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Indications for and Limitations of Reconstruction of Auricular Defects with the "Mid-moon Flap" and Evaluation of Outcome by the Aesthetic Numeric Analogue Score

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Summary: A variety of skin grafting techniques and local flaps have been described for medium-sized auricular defect reconstruction. Despite this, the reconstruction of a medium-sized auricular defect starting from the opposite surface is not yet reported in the literature. In the present article, the authors describe a novel surgical approach, the "mid-moon flap" technique, used for 87 patients in that kind of reconstruction. Eighty-seven patients presenting tumors located on the pinnal surface were enrolled in this study. The patient distribution included 68 men and 19 women, aged from 52 to 94 years, with a median age of 77.4 years. For all the patients, a customized cutaneous flap, named the mid-moon flap, was performed for auricular defect reconstruction. Histopathology reports confirmed the diagnosis of malignant tumors, with complete excision of the lesions in all cases. Follow-ups ranged from 6 to 36 months, with a mean of 18 months. There were no recurrences of the malignancy during the study, and the aesthetic outcome was globally considered good. The authors reported that the mid-moon flap technique is most appropriate for medium-sized auricular defects for two principal reasons: it covers the recipient area very well and, at the same time, leaves almost imperceptible relics on the donor area without causing any morphofunctional alteration of the ear.
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INTRODUCTION

The external ear represents a peculiar structure, with its particular anatomical conformation, morphologically linked to its functions. The anterior surface skin is tightly attached to the perichondrium, and the subcutaneous vascular plexus is not always identifiable between the two layers. The posterior surface of the ear is instead loosely attached, and it contains subcutaneous fat, even if rather thin.[1] Reconstruction of the ear represents a major challenge for the plastic surgeon, given the importance of ensuring restoration of the orientation, size and shape of the reconstructed ear, as well as the external auditory canal and postauricular sulcus as close as possible to the contralateral ear.[2] To achieve that goal, the authors adopted a novel surgical approach, based on a cutaneous flap obtained from the opposite surface of the ear. They named it the "mid-moon flap." That singular definition depends on the particular form that the flap assumes overturning from a surface to the other one of the ear, looking like a half of the visible face of the moon.

MATERIALS AND METHODS

Eighty-seven patients presenting tumors located on the pinnal surface were enrolled in this study; they were treated at the division of plastic surgery of the IRCCS—Centro di Riferimento Oncologico della Basilicata, Italy, from January 2014 to June 2019. Informed consent was obtained from all patients enrolled in the study. The patient distribution included 68 men and 19 women, with ages ranging from 52 to 94 years. The mean age was 77.4 years. The histological distribution of the 87 enrolled

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Table 1. Patients and Characteristics

	Men	Women	Total	Right Ear	Left Ear
Mean age	76	79			
Basal cell carcinoma	22	9	31	13	18
Squamous cell carcinoma	32	6	38	18	20
Others	14	4	18	9	9
Total	87				

patients included 31 patients affected by basal cell carcinomas, 38 patients affected by squamous cell carcinomas, and 18 patients affected by other histological types (Table 1). The average detected diameter was 1.18 cm for basal cell carcinomas and 1.47 cm for squamous cell carcinomas. In 18 cases, basal cell carcinomas have affected the left ear, and in 13 cases, the right one. Twenty cases of squamous cell carcinoma occurred on the left ear, and 18 cases, on the right ear. Nine other tumors affected the left ear, and nine, the contralateral one. For all of the patients, the lesions were excised under local anesthesia, under intravenous antibiotic prophylaxis. Appropriate margins were obtained based on the tumor behavior and the size of the lesion. All resected specimens were submitted for pathological analysis to determine the histological diagnosis. Flap reconstruction was performed at the time of tumor excision in all of these cases. The trial was regularly submitted to and approved by the institutional review board, and a written informed consent had been requested and obtained by all the participants. For all patients, a "short-term" antibiotic prophylaxis by second-generation cephalosporins was performed. Subsequent postoperative checks were cadenced periodically every week. No major complications were noticed (skin necrosis, infection, and chondritis). A *t* test was used to perform the statistical analysis.

SURGICAL TECHNIQUE

The classic revolving door flap, described by Masson et al in 1972,[3] includes the postauricular and mastoid skin and the subcutaneous tissue exposed by removal of the cartilage, but the authors adopted a different surgical technique, based on a cutaneous flap obtained from the opposite auricular surface and overturned on the recipient area (Fig. 1). The surgery was performed on an outpatient basis, under local anesthesia with infiltration of mepivacaine hydrochloride 1% and epinephrine (1:200,000). After removing the neoplastic lesion, the auricular cartilage is incised en bloc with the skin of the posterior surface of the auricle, for the entire extent of the anterior substance loss, except for the contralateral margin of the first incision. This nonincised margin will represent the vascular pedicle of the reconstruction flap. If necessary, to allow the transposition of the prepared flap from the donor area of the posterior surface to the anterior recipient area of the auricle, just enough of the auricular cartilage is removed to facilitate this operation. The free edges of the flap are then sutured to the

