

Reconstructive Surgery of Auricular Defects: An Overview

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Abstract

Context: Despite the ongoing advances in surgical procedures and promising progress in bioengineering techniques, auricular reconstruction remains a significant challenge in plastic surgery. There are different causes for acquired auricular defects, including trauma, tumor ablation and burns. The management options for upper, middle and lower third auricular defects are briefly reviewed in the current paper.

Evidence Acquisition: Original research papers investigating the plastic surgeons, otolaryngologists and maxillofacial surgeons in approaching the complicated issue of auricular reconstruction published from January 1995 to December 2014 were aggregated and used in the current study.

Results: Utilizing autologous stem cell populations to treat craniofacial defects is a promising field of ongoing investigations. Studies show that cartilage stem/progenitor cells (CSPCs) are highly chondrogenic and can produce elastic reconstructive material with long-term tissue restoration.

Conclusions: Auricular reconstruction surgery is a challenging plastic procedure that requires great expertise and expert knowledge of the various techniques available. Novel techniques in the fields of reconstructive bioengineering and regenerative medicine are promising but further research is required before widespread clinical application.

Keywords: Auricular Appendage, Reconstructions, Auditory Prosthesis, External Ear, Cosmetic Reconstructive Surgical Procedures

1. Context

Reconstruction of the auricle is aesthetically demanding. Various techniques are used according to the defect size, location, and tissues involved. A wide range of acquired and congenital deformities and surgical techniques are available; the complex anatomy poses a formidable challenge to plastic surgeons performing auricular reconstruction. In addition, selecting the best surgical approach to restore a complete and functional auricle is further complicated by individual preferences, aesthetic expectations and the soft tissue and cartilage available (1, 2).

Several factors should be considered to achieve symmetry, normal position and appearance. Important aspects that ensure a successful ear reconstruction include attention to tissue manipulation and availability of well-vascularized functioning tissue (3) aesthetic considerations and patient expectations. The psychosocial benefits of auricular reconstruction should also be considered (4).

Trauma and surgical excision of tumors are among the main causes of acquired auricular defects. Traffic accidents, sports injuries, burns, bites and falls are major

sources of traumatic injuries of the external ear (5). The most common etiologies are car accidents and bites that require appropriate antibiotics prior to delayed wound closure (6). Ear cancer is rare and most of the malignancies involve the skin of the external ear. Basal cell carcinoma (BCC) is the leading tumor among non-melanoma skin cancers that involves the auricles. BCC most commonly involves the preauricular area and auricular helix and may result in considerable tissue destruction (7). Studies suggest that BCC of the ear is likely to be of an aggressive phenotype and most commonly affects men (8).

The Mohr microsurgery is employed in many cases of ear BCC and it could result in considerable iatrogenic defects since it involves gross repetitive tissue curettage until clear margins are reached (9). Moreover, as the auricle is exposed to sunlight it is vulnerable to developing squamous cell carcinoma (SCC) and melanoma (10, 11).

Various detailed historical accounts of ear reconstruction are available and description of a partial earlobe reconstruction seems to be the earliest documented case

mentioned in an ancient Indian text (12). Currently, the ever-growing fields of biotechnology and bioengineering play a crucial role in introduction of novel therapeutic options in ear reconstructive surgery; investigations on culturing and bioengineering ear cartilage are promising (13-16). The current article briefly reviewed reconstructive surgery of the acquired external ear defects. The provided information may aid plastic surgeons, otolaryngologists and maxillofacial surgeons to approach the complicated issue of auricular reconstruction.

2. Evidence Acquisition

Original research papers investigating the plastic surgeons, otolaryngologists and maxillofacial surgeons in approaching the complicated issue of auricular reconstruction published from January 1995 to December 2014 were aggregated, coded, and used in the current study. The following libraries and online sources were searched: PubMed, MEDLINE, Wiley, EMBASE, ISI Web of Knowledge and Scopus.

The terminologies that were used to identify these articles included: plastic surgery, auricular defects, reconstructions, ear trauma, bioengineering, facial surgery. The articles obtained from different databases into the bibliographic software package EndNote were imported and merged into one complete database. Two review authors independently assessed the titles and abstracts of all articles found by the searching method outlined above.

