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Auricular reconstruction after Mohs' surgery. a review

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Introduction

Deformities of the external ear have either a congenital or a traumatic origin. The latter group includes deformities resulting frorn tumor surgery. The external ear has little functional influence on hearing, but is able to support eye-glasses. Considering the auricle as both a functional and aesthetic appendage, it is obvious that even minor auricular deformities may be a cause for psychosocial stigmatization. Although auricular reconstruction has been performed for a long time, its technical complexity is still con-sidered a challenge. Many recent innovations have made excellent reconstruction possible, and this article presents a discussion of all feasible methods.

Multiple factors influence the management of auricular defects. The anatomy of the auricle is complicated by its multiply curved and bent contours. Apart from reconstructing a normal appearing auricular contour, the visible normal ear dictates symmetry, compounding the dif-ficulties involved.

In the case of auricular skin malignancies, tumor histology, location, extent of disease (Table 1) and treatment modality all influence the degree of confidence of tumor control and, indirectly, the method of reconstruction. For every defect, the size, location, availability and condition of the adjacent skin, as well as the age and state of health of the patiënt, should be con-sidered. Moreover, the patiënt's aesthetic stan-dards and goals present variables to be included in the decision making process. With this large number of factors in mind, the surgeon must choose from a variety of reconstructive options available, ranging from primary side-to-side clo-sure, secondary intention healing, skin grafts, as well as local and regional flaps, sometimes sup-plemented with autogenous cartilage grafts for structural reconstitution. Proper planning and optimal soft tissue management is essential to minimize the number of procedures involved while preventing unnecessary scarring.

Pertinent anatomy

With the exception of the lobule, the shape of the upper two-thirds of the auricle is determined by a single piece of elastic cartilage covered by a skin soft-tissue envelope. The structural support of the auricle largely depends on three carti-laginous arches, including the conchal, ante-helical, and helical arches which are arranged in three laterally progressive levels[1]. The lateral surface skin is relatively thin and closely adherent to the underlying cartilage creating the complex convolutions of the auricle. On the

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Table l. Auricular defect classification

Extent of defect
- defects of cutaneous covering
- with or without intact cartilage structure
- full thickness defects

Location of defect
- helical rim (superior/lateral)
- cavum conchae/ triangular fossa
- scapha / antihelix
- lobule
- posterior ear

medial site the skin is thicker, more loosely attached and in relative abundance. This difference in skin mobility gives more latitude for rearrangement of skin soft tissues on the medial side, in terms of graft and flap harvesting, compared to the lateral side. Visually, the ear will be perceived as an ear if at least three curved lines suggest the basic shape of the helix (and lobule), antihelix, and tragus.

The arterial blood supply to the auricle is derived from the external carotid artery and specifically from two of its branches, the superficial temporal artery and the posterior auricular artery. The excellent auricular blood supply does not preclude, and even dictates, the use of local anesthetic in combination with adrenaline around the ear for surgical purposes. Although in exceptional cases axial pattern flaps are used, most of the local flaps on and around the ear are random pattern flaps, which derive their reliability from the extensive vascular network on and around the ear. Essentially, all the arterial and venous connections come from inferior, so this must be considered in the flap design.

The lymphatic drainage pattern of the ear is important when dealing with auricular malignancies[2]. The major part of the auricle drains posteriorly into the mastoid and infra-auricular lymph nodes, then into the jugulodigastric and upper cervical nodes and subsequently into the posterior and anterior cervical triangle. The exception is formed by the tragus and helical root, which drain anterior to the parotid field and to the nodes of the upper jugular chain. Major posterior-inferior lymph flow may induce prolonged swelling in postero-inferior based flaps. This may be used creatively to enhance fullness of the flaps designed for helical rim reconstruction.

Auricular malignancies

Actinic exposure, by way of its projection from the face, makes the auricle a common site of cutaneous malignancy Of all skin cancers, malignancies of the auricle constitute about 6%. Although reported with variation, the relative frequency of squamous cell carcinoma, basal cell carcinoma and melanoma of the auricle and periauricular structures is 50-60% for squamous cell carcinoma, 30-40% for basal cell carcinoma and 2-6% for malignant melanoma[3]. Most cutaneous malignancies are found on the helix, antihelix, and posterior surface of the ear[4]. Less commonly, tumors may arise in the conchal bowl, on the lobule or tragus.

Most basal cell carcinomas are either noduloulcerative or of a superficial type. These tumors have a predominant expansive type growth pattern accounting for a circumscript, well-defined border and a relative high cure rate with conventional treatment modalities. Basal cell carcinomas with aggressive histological features, such as morpheaform, sclerosing and infiltrating types are less circumscript, more invasive with unpredictable tumor extensions.

Various other factors may account for the high rate of recurrence, morbidity and even mortality, associated with auricular neoplasms compared to other cutaneous tumors in general[5]. It has been suggested that embryonic development may play a role in the spread of auricular cutaneous malignancies. The planes of fusion of embryological structures may present pathways along which microscopic spread of tumor may occur[6]. Mapping of skin cancer spread about the pinna supports this concept[7]. Perichondrium and cartilage also may represent both a barrier to tumor spread and a pathway, especially in recurrent auricular neoplasms[5,8].

