Ear trauma: treatment and reconstruction. A comprehensive approach

Trauma de orelha: tratamento e reconstrução. Uma abordagem compreensível

Antonio J. V. Forte[1], Nivaldo Alonso[2], Renato S. Freitas[3], Deepak Narayan[4], John Persing[5]

RESUMO

Neste artigo, os autores discutem o tratamento e a reconstrução de orelhas pós-trauma. Eles discutem diferentes técnicas para reconstrução, incluindo retalhos cirúrgicos e próteses. Os autores afirmam que cirurgias reconstrutivas da aurícula ainda são procedimentos difíceis mesmo para os cirurgiões mais experientes.

Descritores: Orelha/cirurgia. Orelha/lesões. Ferimentos e lesões.

SUMMARY

In this paper, the authors discuss the ears treatment and reconstruction after trauma. They discuss different techniques for reconstruction, including surgical flaps and prostheses. The authors affirm that reconstructive surgery of the auricle is still a difficult procedure even for the most experienced surgeons.

Descriptors: Ear/surgery. Ear/injuries. Wounds and injuries.

1. Médico, Cirurgião plástico.
2. Livre Docente, Chefe do Serviço de Cirurgia Craniofacial do Hospital das Clínicas da Universidade de São Paulo.
3. Professor Adjunto III da Disciplina de Cirurgia Plástica, Universidade Federal do Paraná; Cirurgião craniofacial do Centro de Atendimento Integral ao Fissurado Lábio Palatal (CAIF).
4. Plastic Surgeon, Associate Professor of the Section of Plastic Surgery, Yale University School of Medicine.
5. Plastic Surgeon, Professor and Chief of the Section of Plastic Surgery, Yale University School of Medicine.

Correspondence: Nivaldo Alonso
Rua Afonso Brás, 473, cjto 65 - Vila Nova Conceição – São Paulo, SP, Brasil – CEP 04511-011
E-mail: nivalonso@uol.com.br

INTRODUCTION

Although major contributions from Tanzer[1-4], Firmin[5-8], Brent[9-12] and Nagata[13-15] have been made to this field, reconstructive surgery of the auricle is still a daunting prospect even for the most experienced surgeon[16]. It is the surgeon's task to present the most sound option for the individual situation[17]. The method's choice depends on several factors such surgeon's experience with the technique; anatomic site; adjacent structures; previous surgeries and patient expectation, since elderly patients are more prone to accept small irregularities when compared to teenagers[18]. Ultimately, however the decision to reconstruct must be in the accordance with the patient's wishes.

ANATOMY

Typically, the normal ear is 6 cm long and 3.5 cm wide, and its average width correspond to 55% of its length[17,18]. Three measurements are helpful for appropriate placement of the normal ear: 1) an ear axis tilted generally posteriorly 15 to 20 degrees; 2) a postauricular angle between the mastoid and the ear plane around 25 to 30 degrees, associated with a concho-mastoid and conchoscaphocephalic angle of 90 degrees each; 3) a distance between the posterior of the ear and the lateral orbital rim of about 6 cm[18-23]. In addition, the inferior level of the ear (subaural), the lobule, is aligned with the base of the columella, and the superior level (supra-aural) is at the height of the lateral brow or supraorbital rim[18].

Regarding the blood supply, the superficial temporal and posterior auricular arteries are the major blood supply of the auricle and its vicinities. They both derive from the external carotid artery and its intricate network of vessels nourish even the most narrow of the pedicles in an avulsed ear segment, increasing the success rate of replantation procedures[18,19,24,25]. Three auricular branches are given off the ascending superficial temporal artery: an upper one, a middle one that ends at the tragus and a lower branch that descends at the lower level of the earlobe[25]. The chief supplier of the anteroauricular arterial network is the posterior auricular artery, which follows a very peculiar track ascending through the groove limited by the meatal cartilage and mastoid process and then following its course under the concha. It supplies the mastoid fascia and surrounding before sending branches to the superior two thirds of the posterior auricular area. Through a coronal plane under the concha, the posterior auricular artery traverses between the auricocephalic sulcus and the external auditory meatus, ramifying into several perforating branches to the tringular fossa, cymba conchae, helical root, cavum conchae and earlobe, finally communicating with the upper branch of the superficial artery on the anteroauricular surface. Both arterial territories unite, resulting in an abundance of connections that enable the viability of several flaps[19,25,26]. The superficial temporal venous system is extremely variable and inconsistent, whereas the posterior auricular artery is seldom not followed by its related venae[9,25]. The lymphatic network follows the same pattern of the embryonic derivation of the brachial arch. While the first arch (anterolateral surface) drains anteriorly into preauricular, digastric, inferior parotid, and posterior auricular lymph nodes, the second arch (posterolateral surface) drains posteriorly and inferiorly into posterior auricular nodes and into the posterior triangle of the neck[18].

Cranial and cervical plexus nerves provide the auricle's sensory supply, especially the great auricular nerve[17]. The lesser occipital and auriculotemporal nerves innervate the upper part of the auricle and a vagal nerve branch provides sensation to the conchal region[19,24]. Part of the conchal bowl is also supplied by Arnold's nerve (branch of the facial nerve). Therefore, referred otalgia may occur whenever this complex neural system is affected[18]. Supportive anterior and posterior ligaments associated with the anterior, posterior and superior auricularis extrinsic muscles stabilize the auricle and preserve its projection and orientation[18].

Ear sensation is supplied by cranial and cervical plexus nerves[17]. The sensory supply is chiefly derived from the inferiorly coursing great auricular nerve. The upper portions of the ear are supplied by the lesser occipital and auriculotemporal nerves, whereas the conchal region is supplied by a vagal nerve branch[19,24]. Part of the conchal bowl is also supplied by Arnold's nerve (branch of the facial nerve). Pathology in this complex neural system may give rise to a diverse source of referred otalgia[18]. The three extrinsic muscles - anterior, posterior, and superior auricularis - and supportive anterior and posterior ligaments stabilize the ear to the head and maintain its normal projection and orientation[18].

Anatomic basis of different flaps

The anterior and posterior auricular vicinity has two different patterns of skin: the anterior surface is densely adherent to the underlying perichondrium and the posterior area is freely movable. Therefore, the posterior surface has been the main focus of flap design. Its contents include skin, loose connective tissue (fascia), perichondrium and cartilage. Several flaps have been proposed and Park has described them in details in his anatomic studies[25]. We have compiled the most interesting ones reported in the literature in Table 1.

TREATMENT AND SURGICAL TECHNIQUES

Lacerations and Abrasions

Lacerations and abrasions are among the most ordinary auricular injuries. The golden rule in such cases, after adequate local anesthesia, is to balance minimal debridment and maximal tissue preservation[31]. Simple skin lacerations are primarily closed[19]. If it involves cartilage, the surgeon should try to meticulously align the segments, respecting all perceptible landmarks. Traction is applied to help visualizing the following step[32]. When the helical rim is affected, a vertical mattress suture should be placed initially at the rim to evert the wound edges and level the wound[33]. If there isn't any perichondrial damage, the exposed perichondrium should be skin grafted[34]. Appropriate debridment post abrasion include the total extirpation of fragments, which could result in traumatic tattoo. It's also important to stress the important role of dressing and good wound care in order to obtain a better outcome[19,31].