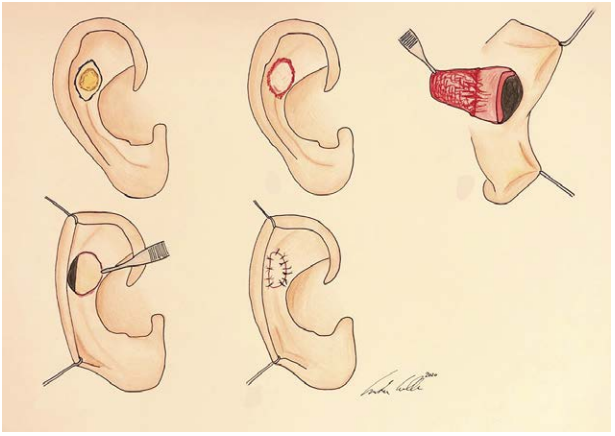

Fig. 1. The mid-moon flap technique for the reconstruction of auricular defects. From left to right, clockwise. Excision area, loss of substance, dissection of the flap (posterior view), anterior placement of the flap, and completed suture of the flap.

corresponding edges of the receiving area. In this way, the flap will have the appearance of a half-moon, hence the name mid-moon flap.

At the end of these sutures, a continuous solution will remain, which connects the anterior surface with the posterior surface of the auricle. A nonfull-thickness incision of the flap is then made at its point of transposition from the back to the front of the ear. Two flaps of skin were created. One is sutured to the still free margin of the loss of anterior substance, residual from the demolition, and the other to the margin of the posterior surface of the auricle, corresponding to the donor area. At the end of all these operations, the complete closure of the bloody area remaining from the oncological demolition will be obtained beforehand and, later, a linear suture corresponding to the donor area of the flap (Fig. 2). It is important to specify that it is precisely the presence of the cartilage that prevents distortion of the auricle, as shown by the postoperative data, among other things. What looks like a weakness is a strength: the presence of cartilage and its elastic properties will shape the flap so that the auricle takes on its original shape and curvature (**See Video [online],** which displays the mid-moon flap for auricular defects.). Suturing of the flap is performed using either absorbable sutures, such as Monocryl 5/0 or 4/0, or nonabsorbable sutures, such as nylon 5/0 or 4/0. The donor site is closed primarily with continuous suture (nylon 4/0). All sutures are removed 7 to 12 days after surgery.

MORPHOMETRIC EVALUATION AND RESULTS

There is a wide variety of shapes, sizes, positions, and external aspects that should be evaluated when examining an auricle. A "standard" ear should be included within an angle of about 20–30 degrees from the side of the head, as mentioned by Avelar.[4] The angle between the mastoid and the ear plane is about 20–30 degrees, and the

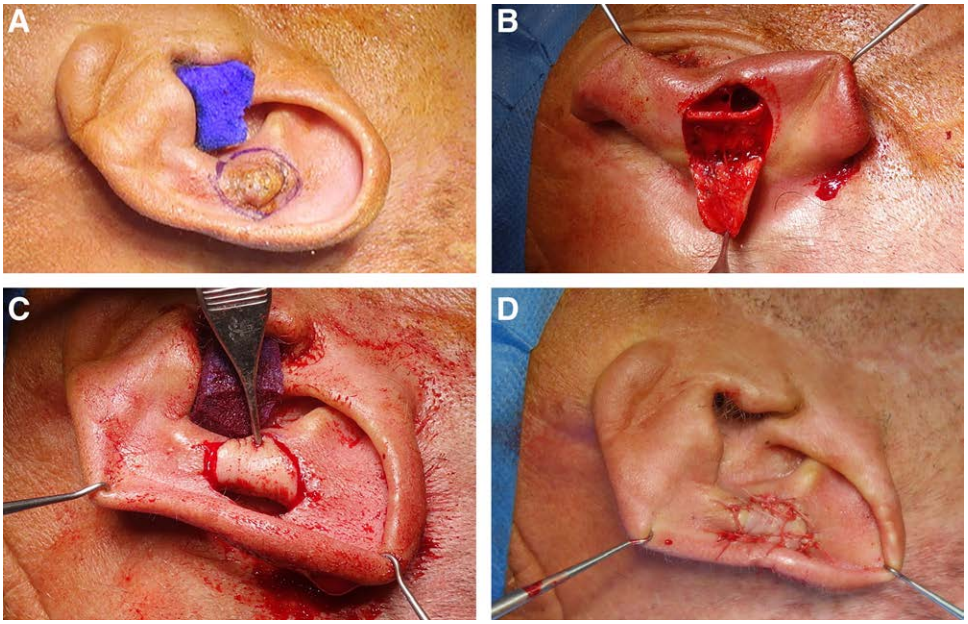

Fig. 2. The mid-moon flap surgical technique. A, Basal cell carcinoma of the conchal surface of the left ear, cutaneous incision at no less than 2 mm from the margins of the lesion. B, Flap raising from the retro-auricular surface. C, Overturned flap with its mid-moon aspect. D, Anterior complete sutures.