There are several methods of therapy for nonmelanoma auricular skin cancers, including conventional excision, radiotherapy, cryotherapy, curettage, electrodesiccation and Mohs' surgery. Radiotherapy, cryotherapy, curettage, and electrodesiccation do not provide histological diagnosis of tumor, nor confirmation of complete removal by pathological examination. Conventional treatment modalities generally result in high cure rates for small circumscript primary tumors with well-defined borders. Obviously, pathologically clear margins should be obtained before definite reconstruction is carried out. However, a compilation of relevant studies has shown that, apart from previously untreated small, well-defined, non-aggressive tumors, confined to the peripheral auricular structure, the highest cure rate may be achieved by Mohs' cutaneous micrographic surgery[9,10] (Table 2). This is particularly true when the malignancy approaches the external auditory canal, either anteriorly or posteriorly. The proximity of the skin to the cartilage is important when deciding whether to resect cartilage with an overlying skin lesion.

Mohs' cutaneous micrographic surgery involves removing thin layers of tumor and utilizing horizontal sectioning techniques. If any residual tumor is identified, precise *oriëntation* allows subsequent layers of involved tissue to be removed until all the tumor has been extirpated[11]. Foliowing this treatment principle, the tumor is removed with the highest cure rate and maximal conservation of the tissue. *Interpretation* of the slides may be done by the surgeon himself or by a knowledgeable pathologist. The need for *communication* in the latter situation must be emphasized.

Mohs[7] surgery aims at the evaluation of 100% of the margins of the specimen. This is in contrast to conventional excision with standard pathologist techniques, which involves vertical sectioning, allowing evaluation of 0.1% of the total margin, representing only a sample of the margins examined by Mohs. The tissue-sparing capacities of Mohs' surgery is of advantage in cosmetic important areas, especially on the ear with only a limited amount of tissue for simple functional and aesthetic reconstruction[12]. The smaller the defect, the easier the reconstruction, the better the aesthetic outcome. Mohs' surgery requires time and expertise, but it allows immediate reconstruction in most cases. Although the method and value of further treatment of incompletely excised basal cell carcinoma is still debated[13], we feel that Mohs[7] surgery has a definite indication in these situations preventing late recurrence.

Table 2. Five-year recurrence rate of primary and recurrent basal cell carcinoma

Treatment modalities	*Basal cell carcinoma*	
	Primary	*Recurrent*
Surgical excision	10	17
Curettage-electrodesiccation	8	40
Radiotherapy	9	10
Cryotherapy 8	>13	
Mohs' micrographic surgery	1	6

Adapted from Rowe *et al.*[10]

Reconstructive principles

Methods of reconstruction can be classified in four groups: side-to-side closure, secondary intention healing, skin gr af t s and skin flaps.

Side-to-side closure

Side-to-side closure of the defect is simple, straightforward and associated with minimal postoperative morbidity and healing time. Side-to-side closure of skin defects on the medial side of the auricle is a practical option because of the relative excess and mobility of skin and subcutaneous tissues as opposed to the lateral side. Small skin defects of the helical rim may also be closed in a side-to-side manner by recruiting skin from the medial side by means of under-mining and advancement. However, too much tension may result in slight flattening of the helical contour. Every attempt must be made to accomplish the closure in a vertically oriented fashion, parallel to the structural borders and relax skin tension lines of the ear.

Full-thickness skin cartilage wedge-shaped defects may also be closed in a side-to-side manner, but this diminishes the circumference and vertical height of the reconstructed ear. This is important if defects encompass one-fifth or more of the auricle. If the wedge is too wide, direct approximation of the edges may cause undue tension and possibly a cupping deformity. In order to mobilize cartilage on the side of the defect, the wedge-shaped excision is sometimes converted to a star-shaped or obliquely oriented crescent-shaped excision by excising additional skin and cartilage on the side of the wedge. Reapproximation of the chondrocutaneous edges are best done in a 'tongue and groove' fashion. A tongue of cartilage is inserted between a groove of posterior and anterior skin flaps. The separation of cartilage and skin edge approxi-mation provides a stronger repair with less ultimate scarring[1]. Healing is of ten uneventful, since the vascular integrity of the remaining cartilage and soft tissues is preserved.

Secondary intention healing

The basis of secondary wound healing is epithelialization and scar contraction. The main indication for healing by secondary intention is dictated by *tumor control factors, depth and size of the defect,* together with *anatomical site* and *adjacent skin characteristics.* Excisional defects of tumors with a significant chance of recurrence may best be managed by secondary intention healing. Secondary intention healing may give the best possibility of detecting early recurrence of an already recurrent tumor. This is especially important in young patients[14]. Split-thickness skin grafting may also allow good observation, but is usually not a good aesthetic option, and is probably inferior even to secondary intention healing in most cases[15].

From an aesthetic standpoint, a relatively small superficial wound in a concave anatomical area in a fair skinned individual is considered an ideal[16]. The ear has four concavities, including the concha, cymba, triangular fossa and concha mastoid sulcus. In concave areas, the centripetally oriented scar contraction forces will help 'fill in' the defect, while decreasing the size of the final scar. Skin defects overlying convexity tend to heal aesthetically less well with secondary intention, as scar contraction will at best produce a flat surface, not mimicking the original convexity. In areas with exposed cartilage, small biopsy-type excisions of cartilage can be performed to allow granulation tissue from the opposite side of the cartilage to speed up healing.