Auricular Hematomas
• Needle Aspiration
• Open Evacuation

The major cause of auricular hematoma is blunt trauma. Left untreated, the hematoma potentially leads to cartilage destruction and to neocartilage development, which eventually

Flap design	Characteristics
Fasciocutaneous	Axial-flap raised based on the middle division of the posterior auricular artery. It can be tunneled through slits in the cartilage framework to cover most anterior auricular defects in the anthelix, scapha, concha, and the external auditory meatus[25,27]
Reverse-flow Postauricular Fasciocutaneous	Feasible due to the auricular branches of the posterior auricular artery, which travel to the anterior auricular surface by the helical margin and some pass through fenestrations on the cartilage framework to connect with the branches of the superficial temporal artery[25,28]
Postauricular Chondrofascio-cutaneous	Described by Yotsuyanagi et al.[29,30], this flap is effective in the reconstruction of the earlobe and the helical crus, incorporating the conchal wall cartilage and the overlying postauricular skin. The skin included within the flap consists of two parts: (1) from the mastoid surface, and (2) from the posterior conchal wall. The cartilaginous components include the conchal wall cartilage and the conchal floor cartilage. In earlobe reconstruction, usual harvest of cartilage is limited to that of the conchal wall cartilage directly underlying the postauricular surface and does not include the conchal floor cartilage[25]
Reverse-flow Chondrofascio-cutaneous	It relies on a chondrofasciocutaneous unit based on the retrograde flow of the posterior auricular artery[25]
Mastoid fascial flap	It is possible due to abundance of vascularity to the mastoid fascia. The mastoid branch of the posterior auricular artery plays an important role in this flap[25]

Table 1 – Description of anatomic basis for flaps used in ear reconstruction

destroys the normal auricular landmarks and can result in the conspicuous cauliflower ear deformity[18]. The hematoma is classically thought to accumulate in the virtual space between cartilage and skin; however, some studies believe that this actually occur intracartilaginously[35]. Ohsen et al.[36] injected blood clots in different locations in the rabbit's ear and noticed that clots placed between the skin and the perichondrium were likely to be absorbed after 21 days, while clots placed between perichondrium and cartilage stimulated the formation of new cartilage within the subperichondrial plane over a 4 week period. Pandya[35] suggests that tangential shearing forces between skin and cartilage are more likely to result in hematoma.

Complete extirpation of auricular hematomas is the key to adequate treatment. According to Ghanem et al.[37], auricular hematomas can be divided in two categories to guide therapy. Fluctuant hematomas that are discovered acutely can usually be managed with needle aspiration and a bolster dressing[19]. This will keep skin and perichondrium coapted to the underlying cartilage framework, preventing recurrent fluid accumulation below the perichondrium. This could lead to a loss of definition of the auriclar framework[18,31]. Hematomas located within the cartilage itself may be predispose to recurrence and warrant more aggressive initial treatment. Postoperative antibiotic prophylaxis against skin flora is generally recommended[37]. The second group represents those older hematomas that tend to be more fibrotic in nature or those that are recurrent after needle aspiration, which often require an open evacuation or placement of a drain. If significant distortion is evident, all abnormal neocartilage and fibrous tissues should be aggressively debrided through adequate access.

Thermal Injury of the Ear
- Preauricular Flap
- Temporoparietal Fascial Flap
- Pocket Technique

Burns of the face involve the ear in 90% of cases and the most important factor in treating a burned ear is to prevent chondritis from developing[33,38]. The appropriate topical antibiotic agent for the ear is Mafenide, which has relative low toxicity, broad spectrum and ability to penetrate well both eschar and cartilage[39]. In case it becomes suppurative, Pseudomonas infection should be suspected and immediate debridment is advisable[33].

Cold thermal injury may occur due to tissue water crystallization and microvascular changes leading to thrombosis and necrosis[40]. Immediate treatment should be initiated with aseptical cleansing, rapid warming by gauze soaked with warm saline solution and injection of heparin or low-molecular-weight dextran to prevent thrombosis and reduce the tissue loss[33].

Reconstruction of the burned ear is achieved with the use of costal cartilage framework. However, the covering tissue that occupies the vicinities of the lesion might be limited due to excessive scarring. If the postauricular surface and lobule are the only affected structures, Kumar and Shah[41] suggested the use of a preauricular flap. The flap is planned, raised and its anterior margin is extended up to the attachment of the pinna. The posterior margin of the flap is extended approximately 0.5 cm below the proposed site of earlobe's attachment. It is then folded on itself and positioned over the posterior surface of

the ear lobe. Reconstruction of the middle third burn defect is achieved using the temporoparietal fascial flap as soft tissue coverage, associated to a sculpted costal cartilage frame. Upper third burn defects are successfully managed with Mladick's pocket technique[42]. Because burn injuries usually spare the deep fascia, shaping the subcutaneous pocket becomes safe and possible[43].

Skin Grafting

Skin grafts are only considered an option if perichondrium is present, since grafts are likely to fail if disposed over bare cartilage[17]. In the concha and triangular fossa, the exposed cartilage can be excised and a skin graft secured directly onto the postauricular skin[18]. Full thickness skin grafts provide good color and texture match while preserving the normal auricle contour, even though they are less predictable on the lobule or helical rim[18]. Excess skin from upper eyelid and preauricular regions are the optimal alternative, although an inferior color match result is acceptable when using grafts from supraclavicular area, buttocks and inner upper arm[17]. Reconstruction of the lobule may not be accomplished with full thickness skin grafts due to secondary wound contracture[18]. Split thickness grafts may be taken from a donor area without difficulty under local anesthesia.

Superficial Defects

According to Pham et al.[18], full thickness skin graft is appropriate to manage most of superficial defect on the lateral surface. Donor site include the pos- and preauricular skin and supraclavicular area. The graft is thinned and secured with numerous central tacking suture, preserving the height, contour and definition of ear silhouette. Bolster dressing is not required.

Preauricular Defect

Calhoun and Chase[17] suggest that preauricular defects are closed primarily if there's no perceptible tension. It might distort the lobule and the tragus if the wound is closed under tension. A facelift approach is used if permissible and other options include a check-neck rotation or any suitable local flap.