concho-mastoid angle is 90 degrees. Starting from these morphological cornerstones, authors used an evaluation tool, which can be considered able enough to standardize the degree of patient satisfaction after the auricular reconstruction intervention. This score, developed by Funk et al,[5] is based on the Aesthetic Numeric Analogue-scale (ANA-scale). All the patients expressed their evaluation: "0" had to be similar to the worst assessment, "10" to the best. The terms that had to be related to the numbers included 11 different descriptions of patients' satisfaction with the aesthetics: "insufficient," "unsatisfied," "poor," "sufficient," "neutral," "agreed," "satisfied," "as requested," "perfect," "harmonic," and "highly satisfied." Paired student *t* tests were used to compare pre- and postoperative ANA scores. Findings are reported as mean and standard deviation (SD; Table 2). This scale was written and validated in Italian. All changes directly linked to surgery with a *P* value of 0.05 or less were statistically significant for the study. Donor-site scars were globally judged acceptable; the color and texture of the flaps matched well with the surrounding skin. Aesthetic outcomes were considered good for all the evaluated parameters; no auricular deformation occurred, and hearing was not affected in any case. Histopathology reports confirmed the diagnosis of malignant tumors, with complete excision of the lesions in all cases. Follow-ups ranged from 6 to 36 months, with a mean of 18 months. No cases of recurrence have been reported. The authors scrupulously followed the international guidelines for ultrasound follow-up: in particular, the occurrence of local recurrences and the state of scarring was carefully assessed at 3 months, at 6 months, and at 1 year.[6,7] An ultrasound check control of the lateral-cervical lymph node stations was performed at 1 year after the intervention. Potential complications can include flap necrosis, recurrence, and infection, but authors did not observe any of them.

Table 2. ANA Results (*T* Test)

Parameter	Preoperative Mean Score	SD	Postoperative Mean Score	SD	*P*
Global appearance	8.3	0.12	8.6	0.15	0.0025
Size of the ear	8.6	0.13	8.9	0.14	0.048
Shape of the ear	7.9	0.16	8.5	0.30	0.0031
Skin thickness of the ear	8.3	0.10	8.6	0.15	0.0022
Skin quality	7.8	0.12	8.2	0.19	0.0038

DISCUSSION

Reconstruction of the external ear poses a significant challenge, particularly in the case of a relevant complexity defect. The primary goals of auricular reconstruction include the restoration of the shape and size for the reconstructed ear to match the contralateral ear as closely as possible, maintaining the postauricular sulcus as well as the external auditory canal. Because the skin of this area closely adheres to the cartilage below, the reconstruction of the area and its shape is difficult to obtain. Many surgeons still use skin grafts to repair defects in this area. However, skin grafting may cause complications, such as delayed wound healing, pigmentation, and contraction. To reduce the risk of these complications, reconstruction flaps should be considered as an alternative repair technique, in order to avoid the mechanical distortion of the anatomic structures. That should be considered the

principal goal for the plastic surgeon. Many authors have described postauricular flaps for reconstruction of pinnal defects.[8,9] The classic "revolving door flap," described by Masson in 1972, represents the most used technique: it includes the postauricular and mastoid skin and the subcutaneous tissue exposed by removal of the cartilage. Many revisions of this original technique have been used. McInerney[9] et al described the "trap-door flap" as a versatile way to obtain a valid ear reconstruction, whereas Heinz et al[10] used the anterior pedicle retro-auricular flap for reconstruction of full-thickness defects in several parts of the ear. The present study presents a novel surgical approach, based on a cutaneous flap obtained from the posterior auricular tissue, overturned to provide an adequate thickness, and 87 patients underwent surgical reconstruction with the mid-moon flap. The ANA score allowed for detecting the results perceived by patients, and data were analyzed with the *t* test (expressed as SD – SD/mean). This evaluation method is only a way to evaluate the degree of patient satisfaction with this new reconstructive method and certainly not a way to compare its effectiveness with respect to other reconstructive methods. Aesthetic outcomes were generally considered more than acceptable for all the evaluated categories (Table 2). The versatile technique presented by the authors in this case series has proved to be considered capable of helping the plastic surgeon to bridge losses of substance (maximum 2.5 cm) without compromising the skin tissue of the mastoid area. The mid-moon flap obtains the right color and texture of the reconstructed area (lack of skin grafts) and retro-auricular sulcus preservation, as well as morphologic symmetry (lack of the revolving door flap).

CONCLUSIONS

The authors have evaluated the mid-moon flap technique for the anterior auricular reconstruction of 87 patients, which provides a unique solution to address the multiple challenges of medium-sized, anterior auricular defects, including skin color and texture matching, as well as restoration of the postauricular sulcus, not otherwise obtainable by using skin grafts or the revolving door flap. A limitation of this procedure, in the authors' experience, could be the reconstruction of losses of substance larger than 2.5 cm, which could lead to a deformation of the auricular shape. The authors also consider the future opportunity to perform this technique for the posterior auricular defects. In fact, from a conceptual point of view, the present technique could also be used for posterior defects with similar widths. The future step of this project will be the enlargement of the indications of this flap.

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DISCLOSURE

The authors have no financial interest to declare in relation to the content of this article.

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All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008. The study was approved by the Local Ethical Committee of IRCCS CROB.

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