The obvious advantage of secondary intention healing is that it eliminates the need for additional surgical procedures. In addition, it avoids the creation of further scar tissue by the reconstruction that must be excised if the tumor recurs. Possible distortion by scar contraction may be avoided with proper patiënt selection. A primary disadvantage is the prolonged period required for final healing, which obviously depends on the size and depth of the defect. The patiënt must be willing and able to perform wound treatment, including cleaning twice daily with hydroxyperoxide, coating with antibiotic ointment and covering with non-adherent wound dressing.

Skin grafts

Skin grafts may be used to advantage in reconstructing small-sized lateral cutaneous defects. Skin grafts survive only when given the possibility of vascular ingrowth from the woundbed. An optimal woundbed is provided by an intact, relatively moist, perichondrium or subcutaneous tissue. An unsatisfactory woundbed, such as bare cartilage, may be converted into a favorable grafting recipiënt site by removing cartilage up to the degree when it is not detrimental to the auricular shape. If the viability of the woundbed is questionable, a skin flap rather than a skin gr af t should be used. Skin gr af t subgroups include full-thickness skin grafts (FTSGs), partial thickness skin grafts (PTSGs), and composite grafts (CGs). The donor site for FTSGs is ideally chosen with regard to similarity and color and texture of the missing skin. The contralateral postauricular skin often represents an excellent full-thickness skin graft source. Preauricular grafts are somewhat lighter and less red, and may also be harvested with minimum donor site morbidity. Because of its poor color match and contraction tendency, PTSGs are mostly used for temporary covering. Perforating the FTSG (or PTSG) in a multiple fashion permits egress of serosanguinous liquid which promotes

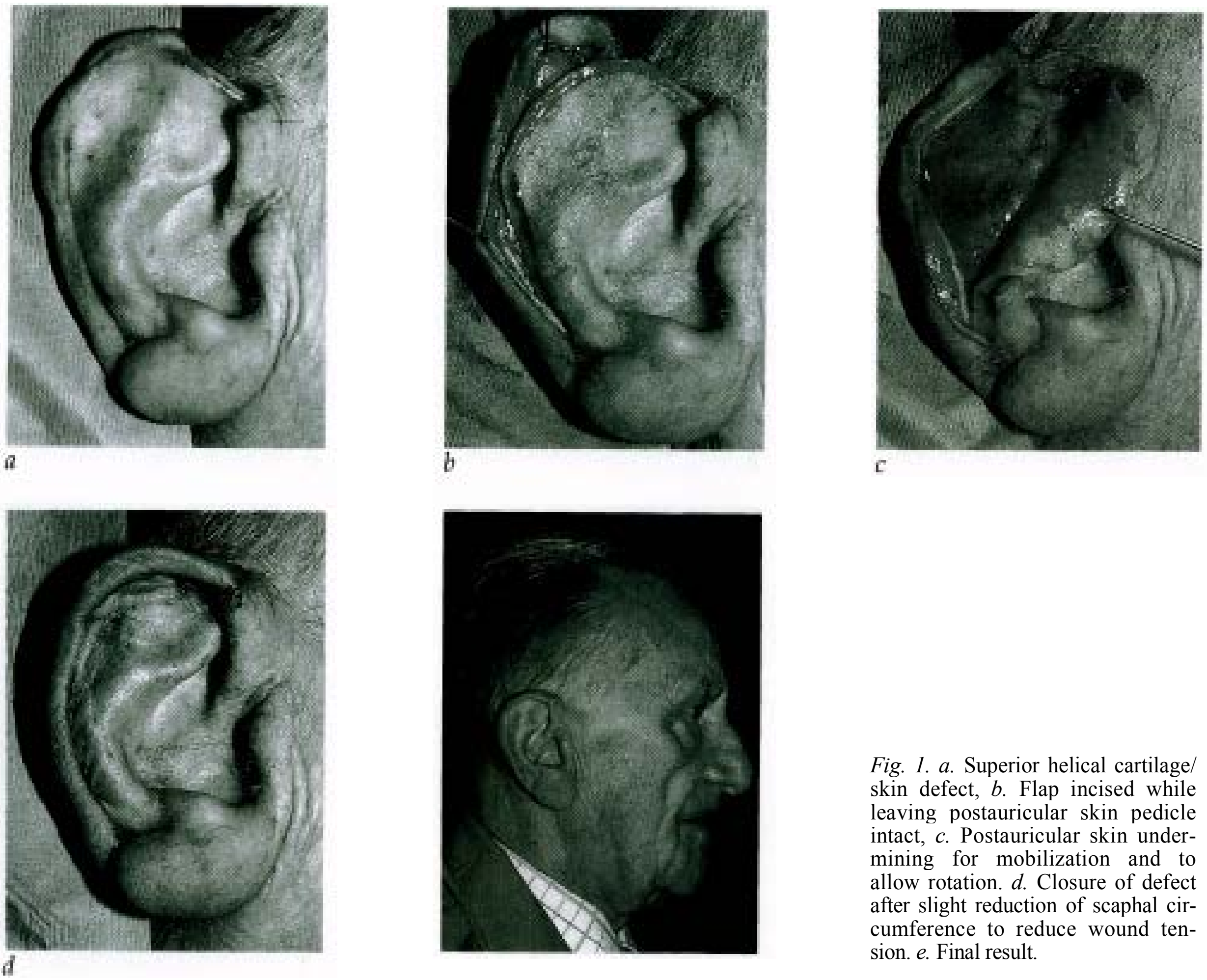


Fig. 1. a. Superior helical cartilage/ skin defect, *b.* Flap incised while leaving postauricular skin pedicle intact, *c.* Postauricular skin undermining for mobilization and to allow rotation. *d.* Closure of defect after slight reduction of scaphal circumference to reduce wound tension. *e.* Final result.

improved graft take[17]. During the early postoperative phase, the graft may be immobilized by through-and-through mattress-type quilting sutures and some type of bolster dressing. Bolster fixation may be accomplished without suturing, using skin adhesive and steristrips. By definition, composite grafts consist of more than one anatomical layer. Composite grafts, such as a three-layer skin, cartilage-skin graft from the contralateral ear and cutaneous-perichondrial grafts from the conchal bowl, are mainly used for nasal reconstruction and have limited application in ear reconstruction.