Ear Lobe Repair and Reconstruction
- Incomplete and Full Thickness Tear
- Postauricular Transposition Flap
- Two-staged Neck Flap
- Reverse-Flow Postauricular Flap
- Tubed Flap

The repair of a torn earlobe is a frequently requested procedure. Torn earlobes result from various forms of trauma, including earring entanglement, hairbrushes clothing, and heavy earrings. There are some principles that one should observe when performing an earlobe repair[18,44]. Incomplete tears are adequately repaired by excising the enlarged margins on the lateral and medial surfaces then meticulously reapproximating the wound edges. It is believed by some, that converting partial earlobe tears to complete ones can enhance cosmesis[44,45]. Niamtu III suggests that, when repairing a full thickness earlobe tear, the use of one or two resorbable deep sutures and the placement of a key suture on the most inferior portion of the earlobe produces good results[44]. Pham et al.[18]

recommend meticulous realignment and skin edge eversion of the helical rim to avoid obvious contour irregularity. To prevent notching, a Z-plasty or a half Z-plasty may be added to the repair. Another option is a small L-flap that may be used in totally or near-totally split earlobe[46-49]. It has been described that the earlobe may be repaired with preservation of the earring canal. The length and width of the flap must be long enough so that it can be rotated over itself and secured in place. Not unusually this technique adds a rim of tissue to the hole, making the site bigger than needed[50,51]. Alternatively the patient may be advised to close the wound first and then re-pierce the ear once healing is complete.

A posterior ear transposition flap is a good reconstructive option for most earlobe defects. Advantages include the hidden donor area, the proximity of the flap and the satisfactory cosmesis. Although primary closure or grafting of traumatic lobular defects has been recommended, this approach frequently yields inferior aesthetic results[52,53].

When formal reconstruction is desirable, Calhoun and Chase[17] suggest that a two-staged neck flap is also a pertinent technique. Either horizontal or vertical flaps can be chosen when designing the inner and outer lobule surface. The skin is outlined and the upper edge, the "outer surface" of the flap, is sutured to the top of the native ear. Two to four weeks later, the remaining area is elevated. Pedicled on the attachment, the "inner surface" is folded under before securing the inner and outer surfaces together.

Park and Chung[28] report a reconstructive technique with a reverse-flow postauricular flap, but the practical applicability of the flap is impaired by the flap dissection difficulties, the need for a delayed procedure and the need of donor site coverage[52].

Tube flaps are not good options for cosmetic and practical reasons. Alanis[54] recommended the use of a lateral cervical skin flap, though it creates a conspicuous scar on the donor site[52]. Alcochel et al.[55] described this procedure in one-stage, which presents as advantages no further need for surgery or skin graft. The first flap is raised based on a medial pedicle from the postauricular skin and a second one raised from the anterior surface of the helix and antihelix. This little flap supplies the posterior of the new earlobe in addition to the lower folded prolongation of the main and first one. The exposed cartilage is covered by the upper portion of the retroauricular flap and the mastoid donor defect is closed by direct suture.

Helical Root and Rim
- Helical Rim Advancement Flap
- Preauricular Flap
- Wedge/Star-shaped Excision
- Tunneled Flap Based on the Superior Auricular Artery
- Adjacent Sliding Transfer of the Remaining Helix

According to Calhoun and Chase[17], helical rim defects are classified as those involving the root and those involving the rim. Root defects are managed with pedicled flaps based on the preauricular skin or above the ear skin, providing a good match in color and texture.

For rim defects smaller than 2 cm, a helical rim advancement flap is an option to close the wound layers superiorly and inferiorly. This single stage procedure is based on the rich vascular network of the helical rim[18,56]. This technique may

rarely cause minor lobule distortion. If additional tissue is necessary, V-Y advancement of the superior helical segment is an option with minimal deformation of the helical base[57]. Advancement flaps generate an ear smaller in height. However, it doesn't endanger the result, since one usually visualizes one ear at a time[19]. Elsahy[58] proposes the use of a preauricular flap in case of anterior helix defects. The flap is designed at the junction between the ear and the face and it is superiorly based. The donor site is primarily closed. Advantages of preauricular flap are that it is a one-stage operation; it is easy to dissect and the donor area is located in a favorable face-lift incision site. The disadvantages are the possibility of transferring hair-bearing skin to the ear; and if the defect is large, the technique may require a secondary procedure for contour irregularities. For very small defects of the helical rim, one can also use a bipedicle advancement flap[59].

For small composite defects of the helix and antihelix, a wedge or star-shaped excision technique is a preferable option[19]. It consists in a full thickness excision of skin and cartilage with the apex pointing to the anterior surface of the ear and extending to the conchal area. When designing the wedge, it's important to define an apex angle smaller than 30 degrees[18]. The resulting wound is then closed primarily, in layers, with the cartilage secured by long lasting sutures[19]. It is helpful, when possible, to use an offset skin closure around the rim. To decrease the risk of rim notching, the skin should not be approximated and secured over the cartilage space[17]. Usually, the ear is shortened slightly but maintains the premorbid contour[17]. The advantages of wedge resection are it is a one stage operation; dissection is simple, and fast; and there is minimal resultant scar. Disadvantages include: it can be applied only for small defects of the helical rim and neighboring structures. The wedge should be located in the superior or posterior third to avoid deformity of the ear. If the defect is larger or located near the anterior helix, wedge resection cannot be used without severe deformity of the ear[60].

Another option is the tunneled superior auricular artery based flap described by Uraloglu et al.[61]. It offers a simple single staged solution for anterior auriculohelical defects, especially when the base displays perichondrium loss. The flap has a reliable pedicle, which is the superior auricular artery, and the donor site is closed primarily, typically leaving a fine scar. Ferri[62] suggests that partial losses of helix can also be treated with adjacent sliding transfer of the remaining helix, bearing in mind that it may result in a smaller contralateral ear.

For helical rim defects larger than 2 cm, primary wedge closure is more difficult because of the width of the defect and a better closure is accomplished with a tubed pedicled postauricular flap. Three weeks after transferring the flap the superior pedicle is divided and sewn at the superior aspect of the helical rim defect, leaving the inferior limb intact. Three weeks later, the rest of the flap is transferred.

Full thickness defects of the helix and antihelix can be reconstructed with an up to 1.5 cm wide graft from the contralateral ear, which slightly decreases the size of the normal ear, making both of them more symmetric[19]. The graft consists of skin and cartilage and its size correspond to one-half of the defect dimension[17]. Although they look great in the immediate postoperative time, the graft may unpredictably shrink and there may be distortion of the donor ear shape[18].

Tubed flaps
- Three-stage Technique
- Two-stage Technique

Tubed flaps are the preferable option for rim defects larger than 2 cm. A long narrow bipedicled flap can be designed either preauricularly, on the neck, or, more often, on the postauricular region. The later one is more convenient for a lateral lesion involving the upper and middle third of the rim[18]. According to Dujon and Bowditch[63], if the length is greater than 2 cm, a narrow pedicle is left on the center and later divided. In the first stage, the tube is developed and its length corresponds to the defect with an additional 0.5 cm to allow shrinkage. The flap is carefully elevated at the subcutaneous level, preserving the subdermal plexus. Approximately three weeks later, one limb of the tube pedicle is divided. Before transposing the divided pedicle, it is necessary to open the free limb and to extirpate from it a few millimeters of the longitudinal scar of the tube. The free end is inset into the defect, incorporating a "V" or "Z" plasty on the rim to prevent notching[64]. Three weeks later, the other end of the flap is raised and secured in place[17]. The donor site is closed primarily. A disadvantage of this technique is that some color mismatch may occur, though the ear remains with an adequate height[18]. Schwabegger et al.[65] report that the use of a tourniquet (rubber band) by the patient three times a day, before completing the third stage of the helical rim reconstruction, may enhance the reliability of this procedure.

