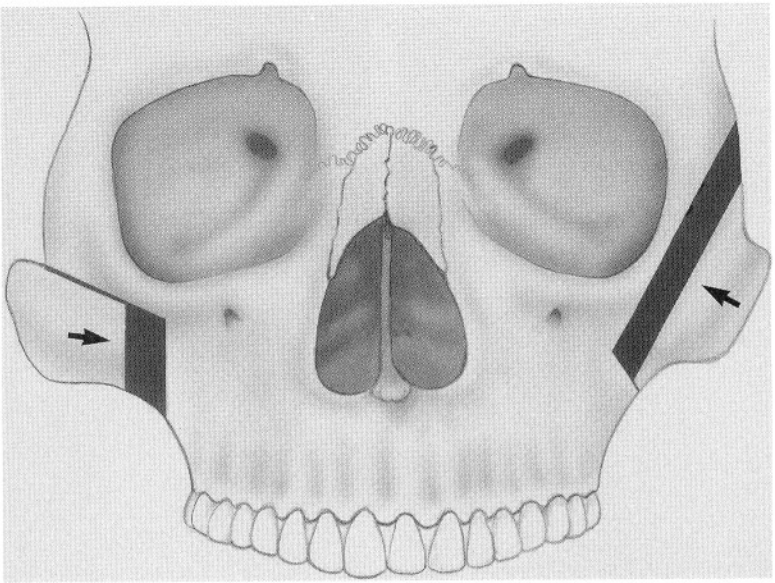

Fig. 11. Malar reduction, differences in osteotomy design: Mommaerts et al (left) compared with Kim and Seul (right).

fracture [25]. This resulted in overall reduction of the malar body, lateral orbital wall, and zygomatic arch. These aesthetic operations were of a rather extreme nature, however, with diplopia and changes in orbital volume as possible complications. Another disadvantage was the need for a coronal approach.

Less invasive techniques emerged when the intraoral approach was used to perform malar osteotomies that did not involve the intraorbital space. Their designs are very similar to the osteotomies used for malar augmentation. Instead of placing a spacer in the osteotomy gap, a second osteotomy is performed parallel to the first and the bony segment in between is removed.

Recently, an osteotomy for malar reduction was described that is similar in philosophy to the ZSO [26]. The L-shaped osteotomies transect the maxillary sinus. The authors state that this design preserves the natural curve of the malar prominence while allowing more reduction in comparison to a double straight osteotomy technique [27]. This is the same philosophy as the ZSO. But the differences in design (Fig 11) between the ZSO and the reduction malarplasty proposed by Kim and Seul include: (1) the L shape is rotated in the technique of Kim and Seul in order to include reduction of the inferolateral orbital rim which is most often enlarged proportionally in the prominent Oriental zygoma, and (2) accordingly, the bony segment is removed in the upper leg to allow lateral orbital rim reduction and to create a superior component along with the medial displacement, thereby repositioning the malar eminence in a more superior and thus more pleasing position.

A greenstick fracture of the posterior part of the zygomatic arch is performed with a sharp, curved osteotome. This is accomplished through the intraoral incision by approaching the arch from its medial side. After mobilization, rigid internal fixation with miniplates on the zygomaticomaxillary buttress and/or zygomatic body secures the zygoma in its new position. This technique allows for considerable malar reductions.

Intraoral malar reduction techniques have been accused of causing "cheek droop" [24,28]. In our opinion, this is primarily caused by extensive subperiosteal detachment. Performing malar osteotomies instead of burring or chiseling of the malar prominence allows far less subperiosteal tunneling.

Summary

We have used the ZSO as an alternative for malar augmentation with alloplasts. The technique of the ZSO is relatively simple and fast. In our 10-year experience, we have noted good results. One of the biggest advantages is that the augmentation is very predictable and a symmetrical result was obtained in all 50 bilateral cases. The amount of augmentation that can be achieved with the ZSO is greater than with Powell's original technique, especially in the

amount of anterior projection. All patients were satisfied, except for one male who complained of excessive malar volume postoperatively. This was easily corrected by a second procedure. Patient morbidity is low. The only annoying complication was maxillary sinusitis from fragmenting of spacer material (hydroxyapatite or calcium carbonate blocks). This occurred at three sides (out of a series of 105 osteotomies). After treatment of these patients with antibiotics, all spacer materials remained in place, maintaining the final augmentation results.

Overall, the ZSO compares favorable in results and complication rates with malar augmentation with alloplasts. This procedure should be learned and considered in any patient desiring augmentation of the malar region.

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