Localflaps

Local flaps provide excellent aesthetic camouflage in most auricular defects, largely because of their optimal match with surrounding tissue in terms of texture, color and thickness. Moreover, by bringing in additional tissue, the circumference and vertical dimension of the auricle may generally be maintained. A well-designed flap with a good vascular pedicle heals quickly, is highly resistant to infection, minimizes contraction, and can be formed in one stage[15]. Local flaps bring in their own blood supply and cover bare cartilage, or may be used in conjunction with autogenous cartilage grafting for structural reconstitution of the auricle in the case of through-and-through defects. When con-

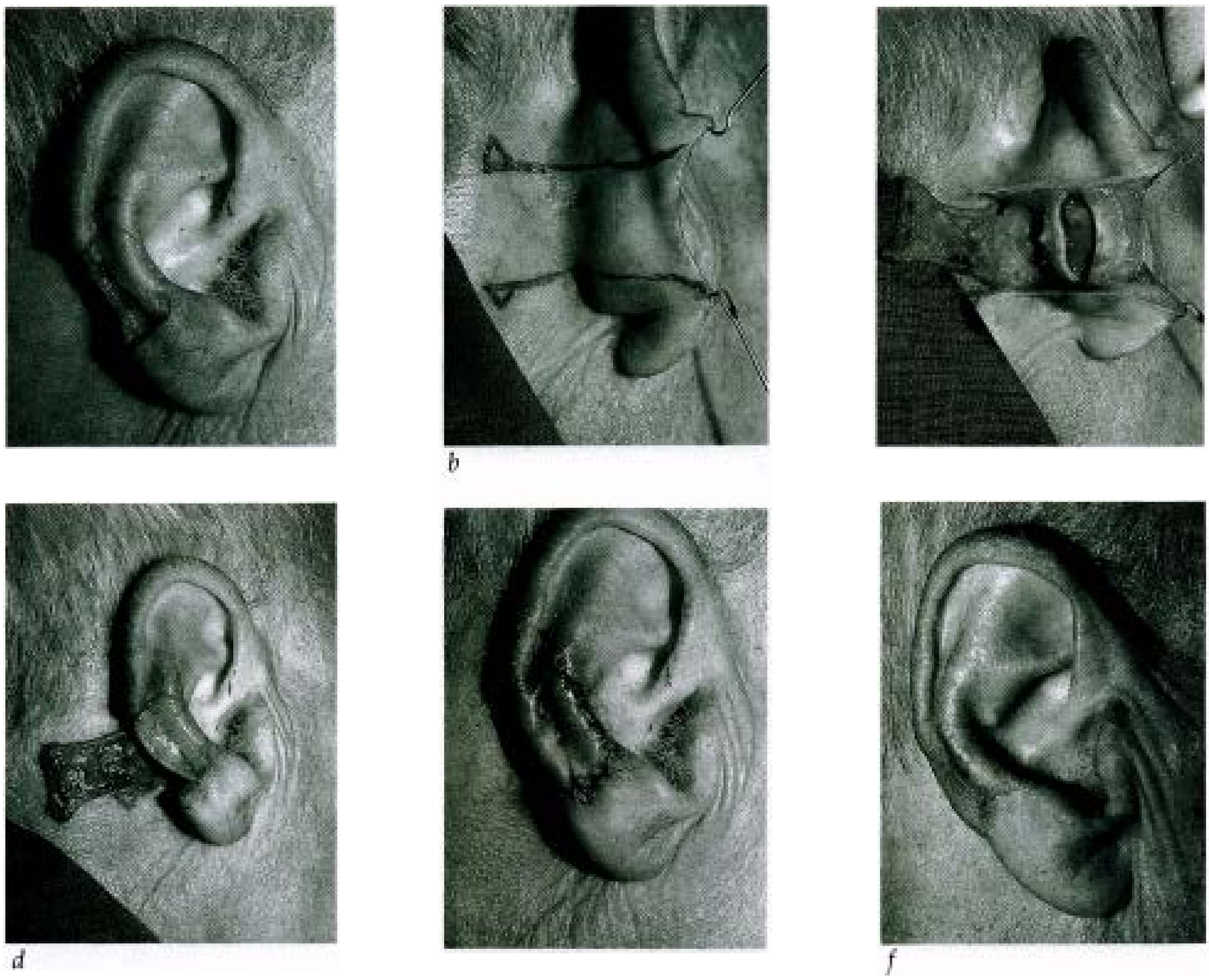


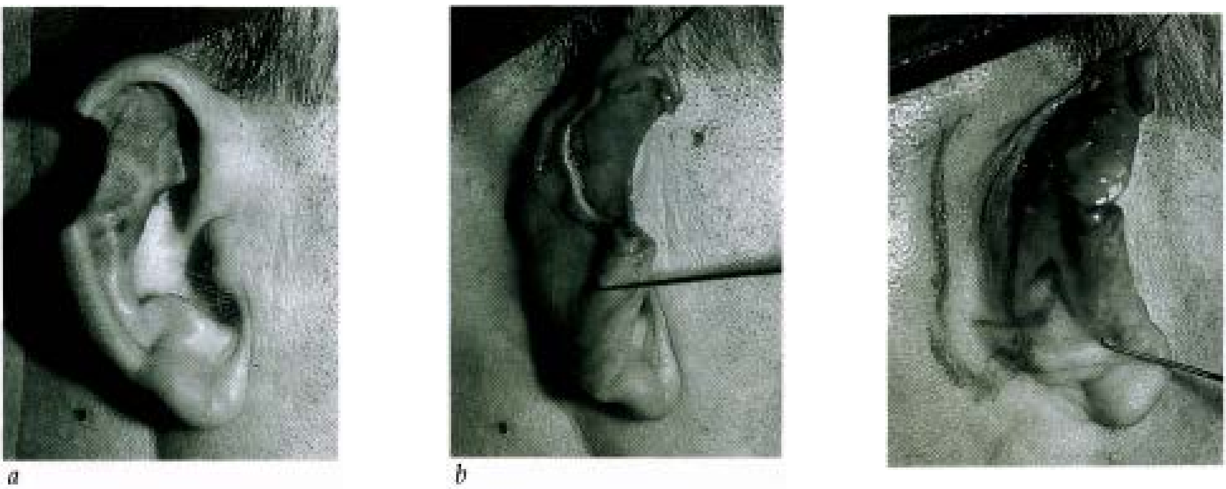
Fig. 2. a. Combined helical/antehelical defect, *b.* Postauricular advancement flap with possible Bürrow's triangle outlined. *c.* Graft of concha taken to reduce height and increase reach of advancement flap. *d.* The excised cartilage used as a free graft to reconstruct the helical contour, *e.* Flap inset. *f*. Final result.