Ellabban et al.[66] describe a similar technique but in two stages. First, a postauricular flap is carefully lifted at the level of the subcutaneous tissue. The posterior margin is sutured to the defect's posterior margin. A cartilage graft is inserted when necessary and finally, the anterior margin is sutured to the defect's anterior margin. The free caudal and cephalic portions of the flap are tubed and the donor site is closed by anterior advancement of mastoid skin. During the second stage, both limbs are separated after 3 weeks and inserted at the helical edges using V or Z-plasty. They report that immediate transfer of the flap to the ear defect is more advantageous than tubing it away from the ear, as it reduces the number of surgical procedures for reconstruction and avoids the shrinkage of postauricular skin that occurs during tube transfer.

Conchal Bowl
Defects in this area are more commonly dealt with full thickness graft directly over the wound[18]. Park and Hood[19] explain that the posterior conchal skin can be used to bring richly vascularized skin, as a revolving-door flap. This flap has a postauricular pedicle. The posterior-medial skin of the concha is rotated into the conchal defect to redefine the anterior portion, while the mastoid skin is been recruited to cover the posterior portion of the conchal bowl. For defects that transpose skin and cartilage, a retroauricular island transposition flap or pull-through flap is a suitable option. Defect and donor site can be closed in one stage[17].

Large Composite Defects
- Temporoparietal Fascial Flap
- Postauricular Skin Flap
- Postauriculomastoid Skin Flap

- Chondrocutaneous Flaps
- Management of Deformity after Perichondritis and Chondral Necrosis

Large composite defects bigger than 30% of the auricle often require support framework and soft tissue coverage[18]. Alloplastic material continues to demonstrate higher rates of infection, rejection and extrusion[67,68]. For reconstruction of these large composite defects, it is helpful to divide the ear into vertical thirds based on the lateral aspect of the ear[19]. Although the upper pole is closer to the scalp skin, this later is usually thicker and hair-bearing[18]. Such defects are optimally reconstructed using a temporoparietal fascial flap. Its advantages include good cartilage coverage and support for full thickness skin graft. Park reports that lower two-third defects should be repaired using postauricular skin flaps due to the vicinities' characteristics, which include thinness and lack of hair[19]. Postauriculomastoid skin is also thin and provides a very good color match. If the helical rim is affected by a large composite defect, a chondrocutaneous helical flap and a bipedicled tubed flap are great alternatives[69]. Reconstructive options, if skin and perichondrium are lost, include a retroauricular flap based superiorly (banner flap), a retroauricular flap based inferiorly and a retroauricular and medial skin flaps introduced through the cartilage to the lateral surface of the ear[58].

Several variations of chondrocutaneous flaps have been described since Antia and Buch[56] published their technique. Elsahy described a rotation advancement chondrocutaneous flap, which consist in a flap designed on the lower half of the antihelix, whose base is superiorly directed and adjacent to the defect. It is supplied by branches from the perforators at the helical root[70]. He also advocates the use of a rotation flap for peripheral defects involving the helical rim and adjacent scapha. It is designed on the lower antihelix, superiorly based and adjacent to the defect. These flaps present several advantages: a one-stage operation; versatility in the reconstruction of defects involving the helix, scapha, triangular fossa, superior and inferior crura, and the antihelix; the hidden scar in the scapha as it maintains the vertical height of the ear; and easy closure[60].

Davis[71] described a similar flap designed on the concha whose base is located anteriorly near the root of the helix. In this single-staged procedure, the flap is lifted up and consists of the lateral skin and the missing upper third of the ear underlying conchal cartilage. The conchal donor site is covered with a split thickness skin graft. Millard[72] used the medial and the retroauricular skin as a flap based anteriorly, which can be raised with a fragment of cartilage taken from the medial surface of the auricle as a chondrocutaneous flap.

Some of these large defects result from ear piercing complications, especially piercing through cartilage, which increases the incidence of infection and reduce allergic reactions when compared to soft tissue piercing[73,74]. *Pseudomonas aeruginosa* is the organism involved in 95% of pierced cartilage infections[75,76]. Because high ear-piercing usually occurs in the scapha, a cosmetic deformity involving the area extending from helix to antihelix may occur when its infection results in perichondritis and chondral necrosis[73].

Margulis et al.[75] reports that after control of the infectious process, patients present a deficient and deformed cartilage surrounded by scarred tissue. They propose that additional cartilage can be obtained from the ipsilateral concha if an intact antihelix is present. In case extensive cartilage has been lost, costal cartilage is the next choice. The patient may also present with badly damaged and scarred skin. A desirable treatment option for soft tissue coverage is the ipsilateral temporal-parietal fascial flap covered by full thickness skin graft. After the procedure completion, wounds are carefully cleaned and dressed with Bacitracin, Xeroform, fluffed gauze and head wrap. The peri operative antibiotics are continued for a period of 36 hours and the dressing is left untouched for the one week. Contact play and sports are prohibited for at least six weeks after surgery[77].

Temporoparietal Fascial Flap

When insufficient skin is available for reconstruction, a temporoparietal fascial flap is a powerful tool to provide cartilage coverage and skin graft support. The temporoparietal fascia, also referred as superficial temporal fascia, is a thin, fascial layer continuous with the galea aponeurotica of the scalp and the facial superficial musculoaponeurotic system[18]. The advantages related to the use of this flap include proximity to the auricle, vascularity from the superficial temporal artery and its incomparable thinness, allowing a better framework definition[19]. As stated by Pham et al.[18], the superficial temporal artery arborizes into the larger posterior and smaller anterior branches at approximately 2 cm above the zygomatic arch. These branches send perforators to the overlying cutaneous tissue and deeper temporal fascia and muscle. The vein lies just superficial to the artery and is more vulnerable during raising the flap. The frontal branch of the facial nerve is located immediately deep to the temporo-parietal fascia and intersects the zygomatic arch two fingers' breath anterior to the root of the helix. The auriculotemporal nerve, which innervates the flap and the overlying skin, is situated posterior to the artery, within 5-mm distance, and follows the artery superiorly for 1.5 cm above the helix and then diverges.

Pham et al.[18] suggested that the size of the flap can be estimated by using a template of the defect, even though wide lifting allows the flap to be molded accordingly. According to Park and Hood[19], the flap incision begins superiorly and is carried through the loose areolar tissue down to the level of the deep temporal fascia. The posterior branch of the superficial temporal artery is included in the flap, while it is narrowed to 2 cm in width at the base. It is necessary to elevate the flap as thin as possible, excluding the inominate fascia and subcutaneous fat, which contributes for a more visible ear contour[19,78]. The flap is then tunneled, the donor site is closed in layers and a circumferential head wrap is positioned[19,79]. Postoperative compression is advised in some patients[78].