3. Results

3.1. Acute Ear Trauma

Appropriate management of the acutely traumatized ear is of vital importance and improper treatment could lead to a cauliflower ear following auricular hematoma. Management of cauliflower ear is a challenging reconstructive procedure and requires reshaping of the auricle after excision of the deformed cartilage (17, 18). Moreover, the bluntly traumatized auricle is vulnerable to infection, necrosis, and contracture. There was no consensus on the evidence-based management of acute auricular hematoma and systematic reviews of the literature highlighted the need for further research before recommending the optimal management strategies (19). The current management of auricular hematoma mainly depends on its size; while smaller hematomas should be aspirated; larger ones require open surgical drainage. Further studies are required to elucidate the efficacy of post-drainage interventions including splinting or bandaging (19, 20). New techniques using fibrin glue and an 18-gauge catheter with a compression dressing are recently proposed. Cost-effectiveness and efficacy of these management options remain to be confirmed by further studies (20, 21). Use of local flaps in soft tissue defects, initial realigning of the helical rim and anatomical repair of ear lacerations should be considered in management of acute ear trauma. In cases of ear ampu-

tation, staged reconstruction or replantation techniques should be used (22).

3.2. Basic Surgical Principles and Classification of Auricular Defects

Based on the involved tissue, auricular defects are categorized into cutaneous and cutaneous-cartilaginous defects (23). Primary closure is usually applicable in cases of medial auricular cutaneous defects due to malleable nature of the tissues involved. However, primary closure is not usually possible for lateral cutaneous defects and skin grafts from the medial surface or the contralateral postauricular area are usually required (24-26).

Lack of supporting structure and sophisticated anatomical alterations of the external ear make cutaneous-cartilaginous defects more challenging to deal with. Depending on the extent of damage, primary repair, local flaps, skin grafts and regional flaps are used in the reconstructive procedures (27). A successful auricular reconstruction with satisfactory aesthetic results depends heavily on functional vascular supplies and decreased tension at the site of reconstruction to ensure tissue vitality. Currently, temporoparietal fascia flaps are widely used in regional flaps that provide a well-vascularized environment (28). Small defects could be reconstructed by excision and primary closure if decreased auricular height could be appropriately managed to avoid cupping of external ear structures (3). Use of various alternative flaps including superior pedicle postauricular chondrocutaneous flaps and autologous contralateral conchal cartilage grafts are promising and are topics of ongoing research (29, 30). Reconstruction of the tragus can also be achieved with a preauricular cutaneous flap transposed to the defect and folded onto it. The flap can be based either inferiorly or superiorly.

3.3. The Upper Third Auricular Defects

There are several techniques to reconstruct the upper third defects; factors such as size of the defect and availability of skin grafts mainly determine the superior options in each case (31, 32). Fortunately, minor defects cause less cosmetic issues and hair may cover the site. For upper auricle defects, smaller than 2.8 cm, the helical advancement technique is advantageous and complications are rare (33). A variation of this flap, which is detached from the anterior and posterior helical surfaces, maximizes mobility at the cost of threatening tissue viability (34). In another variation, first described by Anita and Buch more than forty years ago, flap viability is not jeopardized but movement is considerably limited as the posterior skin remains intact (35). Large upper third defects are often managed by contralateral cartilage grafts and postauricular skin flaps and in case of insufficient graft donor sources, use of compound pedicle flaps is recommended (26, 36). Preauricular flaps, designed at the junction of the ear and face with the pedicle based superiorly or inferiorly, may cover some small antihelical defects.

3.4. The Middle Third Auricular Defects

In contrast to the upper third auricle, middle auricular defects do not substantially disturb functions like support of eyeglasses. However, the retroauricular skin is thinner and the deformed structures are more visible (37). Based on the same principles, chondrocutaneous advancement flaps could be also used in approaching middle third auricular defects (35). Good cosmetic results are reported by using superior pedicle postauricular chondrocutaneous flaps in management of full-thickness upper and middle third auricular defects (29). Reduced vertical height is a major problem if small middle third defects are repaired after turning the traumatized site into a wedge. Retroauricular composite flaps and autogenous cartilage harvested from conchal cartilage are used to reconstruct larger defects. Use of small local flaps raised from the lobule is an effective alternative in patients with abundant lobular tissue; recent studies highlight the simplicity and minimal anatomical deformity of this technique (38).

3.5. Lower Third Auricular Defects

Lower third auricular structures including lobule are more mobile and flexible; therefore, reconstruction of the defects at these locations is often less challenging. In addition, as mentioned earlier the lobule can act as a potential source of advancement flaps. Various techniques are introduced in the literature to address traumatized earlobes. In cases of full-thickness major trauma that involve a great proportion of the lobule, more burdensome techniques, using cartilage grafting, are often required. One famous technique is the double flap proposed by Preaux and modified by Brent who recommended the use of bipedicle chondrocutaneous flaps and contralateral cartilage grafts (39, 40). Davis introduced another approach based on a mastoid flap for anterior earlobe reconstruction and a posterior flap turned over from the anterior helix surface (41). More easily implemented techniques are also gaining acceptance and reconstruction of ear lobule through a one-stage procedure is reported with favorable aesthetic and symmetric outcomes. These techniques include the use of the Limberg-flap, a double-over skin flap, two superiorly based flaps rotated towards the middle or a bilobed flap with an anterior base (42-44).