sidering local flaps, one should evaluate a number of essential prerequisites and inter-actions including: local available tissue reservoirs, type and effect of tissue movement, vas-cular supply, lyrnphatic return, and residual donor site defect.

Postauricular and preauricular areas present a relative tissue excess which rnay be used for local flap harvesting. The flap dimension should allow primary donor site closure and be oriented for optimal scar placement. The predominant types of movement of local flaps include advancement, rotation and transposition. Advancement and rotation both are variables of a sliding motion. Transposition involves movement of tissue over non-involved areas and flap defect inset in a single stage. Interpolation is principally the same movement as transposition, but involves maintenance of a pedicle over a non-involved area and subsequent pedicle division during a second stage.

Regional reconstruction

Functional and aesthetic reconstruction of the external ear can be simplified by a regional ap-proach, utilizing the principles and preplanned



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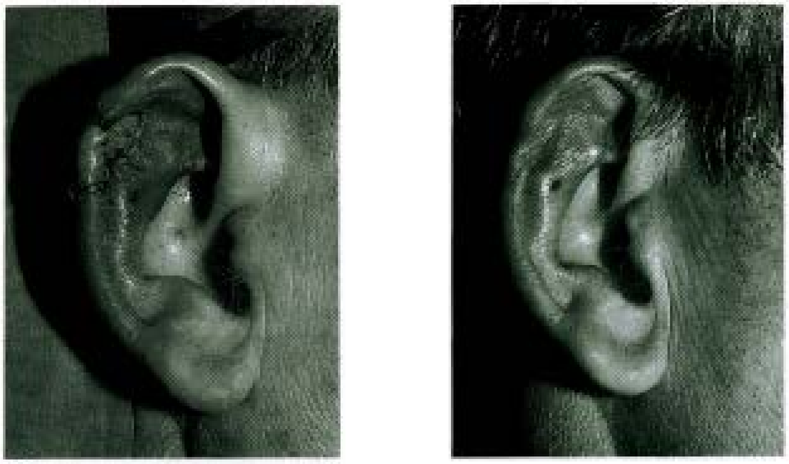