Reported complications include partial flap necrosis, total flap necrosis, paralysis of the frontal branch of the facial nerve, infection of the cartilage framework, changes in hairline, secondary operation and poor aesthetic results[78]. Other disadvantages exist: the flap usually obliterates the retroauricular sulcus, the graft is located in visible site, alopecia may follow the flap dissection, scar may be conspicuous, congestion of the flap may distort the subtle auricular contour[60].

Upper-Third Defects
- Temporoparietal Fascial Flap
- Pocket Technique
- Yotsuyanagi Flap
- Extended Retroauricular Flap
- Ascending Helix Free Flap

Defects of the entire upper half of the auricle are best reconstructed in a manner similar to repair of congenital microtia[17]. Calhoun and Chase[17] believes that adults with acquired defects to this area have more problems with the hairline as a result of associated trauma to the area, which favors the temporoparietal flap option. He suggests that cartilage can be taken from either septum or conchal bowl and that it can be slipped into a pocket beneath the skin surrounding the remnant ear. Approximately 3 weeks later, the skin beyond the helical rim is incised and tubed around the rim, while a full thickness skin graft is applied over the fascial flap. It's important to exaggerate the carved cartilage shape, so that the coverage won't hide the contour[19]. Other methods include the Yotsuyanagi flap, in which the conchal bowl pedicled on the anterior helical crus is used to fill the anterior aspect of the wound, while another transposition flap based on postauricular skin is applied posteriorly[80].

Butler reports the use of an extended retroauricular flap and cartilage grafts to reconstruct full-thickness middle-third ear defects, which involve the posteromedial auricular skin, auriculocephalic sulcus and retroauricular skin[81]. Supplementary thin and hairless skin is obtained including triangular extensions of retroauricular skin to the flap, while flap length can be augmented by extending it posteriorly. Advantages include a pleasing aesthetic result in patients who lack retroauricular skin, the auricle contour is preserved and the flap donor site is hidden in the hair-bearing scalp. Disadvantages include use of scalp skin, which is thicker than auricular skin even after defatting; hair growth might occur if hair follicles are not removed completely, what would require laser treatment, shaving or other depilation method; the reconstructed area may be bulky and the contour imprecise. One strategy to dodge this is to re-elevate the entire flap in the subcutaneous plane during the second stage and return it to the original donor site. A thin layer of vascularized tissue is kept on the surfaces of the cartilage grafts, and a skin graft is used to cover them[81].

Maral and Borman[82] described the use of an ascending helix free flap from the opposite ear to reconstruct the upper portion of the ear. The flap is designed to be a reverse flow composite auricular flap lifted up from the ascending helix of the auricle and based on distal superficial temporal vessels. It allows tissue transference of the same quality with equalization of dimension and good cosmesis of the ear. The donor-site morbidity is minimal. The disadvantage include the substantial effort to repair a small defect, even though it produces a predictable and aesthetically pleasing result if planning and technique are adequate[82].

Lower Two-Third Defects
- Human Bites in Earlobe and Lower Helical Rim
- Adipofascial Flap

Several techniques are available for defects of the lower half of the auricle, which are usually easy to manage. Most of these procedures are two-staged[18]. Functionally, the lower half is not essential and therefore, if there's enough conchal bowl to support a hearing aid, these procedures are primarily cosmetic[17]. The structural graft follows the same principles above described and coverage can be managed with postauricular skin as a pedicled flap[18,19].

Wolf et al.[83] described a single staged technique to address human bites in the earlobe and lower helical rim. These three-dimensional defects usually require a specific creative solution for each injury. The size of tissue defect is measured and the designed flap is marked on the preauricular glabrous skin. A caudally based preauricular flap is lifted and the donor site is closed primarily. The flap is long and durable but relies on a narrow cutaneous pedicle. Ergo, it should be elevated with a thick proximal pedicle for better nourishment and a thin distal end, which will be pliable for helical reconstruction. In addition, the medial border of the flap should be shorter than the lateral one and it should be aggressively thinned to a more natural appearance of the lobule. Advantages include acceptable aesthetic results and recruitment of local remaining skin.

Finally, Prakash and Tandon[84] have described a two-stage procedure using an adipofascial flap. In the first stage, the adipofascial flap from the retroauricular area is dissected and secured to the defect margins. A split thickness skin graft is attached over the adipofascial flap. Three weeks later, the prefabricated adipofascial flap is detached and inserted over its final place. The donor site is closed primarily. The advantages are that it is comparatively thinner flap and there is no donor-site morbidity associated to skin grafting[84].

Avulsion and Amputation
- Mladick's Pocket Technique
- Baudet's Pocket Technique
- Single-stage Ear Replantation
- Platysma Myocutaneous Flap
- Microvascular Ear Replantation

Exposed cartilage will eventually become deformed because of the scarring in the vicinities. Even covering the area with a temporoparietal fascial flap won't prevent it, since scarring still occur at the interface[45]. Therefore, every effort is valid to replace the soft tissue to its normal position if any portion remains connected. Survival is based in the high vascularity of the ear[85]. Mladick's pocket technique treats totally avulsed segments as composite free grafts. It consists in dermabrasion of the avulsed segment and surgical attachment of the cartilage to its original position. The same segment is buried in a subcutaneous postauricular pocket. After two weeks, it is removed and allowed to reepithelialize[42]. The cartilage is protected from deformity by maintaining its dermal connection to the skin, which allows the reattached ear to rapidly revascularize within the subcutaneous pocket and then to be elevated before scarring at the dermis-pocket interface occur[45].

Baudet et al.[86] described a similar technique in which only the postauricular skin is removed and small fenestrae are created. The amputated part is reattached and buried over the mastoid region. The ear is released three weeks later and the ear and/or the mastoid bed are covered with skin graft. Elsahy[87] describes an ear replantation technique combined with local flaps in a single-stage operation. A superiorly based skin flap

on the medial surface of the ear is designed. The flap is raised and brought to the lateral surface of the ear through the cartilage at the junction between the ear and its amputated part. The donor area is closed with the V-Y technique and the part of the flap passing through the cartilage is de-epithelialized. The lateral skin of the avulsed segment is removed and the segment is reattached. Finally, the skin flap is advanced over the amputated part to replace the removed skin. A disadvantage of this technique is the conspicuous scar located on the lateral surface of the ear.

Mello-Filho et al.[88] proposed a modified use of a platysma myocutaneous flap for the replantation of avulsed ears. The original technique was first described by Ariyan and Chicarilli[89], in 1986. The advantages are: easy surgical technique that can be applied to totally or partially avulsed ears; the possibility of saving ear cartilage regardless of the ear's surrounding tissue; similar skin tissue to that of the ear; stable and adequate aesthetic result with hairless coverage. Disadvantages include the need for two surgical steps; a scar in the supraclavicular donor region; possibility of flap necrosis with a total loss of the implanted ear[88].