3.6. Large Defects of the Auricle

Reconstruction of defects larger than one-third auricular is a daunting task and requires great expertise. Larger ear defects present unique and complex challenges to plastic surgeons due to the delicate and intricate architecture of external ear structure that is difficult to duplicate surgically. Despite complexities during reproduction of the intricate auricular anatomy, detailed information on landmarks, size and position could help the surgeon achieve satisfactory outcomes. Autogenous cartilage and skin grafting, temporoparietal flaps covering costal carti-

lage grafts and tubed-pedicle flaps from the retroauricular or supraclavicular sites can be used to manage large auricular defects (45-47). Tissue may be expanded in the retroauricular region for coverage in conjunction with grafts or reconstruction of large defects.

Autologous rib cartilage is a widely employed technique for total reconstruction of the auricle. To restore the natural ear shape, rib cartilage frameworks should be appropriately sculpted and the skin should be carefully used to ensure successful reconstruction and reduced complications (48). Use of alloplastic material and bioengineered cartilage are areas of ongoing investigation. Porous polyethylene is currently considered the most favorable alloplastic framework and recent reviews of the literature underscore the benefits of its open porous structure and biocompatibility (49-51). In cases of total or nearly total defects, superficial temporal and posterior auricular arteries play a crucial role in creating the required microvascular anastomosis for successful ear replantation (52).

3.7. Reconstruction of the Burned Ear

The external ear is highly susceptible to thermal injuries and progressive deep burns due to its exposed anatomical structure. Reconstruction of the burned auricle is a significant challenge for most plastic surgeons. Early debridement of ear burn wounds before occurrence of irreversible cartilage changes is highly recommended. Surgeons' preference and local tissue availability are the most important variables to consider before choosing the optimal modality for repair (53, 54). Integrity of the mastoid skin is considered a reliable prognostic factor in patients with burned auricles. Superficial temporal fascia or an indirect expansion could be used and in rare cases, free contralateral superficial temporal fascia may become necessary before placing a prosthesis (55). Use of postauricular advancement flaps and skin grafts to cover the helix and antihelix respectively are suggested as a straightforward technique with low complication rates to manage extensive ear burns acutely (56). In addition to postauricular skin and fascia, free radial forearm flaps and free lateral arm fascial flaps are also used to reconstruct the burned auricle. These techniques may be limited by lack of viable local tissues or free flaps following extensive burns (57). Innovative techniques combining scalp tissue expansion with porous polyethylene reconstruction is recently introduced, which use temporoparietal fascia flaps and does not require costochondral grafting (58). Use of bone-anchored extraoral implants is also investigated in burn patients with lasting aesthetic results and low complications (59).

3.8. Prosthetic Reconstruction of the Auricle

In some cases of extensive auricular defects, especially in older patients, surgical procedures may not lead to satisfactory results and prosthetic reconstruction should

be used. From a historical perspective, ear prostheses are broadly used and various attachment techniques are tested since ancient times (60). In addition to the aesthetic concerns, perfect fitting of the prosthesis is of utmost importance. Titanium screw implants address issues such as bone healing, vascular integrity and integration of foreign objects into patients' bodies (61). Studies confirmed reliability of auricular prostheses anchored to the extraoral bone-integrated implants and evidence is accumulating the patient satisfaction and rapid return to normal life following such procedures (62).

3.9. Novel Bioengineering Techniques in Auricular Reconstruction

Utilizing autologous stem cell populations to treat craniofacial defects is a promising field of ongoing investigations. Studies show that cartilage stem/progenitor cells (CSPCs) are highly chondrogenic and can produce elastic reconstructive material with long-term tissue restoration. (63).

Bioengineering absorbable materials that could serve as templates for cartilage healing are also a logical perspective currently studied to simplify reconstruction procedures (64). Three dimensional templates made of bioresorbable and nonbioresorbable materials are tested but problems are encountered due to uneven biodegradation rates and further research is required before application of these novel techniques in the clinical setting (65, 66).

4. Conclusions

There are different causes for auricular defects including tumor ablation, traumas and burns. Auricular reconstruction surgery is a challenging plastic procedure that requires great expertise and expert knowledge of the various techniques available. Current techniques could be further modified with respect to their cost-effectiveness and simplicity. The reconstruction method is dependent on defect size and location. Novel techniques in the fields of reconstructive bioengineering and regenerative medicine are promising but further research is required before widespread clinical application.

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Footnote

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technical, and material support: Ali Ebrahimi, Alireza Kazemi, Hamid Reza Rasouli, Maryam Kazemi Mohammad Hosein Kalantar Motamedi; study supervision: Ali Ebrahimi and Mohammad Hosein Kalantar Motamedi.

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