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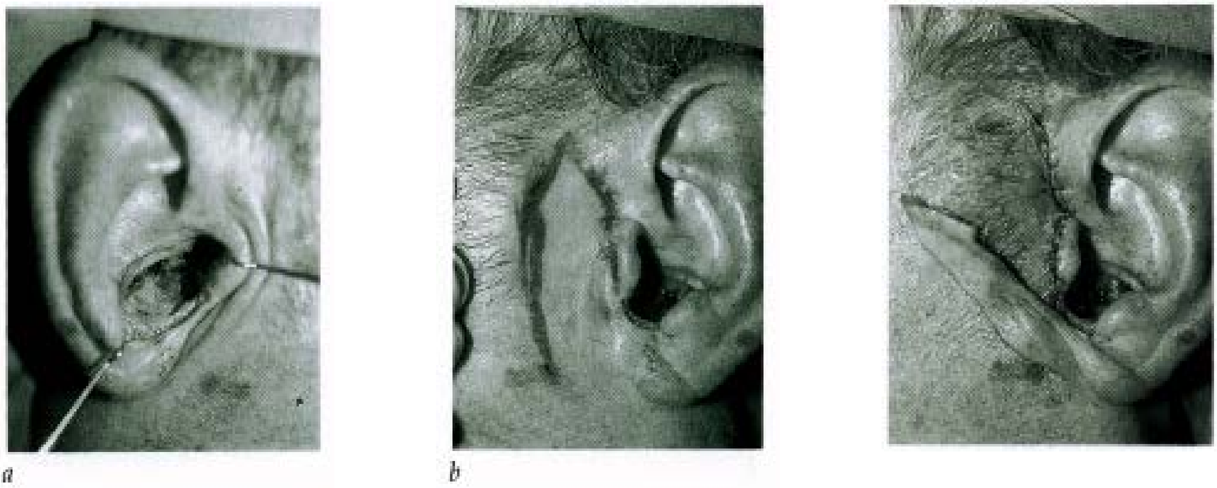
Fig. 3. a and b. Combined auricular defect involving postauricular skin, cartilage, helix and scapha. *c.* Auricular cartilage framework reconstructed with autogenous graft taken from the opposite auricle, transposition flap outlined. *d.* Flap inset. *e.* Final result. Obviously the smooth curves and contours are difficult to reconstruct given the thin aesthetic covering.

techniques of surgical repair described above. The vast majority of auricular reconstructions after tumor surgery can be performed under local anesthesia. Practical reconstruction meth-ods applicable to the *helical rim, concha/ triangular fossa, scapha jantehelix, lobule* and *posterior ear* will be discussed.

Transposition flaps designed from the non-hair-bearing, loose, preauricular or postauricular skin may be used for *anterior superior helical rim* defects. A relatively long pedicled flap can be used with a 1:4 or even 1:5 width to length ratio. Flaps carry their own blood supply, favoring rapid healing and the subsequent ability to withstand the pressure of eyeglasses after the healing is complete.

Alternatively, helical rim defects can be repaired with helical-chodrocutaneous advancement flaps[18]. A skin cartilage incision on the lateral side of the auricle just inside the helical rim is made, leaving the postauricular skin intact as a blood vascular pedicle. Undermining of the postauricular skin allows mobilization and advancement of the chondrocutaneous advancement flap into the defect. Most tissue advancement is obtained from an inferior flap that takes advantage of the laxity of the lobule[19]. Superiorly, the helical crus may be advanced and rotated using V-Y incision and closure[20]. Inadequate closure or too much tension on the wound edges may be alleviated by reducing the circumference of the cartilage of the scapha. Shave excision of scaphal cartilage or offset wedges reaching into the conchal bowl may be helpful.



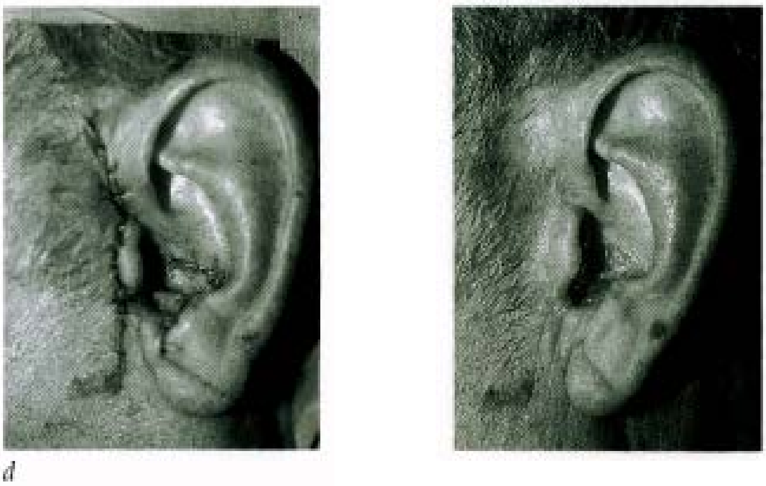


Fig. 4. a. Defect of concha reaching into the auditory canal. *b.* Inferior-based transposition outlined while stretching skin to maximize visibility to non-hair-bearing and hair-bearing transition zone. *c.* Flap harvested/donor side closed prima-rily. Scar in horizontal skin crease and aesthetic unit border, *d.* Flap inset. *e.* Final result.

Closure is performed using long-lasting PDS sutures for cartilage approximation with subsequent extreme eversion of the skin wound edges (Fig. 1). Obviously these maneuvers diminish auricular dimensions. Additionally, a Z-plasty may be incorporated into the design to prevent notching.

As mentioned earlier, primary closure of small vertical defects of the helical rim is possible after mobilization and undermining of the postauricular skin, without additional incisions. However simple the procedure, the obligatory tension may result in some flattening of the helical contour.

Longer helical defects ranging from 2-4 cm are amenable to a three-staged reconstruction, using a postauricular tubed pedicle flap[1,21]. For defects on the lower helical rim, the relative laxity and tissue excess of the lobule provides reconstructive latitude.

Lateral helical defects ihat include the scapha may be converted into wedged-shape defects with subsequent primary closure. Again, only small-sized wedges can be closed primarily, because approximation of the cartilage tends to push the upper and lower ear outward, producing a cupping deformity Moreover, the smaller reconstructed ear may draw attention when compared with the normal counterpart in frontal view.