According to Kind[90], microvascular ear replantation is an incredible proof of microsurgery power, even if it requires long operative time and several blood transfusions. He states that dissection of the amputated part is preferably done with an operating microscope and it can start while the patient is being prepared for the procedure. The posterior auricular artery gives off branches to meet the superficial temporal artery and these branches are suitable for microvascular repair if the artery found near the wound edge is related to that on the avulsed ear. If an artery is identified but there's insufficient length, vein grafts or pedicled vessels of the superficial temporal artery are possible solutions. Venous repair starts when arterial inflow is confirmed. It follows the same principle for arterial repair and if the primary artery can be identified, usually there's an accompanying vein that can be fixed. Kind also reports that contraindications to ear replantation are similar to those for other microsurgical procedures: associated major trauma or medical problem incompatible to long operation. Relative contraindications include lengthy ischemia time and self-induced injuries[90].

Venous congestion plays a major role in graft failure and can be reduced with systemic anticoagulation, rheologic agents, hyperbaric oxygen and medicinal leeches. These animals can decompress up to 50mL of congested blood in the amputated part, since their saliva contains a potent vasodilator and anticoagulant[18]. This intrinsic combination of factors will decrease venous engorgement, increase tissue perfusion and protect the flap against thrombosis[91]. Any patient who undergo leech therapy needs prophylaxis specific for *Aeromonas hydrophila*[90]. Hyperbaric oxygen may improve tissue oxygenation by raising the arterial oxygen partial pressure and diminishing tissue venous congestion, though the degree of its influence is still controversial[18].

Total Auricular Reconstruction

Reconstructive options for defects of the soft tissues include dermal grafts, galeal flaps and free flaps. Free skin and muscle flaps are always carried in excess and modeled for several months, waiting at least six months before beginning the auricle reconstruction. Full thickness skin grafts and galeal flaps are suitable options for lowered hair lines and scars from previous reconstructive attempts[16].

In general, according to Tanzer[1-4] and Brent[9-12,92,93], four stages are required: 1) placement of cartilage framework; 2) reconstruction of the lobule; 3) creation of an auricocephalic sulcus; 4) tragal reconstruction. The ear is reconstructed around the external auditory meatus (if it is visible.) In its absence, the location of the ear is decided with the help of the following points proposed by Bhandari[94]:

The external auditory meatus is placed just posterior, and at the same level, as that of the temporomandibular joint;

A point is marked at the angle of the mandible. The ear is placed posterior to a vertical line is drawn through this point;

The distance between outer canthus of the eye and crus of the helix of the normal ear is measured. This distance is taken over to the deformed side and a point is marked for the crus helix of the ear to be reconstructed;

The upper margin of the ear is kept at the same level as that of the normal ear in unilateral deformity and to the level of the eyebrow in cases of bilateral deformity.

First Stage: Cartilage Framework Fabrication and Creation of a Cutaneous Pocket

The most convenient harvesting location is the fusion of the contralateral sixth and seventh costal ribs, where the adjacent-floating eighth rib can be also used as the framework for the helical rim. The incision is made over the superior costal margin in order to avoid the neurovascular bundle. The dissection is carefully continued, avoiding pleural violation. When carving the cartilage, one should define the shape of the auricle first and then create the triangular and scaphoid fossa. The following step is to fabricate a helical rim by cutting a strip along the rounded costal surface[19,93].

Kobus et al.[16] suggest that the framework is fashioned and fenestrated in order to facilitate healing and heighten architectural details. All sharp edges need to be rounded and the base of the rim is cut at 45 degrees, providing a more natural appearance to the ear. The sculpture of the costal cartilage is performed with scalpels, wood-carving gouges and chisels. A template of the contralateral ear is made previously and is used to assist the framework sculpture. A cutaneous pocket is dissected and the framework is positioned within. Remnant cartilage is buried in the posterior scalp area and redeemed during the third stage to provide ear projection[16,18].

Second Stage: Lobule Transposition

The lobule is reconstructed from either an infra-auricular flap or residual parts of the native ear[19,92]. Brent proposes another possibility, which consists in moving the earlobe while separating the ear from the head, in order to form the posterior sulcus and to maintain sufficient earlobe skin[93].

Third Stage: Elevation of the Auricle with Skin Graft

Three months later, the ear is lateralized to recreate the auriculocephalic sulcus and to increase the auricle projection. The posterior region is then covered with a skin graft[19]. Because the ears tend to retract medially, a buried piece of cartilage wedge can be used to prevent this possibility[18,19].

Fourth Stage: Tragus Reconstruction

The final stage involves reconstruction of a realistic tragus with the best curvature and definition of the conchal bowl[18]. Brent[93] reported that his approach consists in an elliptical composite graft of cartilage covered with skin, which may be obtained from the anterolateral surface of the normal contralateral conchal bowl. A J-shaped incision is placed at the proposed posterior tragal margin, in the anterior conchal bowl. A flap is raised to accommodate the composite graft. Soft tissue is excised to deepen the conchal floor and the graft is finally secured within its cavity with its skin directed posteriorly, ie towards the ipsilateral conchal bowl.

Reported complications include haematomas, skin necrosis and infections of the cartilage framework. Fortunately these possibilities are rare (2.5%) and have decreased since the introduction of suction drainage. Poor healing of the skin grafts usually results from infection[16,95]. Sasaki[96] found that contraction is a major problem postoperatively and leads to loss of depth to the auriocephalic sulcus rather than distortion of the cartilage framework.

Prostheses

An auricular prosthesis for external ear reconstruction remains an option for certain clinical situations[18]. Unfortunately, placement of the implant often requires removal of remaining ear structures, which may hinder further autogenous reconstructive endeavors. Osseointegrated implants may be used as a salvage option for an unpleasing outcome after autogenous reconstruction[19,97]. Furthermore, the prosthetic ear can be created to exhibit details that surpasses the best autogenous graft. However, alloplastic frameworks, such as porous polyethylene, have a higher failure and exposure rate than cartilage grafts. This has limited its wide spread use[18,98,99].