Alternatively, a staged postauricular advancement flap can be used for lateral helical and scaphal (full-thickness) defects, or in situations

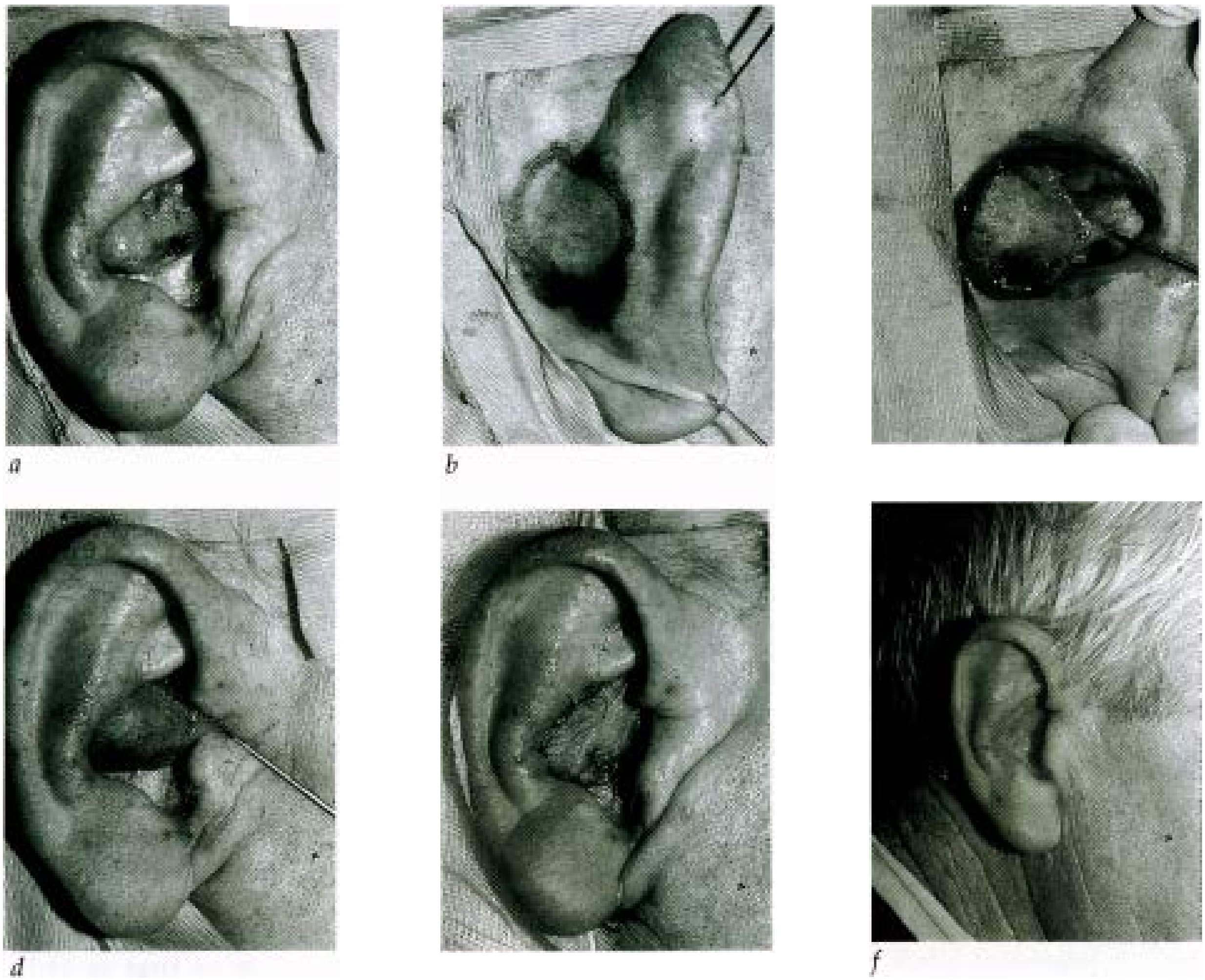


Fig. 5. a. Conchal defect involving skin and cartilage. *b.* Postauricular flap outlined. Two-thirds on the ear/one-third on mastoid. *c.* Flap incised, subcutaneous pedicle is planned in the postauricular sulcus. *d.* Flap revolved in defect, *e.* Defect closure. *f*. Final result with some medialization of the auricle.

of perichondral loss which preclude skin grafting. After two lateral incisions, the remain-ing postauricular and mastoid skin is under-mined towards the scalp. After advancement of the flap, the edges are sutured to the lateral side of the ear defect. The reconstruction may include autogenous cartilage grafts for contour mainten-ance (Fig. 2). A secondary stage may involve pedicle division, flap trimming and folding into the medial edge of the defect. The possible remaining mastoid defect is either allowed to heal secondarily or is skin-grafted. In the case of superior helical defects, there is not enough mobility in the scalp and the hair line is too close for the application of this type of postauricular advancement flap. Alternatively, a postauricular transposition flap may be used (Fig. 3).