REFERENCES

1. Tanzer RC. Total reconstruction of the external ear. Plast Reconstr Surg. 1959;23:1-15.
2. Tanzer RC. Total reconstruction of the auricle: a 10-year report. Plast Reconstr Surg. 1967;40:547–50.
3. Tanzer RC. Total reconstruction of the auricle: the evolution of a plan of treatment. Plast Reconstr Surg. 1971;47:523–33.
4. Tanzer RC. Microtia. Clin Plast Surg. 1978;5:317–36.
5. Firmin F. Microtie reconstruction par la technique de Brent. Ann Chir Plast Esthet. 1992;37:119–31.
6. Firmin F. Ear reconstruction in cases of typical microtia. Personal experience based on 352 microtic ear corrections. Scand J Plast Reconstr Surg Hand Surg. 1998;32:35–47.
7. Firmin F. Auricular reconstruction in cases of microtia. Principles, methods and classification. Ann Chir Plast Esthet. 2001;46:447–66.
8. Firmin F, Guichard S. Microtia in cases of oto-mandibular dysplasia. Ann Chir Plast Esthet. 2001;46:467–77.
9. Brent B. Ear reconstruction with an expansible framework of autogenous rib cartilage. Plast Reconstr Surg. 1974;53:619–28.
10. Brent B. The correction of microtia with autogenous cartilage grafts: I. The classic deformity? Plast Reconstr Surg. 1980;66:1–12.
11. Brent B. The correction of microtia with autogenous cartilage grafts: II. Atypical and complex deformities. Plast Reconstr Surg. 1980;66:13–21.
12. Brent B. Auricular repair with autogenous rib cartilage grafts: two decades of experience with 600 cases. Plast Reconstr Surg. 1992;90:355–74.
13. Nagata S. Modification of the stages in total reconstruction of the auricle: part I. Grafting the three-dimensional costal cartilage framework for lobule-type microtia. Plast Reconstr Surg. 1994;93:221–30.
14. Nagata S. A new method of total reconstruction of the auricle for microtia. Plast Reconstr Surg. 1993;92:187–201.
15. Nagata S. Total auricular reconstruction with a three-dimensional costal cartilage framework. Ann Chir Plast Esthet. 1995;40:371–99.
16. Kobus K, Szczyt M, Latkowski I, Wojcicki P. Reconstruction of the auricle. Br J Plast Surg. 2002;55:645-51.
17. Calhoun KH, Chase SP. Reconstruction of the auricle. Facial Plast Surg Clin N Am. 2005;13:231-41.
18. Pham TV, Early SV, Park SS. Surgery of the auricle. Facial Plast Surg. 2003;19(1):53-73.
19. Park SS, Hood RJ. Auricular reconstruction. Otolaryngol Clin N Am. 2001;34(4):713-38.
20. Nachlas NE, Smith HW, Keen MS. Otoplasty. In: Papel ID, Nachlas NE, eds. Facial plastic and reconstructive surgery. St Louis:Mosby Year Book;1992.
21. Postnick JC, Al-Qatta MM, Whitaker LA. Assessment of the preferred vertical position of the ear. Plast Reconstr Surg. 1993;91:1198.
22. Quatela V, Cheney ML. Reconstruction of the auricle. In: Baker SR, Swanson NA, eds. Local flaps in facial reconstruction. St Louis:Mosby;1995.
23. Tolleth H. Artistic anatomy, dimensions and proportions of the external ear. Clin Plast Surg. 1978;5:337.
24. Brent B. Reconstruction of the auricle. In: Plastic surgery.
25. Park C, Roh TS. Anatomy and embryology of the external ear and their clinical correlation. Clin Plastic Surg. 2002;29:155–74.
26. Atamaz Pinar Y, Ikiz ZAA, Bilge O. Arterial anatomy of the auricle: its importance for reconstructive surgery. Surg Radiol Anat. 2003;25:175-9.
27. Park C, Shin KS, Kang HS, Lee YH, Lew JD. A new arterial flap from the postauricular surface: its anatomic basis and clinical application. Plast Reconstr Surg. 1988;82:498-504.
28. Park C, Chung S. Reverse-flow postauricular arterial flap for auricular reconstruction. Ann Plast Surg. 1989;23:369-74.
29. Yotsuyanagi T. Earlobe reconstruction using a chondrocutaneous flap. Plast Reconstr Surg. 1994;94:1072-3.
30. Yotsuyanagi T, Urushidate S, Sawada Y. Helical crus reconstruction using a postauricular chondrocutaneos flap. Ann Plast Surg. 1999;42:61-6.
31. Havlik RJ, Moore TS. Reconstruction of acquired ear deformities.
32. Mladick RA. Salvage of the ear in acute trauma. Clin Plast Surg. 1978;5(3):427-35.
33. Elsahy NI. Acquired ear defects. Clin Plast Surg. 2002;29:175-86.
34. Musgrave RH, Garret WS. Management of avulsion injuries of the external ear. Plast Reconstr Surg. 1967;40:534-9.
35. Pandya NJ. Experimental production of 'cauliflower ear' in rabbits. Plast Reconstr Surg. 1973;52:534–7.
36. Ohlsen L, Skoog T, Sohn SA. The pathogenesis of cauliflower ear. Scan J Plast Reconstr Surg. 1975;9:34–9.
37. Ghanem T, Rasamny JK, Park SS. Rethinking auricular trauma. Laryngoscope. 2005;115:1251-5.
38. Hammond JS, Gillonward C. Burns of the head and neck. Otolaryngol Clin N Am. 1983;16(3):679-95.
39. Press B. Thermal, electrical and chemical injuries. In: Grabb WC, Smith JW, editors. Plastic surgery. 5th ed. Philadelphia:Lippincott-Raven;1997. p.161–75.
40. Zacarian SA. Cryogenics: the cryogenics and the pathogenesis of cryonecrosis. In: Zararirian SC, editor. cryosurgery for skin and subcutaneous disorders. St. Louis: CV Mosby;1985. p.20.
41. Kumar P, Shah P. Preauricular flap for post burn ear lobe reconstruction. Burns. 2000;26:571-4.
42. Mladick RA, Horton CE, Adamson JE. The pocket principle: a new technique for the reattachment of a severed ear part. Plast Reconstr Surg. 1971;48:53.
43. El-Khatib HA, Al-Basti HB, Al-Ghoul A, Al-Gaber H, Al-Hemti T. Subtotal reconstruction of the burned auricle. Burns. 2005;31:230-5.
44. Niamtu III J. Eleven pearls for cosmetic earlobe repair. Dermatol Surg. 2002;28(2):180-5.

45. Pribaz JJ, Crespo LD, Orgill DP, Pousti TJ, Bartlett RA. Ear replantation without microsurgery. Plast Reconstr Surg. 1997;99(7):1868-72.
46. Miller TR, Eisbach KJ. Repair of enlarged pierced-ear openings. ENT J. 2005;84(5):276-7.
47. Kalpesh G. Repair of the split earlobe using a half z-plasty. Plast Reconstr Surg. 1998;101(3):855-6.
48. Agarwal R. Repair of cleft earlobe using double opposing z-plasty. Plast Reconstr Surg. 1998;102(5):1759-60.
49. Yotsuyanagi T, Yamashita K, Sawada Y. Reconstruction of congenital and acquired earlobe deformity. Clin Plast Surg. 2002;29:249-55.
50. Watson D. Repair of the torn earlobe. Facial Plast Surg. 2004;20(1):39-45.
51. Watson D. Torn earlobe repair. Otolaryngol Clin N Am. 2002;35(1):187-205.
52. Savaci N, Tosun Z, Hosnuter M. Ear lobe reconstruction with a posterior ear flap. Scand J Plast Reconstr Hand Surg. 2000;34:173-5.
53. Mellete Jr JR. Ear reconstruction with local flaps. Dermatol Surg Oncol. 1991;17:176-82.
54. Alanis SZ. A new method for ear lobe reconstruction. Plast Reconstr Surg. 1970;45:254-7.
55. Alconchel MD, Rodrigo J, Cimorra GA. A combined flap technique for earlobe reconstruction in one stage. Br J Plast Surg. 1996;49:242-4.
56. Antia NH, Buch VI. Chondrocutaneous advancement flap for the marginal defect of the ear. Plast Reconstr Surg. 1967;39:472–7.
57. Low D. Modified chondrocutaneous advancement flap for ear reconstruction. Plast Reconstr Surg. 1998;102(1):174-7.
58. Elsahy NI. Reconstruction of the ear after skin and perichondrium loss. Clin Plast Surg. 2002;29:187-200.
59. Shim EK, Greenway Jr HT. Repair of helical rim defects with the bipedicle advancement flap. J Am Acad Dermatol. 2000;43(6):1109-11.
60. Elsahy NI. Reconstruction of the ear after skin and cartilage loss. Clin Plast Surg. 2002;29:201-12.
61. Uraloglu M, Kerem M, Tekin F, Unlu RE, Sensoz O, Uysal AC. Tunnelized superior auricular artery based flap for reconstruction of anterior auriculohelical defect. Ann Plast Surg. 2005;54(6):684-6.
62. Ferri M. Treatment of partial losses of the helix. Plast Reconstr Surg. 1998;101(7):2011-2.
63. Dujon DG, Bowditch M. The thintube pedicle: a valuable technique in auricular reconstruction after trauma. Br J Plast Surg. 1995;48:35-8.
64. Mascio D, Castagnetti F. Tubed flap interpolation in reconstruction of helical and ear lobe defects. Dermatol Surg. 2004;30(4):572-8.
65. Schwabegger A, Anderl H, Ninkovic M. Reconstruction of the helical rim with the rubber band-conditioned postauricular tubed flap. Aesth Plast Surg. 1998;22:48-50.
66. Ellabban MG, Maamoun MI, Elsharkawi M. The bi-pedicled postauricular tube flap for reconstruction of partial ear defects. Br J Plast Surg. 2003;56:593-8.
67. Curtin JW, Bader KF. Improved techniques for the successful silicone reconstruction of the external ear. Plast Reconstr Surg. 1969;44:372.
68. Lynch JB, Pousti A, Doyle J. Our experiences with silastic ear implants. Plast Reconstr Surg. 1972;49:283.
69. Park C, Seum C. A single-stage two-flap method for reconstruction of partial auricular defect. Plast Reconstr Surg. 1998;102(4):1175-81.
70. Elsahy NI. Ear reconstruction with rotation advancement composite flap. Plast Reconstr Surg. 1985;77:567-8.
71. Davis JE. Repair of traumatic defects of the auricle. In: Tanzer RC, Edgerton MJ, editors. Symposium on reconstruction of the auricle. St. Louis:CV Mosby;1974. p.247–8.
72. Millard DR. The chondrocutaneous flap in partial auricular repair. Plast Reconstr Surg. 1966;37:523–7.
73. Iida N, Hosaka Y, Ogawa T. Correction of auricular deformity caused by high ear-piercing: case report. Ann Plast Surg. 2003;50(1):82-4.
74. Simplot TC, Hoffman HT. Complication between cartilage and soft tissue ear piercing complication. Am J Otolaryngol. 1998;19:305–10.

75. Margulis A, Bauer BS, Alizadeh K. Ear reconstruction after auricular chondritis secondary to ear piercing. Plast Reconstr Surg. 2003;111(2):891-7.
76. Skedros DG, Goldfarb IW, Slater H, Rocco J. Chondritis of the burned ear: a review. Ear Nose Throat J. 1992;71:359.
77. Bauer BS. Combined otoplasty technique: analysis and treatment of the prominent ear. Oper Tech Plast Reconstr Surg. 1997;4:109.
78. Park C, Lew DH, Yoo WM. An analysis of 123 temporoparietal fascial flaps: anatomic and clinical considerations in total auricular reconstruction. Plast Reconstr Surg. 1999;104(5):1295-306.
79. Park SS, Wang TD. Temporoparietal fascia flap in auricular reconstruction. Facial Plast Surg. 1995;11:330.
80. Yotsuyanagi T, Nihei Y, Sawada Y. Reconstruction of defects involving the upper third of the auricle. Plast Reconstr Surg. 1998;102:988.
81. Butler CE. Extended retroauricular advancement flap reconstruction of a full-thickness auricular defect including posteromedial and retroauricular skin. Ann Plast Surg. 2002;49:317–21.
82. Maral T, Borman H. Reconstruction of the upper portions of the ear by using an ascending helix free flap from the opposite ear. Plast Reconstr Surg. 2000;105(5):1754-7.
83. Wolf Y, Shulman O, Hauben DJ. One stage reconstruction in human bite injuries of earlobe and lower helical rim. Plast Reconstr Surg. 2001;107(1):286-8.
84. Prakash V, Tandon R. Ear reconstruction using prefabricated adipofascial flaps. Plast Reconstr Surg. 2005;115(2):674-5.
85. Yotsuyanagi T, Yamashita K, Watanabe Y, Urushidate S, Yokoi K, Sawada Y. Reconstruction of a subtotally amputated auricle: a case report. Scand J Plast Reconstr Hand Surg. 2001;35:425-8.
86. Baudet J, Tramond P, Goumain A. A propos d'un procede original de reimplantation d'un pavillon de l'oreille totalement separe. Ann Chir Plast. 1972;17:67.
87. Elsahy NI. Ear replantation. Clin Plast Surg. 2002;29:221-31.
88. Mello-Filho FV, Mamede RCM, Koury AP. Use of a platysma myocutaneous flap for the reimplantation of a severed ear: experience with five cases. São Paulo Med J. 1999;117(5):218-23.
89. Ariyan S, Chicarilli ZN. Replantation of a totally amputated ear by means of a platysma musculocutaneous"sandwich" flap. Plast Reconstr Surg. 1986;78:385.
90. Kind GM. Microvascular ear replantation. Clin Plast Surg. 2002;29:233-48.
91. Frodel JL, Barth P, Wagner J. Salvage of partial facial soft tissue avulsions with medicinal leeches. Otolaryngol Head Neck Surg. 2004;131:934-9.
92. Brent B. Technical advances in ear reconstruction with autogenous rib cartilage grafts: personal experience with 1200 cases. Plast Reconstr Surg. 1999;104:319–34.
93. Brent B. Microtia repair with rib cartilage grafts. A review of personal experience with 1000 cases. Clin Plast Surg. 2002;29:257-71.
94. Bhandari PS. Total ear reconstruction in postburn deformity. Clin Plast Surg. 2002;29:213-20.
95. Harris PA, Ladhani K, Das-Gupta R, Gault DT. Reconstruction of acquired sub-total ear defects with autologous costal cartilage. Br J Plast Surg. 1999; 52:268-75.
96. Sasaki GH. Tissue expansion in reconstruction of auricular defects. Clin Plast Surg. 1990;17:327–38.
97. Wilkes GH, Wolfaardt JF. Osseointegrated alloplastic versus autogenous ear reconstruction: criteria for treatment selection. Plast Reconstr Surg. 1994;93:967.
98. Caccamese JF, Ruiz RL, Costello BJ. Costochondral rib grafting. Atlas Oral Maxillofacial Surg Clin N Am. 2005;13:139-49.
99. Botma M, Aymat A, Gault D. Rib graft reconstruction versus osseointegrated prosthesis for microtia: a significant change in patient preference. Clin Otolaryngol Allied Sci. 2001;26:274–7.