Defects of the concha and triangular fossa can be treated with skin grafting, provided there is an adequate woundbed. Secondary intention healing in this concave area can be applied with predictable aesthetic results. If the peri-chondrium has been resected, the remaining cartilage can in part be removed using a 4-mm punch excision to promote granulation in the woundbed. Alternatively, superior- or inferior-

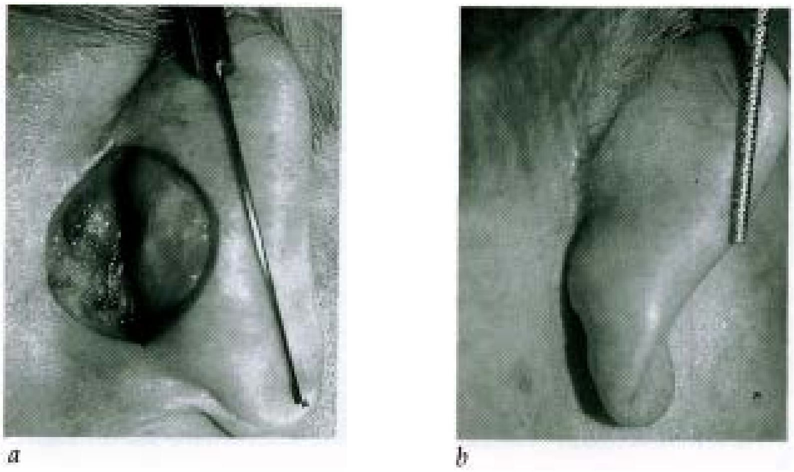


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Fig. 6. a. Large-sized postauricular defect, *b.* Wound healed af ter secondary intention over a period of six to eight weeks.

based flaps harvested preauricularly can be used for conchal and external ear canal defects[22] (Fig. 4). Auricular transposition flaps can also be moved into the defect, using conchal incision and tunnelling techniques. Alternatively, postauricular skin may be recruited, based on a sub-cutaneous pedicle, and pulled through in a revolving-door manner to close anterior conchal skin defects[23]. Primary closure of the postauricular donor site may result in some minimal medialization of the pinna (Fig. 5).

The *lobule* can be repaired by primary closure with a wedge-type excision or variation of direct closure[19]. Again a Z-plasty may prevent notching[21]. A large-sized lobule defect can also be covered by a postauricular flap or full-thickness skin graft. Finally, the entire lobule can be reconstructed with a two-stage inset of a tubed single-pedicled flap[1], or a posterior-inferior based chondrocutaneous flap[24].

Secondary intention healing, skin grafting and skin flaps are acceptable, effective options for reconstruction of the *postauricular area* (Fig. 6). Given the relative mobility and excess of the postauricular skin, various types of flap repair, using both rotation and transposition or a combination, can be executed. Defects which encompass *postauricular skin as well as skin of the helix* may be closed using the same principles of flap repair, while preventing distortive wounds. The secondary defect created by tissue movement will often He in the postauricular sulcus, and thus can be allo wed to heal by secondary intention. Alternatively, Bürrow's triangle, which is excised adjacent to the primary defect as part of the rotation or transposition flap design, can be used for skin grafting (Fig. 7).

Auricular cutaneous defects measuring more than one-third of the auricle are often beyond the limits of available pre- and postauricular non-hair-bearing skin, and therefore regional flaps must be considered. The temporal parietal facia flap can be used to cover the remaining or reconstructed auricular cartilage framework and will readily support a split thickness or full-thickness skin graft. The flap, harvested in the adjacent hidden hair-bearing scalp, has a thickness of 2-3 mm and may be as large as 14-12 cm[25]. Detailed knowledge of the anatomy of the multiply-layered temporoparietal area and the course of the supporting superficial temporal artery and vein, as well as the adjacent frontal branch of the facial nerve, are prerequisites for successful application of this type of flap[26].

Patients with extremely large defects who are at high risk of recurrence, and in whom immediate reconstruction is contraindicated, may be given the opportunity of auricular prosthesis. However, the limiting factor of success of an auricular prosthesis is the means of fixation. Glues, etc., have inherent disadvantages in an area of relative mobility close to the temporal mandibular joint. An advanced method of auricular prosthesis attachment is provided by osteo-integrated titanium implant systems[27]. With this newer form of fixation, prostheses are


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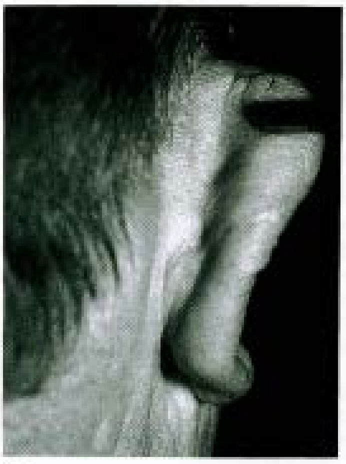
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Fig. 7. a. Helical skin defect. *b.* Broad-based posterior auricular rotation flap; Bürrow's triangle excision is outlined. *c.* Flap rotated, primary defect closed. Secondary defect in favorable position for secondary intention healing. *d.* Helical rim defect closure. *e and f.* Final result.

preferable to total auricular reconstruction, particularly in older patients.

Conclusions

Surgeons who treat malignant tumors of the ear must consider the aesthetic and functional qualities of the auricle, but at the same time appreciate that cure is the primary object of treatment. Our approach to auricular reconstruction can be summarized as having the following principal characteristics: replacing missing tissue with similar tissue; and, providing adequate support for the auricular soft tissue envelope while using a reconstruction which is as simple as possible.

Awareness of the anatomy of the ear in its finest details, conservative ablative surgery using Mohs' technique, and realistic appraisal of the reconstructive goals of surgery, are extremely important in bringing to the patiënt the best possible combination of surgical procedures for aesthetic and functional purposes.

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