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CLINICAL PAPER

Ear Reconstruction Using Autologus Costal Cartilage: A Steep Learning Curve

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Abstract
Purpose Ear reconstruction is a challenging operation with a steep learning curve. In view of its rarity, attaining a high standard for new surgeons is extremely difficult. This study describes the author's experience of 53 ear reconstructions using costal cartilage for congenital and post-traumatic ear deformity.
Methods The author performed 53 autologous ear reconstructions for microtia and post-traumatic ear defect over a period of 5 years utilizing the two-stage technique popularized by Firmin in most of the cases. An assessment of complications, pattern of progress and aesthetic outcome of the reconstructed ears was carried out.
Results There were 4 cases of partial skin necrosis. In early cases, deficiencies were seen in the proportions of the reconstructed ear and the quality of definition. Better shape and definition were evident as more surgical experience was gained. This occurred as a result of increased appreciation of the ear proportions and improved framework carving.
Conclusions The series demonstrates the early learning curve in microtia reconstruction and underlines the importance of appropriate training and case availability in achieving high-quality results in autologous ear reconstruction.

Keywords Ear reconstruction · Learning curve · Microtia · Post-traumatic

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Introduction

The human ear is difficult to reproduce surgically because it is composed of a complex, convoluted frame of delicate elastic cartilage surrounded by a thin skin envelope [1]. Regardless of the size and shape of the deformity, the ultimate goal of total reconstruction of the ear is the construction of an auricle with an appearance as close as possible to that of the normal ear. Multiple surgical techniques have been introduced for ear reconstruction with great success [2–7].

New surgeons who aim to perform ear reconstruction are faced by a number of problems. The relative rarity of microtia means that the case availability will be restricted whilst a steady stream of case is necessary to achieve high-quality results. There is a long learning curve [8, 9], which could well be at the expense of the patient. Complications and unsatisfactory outcomes are extremely difficult to rectify, and a poor result is often a disastrous outcome for the patient.

This study describes the author's experience of ear reconstruction using costal cartilage for congenital and post-traumatic ear deformity since year 2013. Forty-seven consecutive cases were treated in last 5 years. The objective was to assess complications, pattern of progress and aesthetic outcome. All patients were treated with the principles of a two-stage method. The Firmin technique was applied in the majority of cases.

Patient and Method

A total of 47 patients (53 ears) were operated on over a period of 5 years. The group comprised 28 males and 19 females with mean age of 12 years (age 9–34). Unilateral

microtia accounted for 45, bilateral microtia accounted for 6, and 2 patient had severe post-traumatic ear defect. In 42 cases microtia was of lobular type (Fig. 1a) and 9 cases of the conchal type (Fig. 1b), and 2 cases had traumatic amputation of over 50% of the ear (Fig. 1c) requiring rib cartilage for reconstruction. Three patients had microtia associated with hemifacial microsomia.

The first stage of microtia surgery is initiated at the age of 9 or 10 years, when costal cartilage stock is adequate to support framework creation. In patients with coexistent clefts and other congenital anomalies of the facial skeleton, we believe that early surgery to correct the clefts and obtain facial symmetry and normal function of the temporomandibular joint is necessary. This is especially important in Treacher Collins syndrome and in first and second branchial arch defects like hemicraniofacial microsomia, Goldenhar's syndrome.

Surgical Template

In the first stage, a pattern for the construct is made by placing a piece of X-ray film against the normal ear and tracing its anatomic landmarks. The template is then reversed and made several millimetres smaller throughout to accommodate the thickness of the skin cover (Fig. 2a). Once configured, the template is aligned symmetrically with the contralateral ear using the ear's relationship to the nose, the lateral canthus and the position of the lobule.

Rib Harvest and Framework Construction

Rib cartilage is harvested from the ipsilateral side through a 4–5-cm obliquely oriented skin incision overlying the synchondrosis of the 6th and 7th ribs. The muscle is incised to create a wide exposure of the costal cartilages. The anterior perichondrium is excised with the graft. However, the posterior perichondrium is left in situ to prevent violation of the parietal pleura. The 8th rib is most commonly used for the helix because of its length, though the 9th rib can also be harvested if there is a need for additional length to the helical rim. The base of the cartilaginous framework often comes from the synchondrosis of the 6th and 7th ribs (Fig. 2b, c). The remaining structure of the antihelix and antitragus–tragus complex can be created from the thickest parts of the remaining segments and are carved to reproduce the important curvatures surrounding the conchal bowl. The framework was constructed and fixed together using 5-0 stainless steel wires (Fig. 2d). A minimal incision is made in the cartilage adjacent to the wire, and each wire is pulled gently towards the incision, so it is as snug as possible although not buried in the cartilage. Figure 3 shows a framework early on in the series compared to a more refined framework carved in the latter half of the series. Prior to chest wound closure, intercostal nerve blocks are placed, the muscle layer and deep fascia are closed, and a remaining piece of cartilage is banked in a subcutaneous pocket in preparation for the second stage.

Skin Pocket Design

Majority of cases were treated using the technique described by Francois Firmin in which the lobe is transposed and fixed maintaining the post-auricular sulcus behind the lobule (type 2a according to Firmin classification). After placing the cartilage framework into the subcutaneous tunnel, it is fixed to the base with absorbable sutures and suction drainage is used, as in Brent's method.

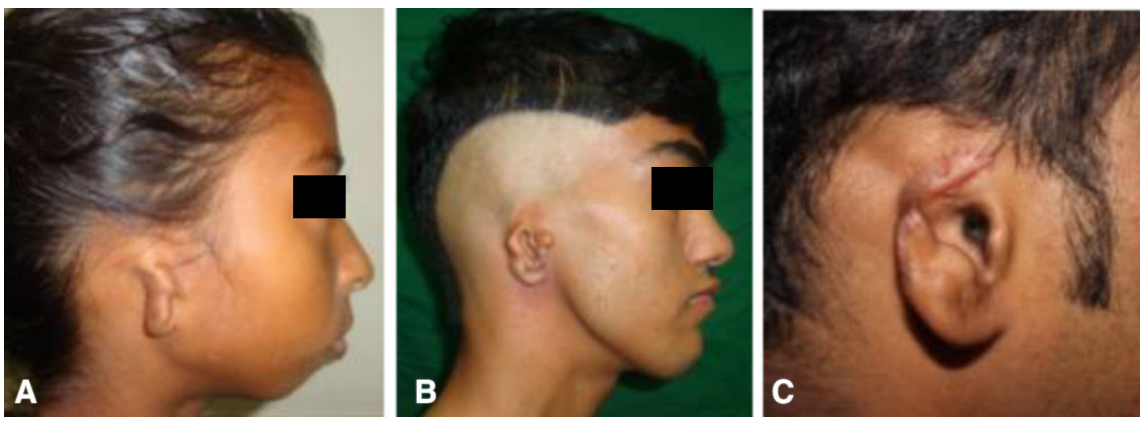

Fig. 1 **a** Lobule type and **b** conchal type microtia, **c** traumatic amputation of ear

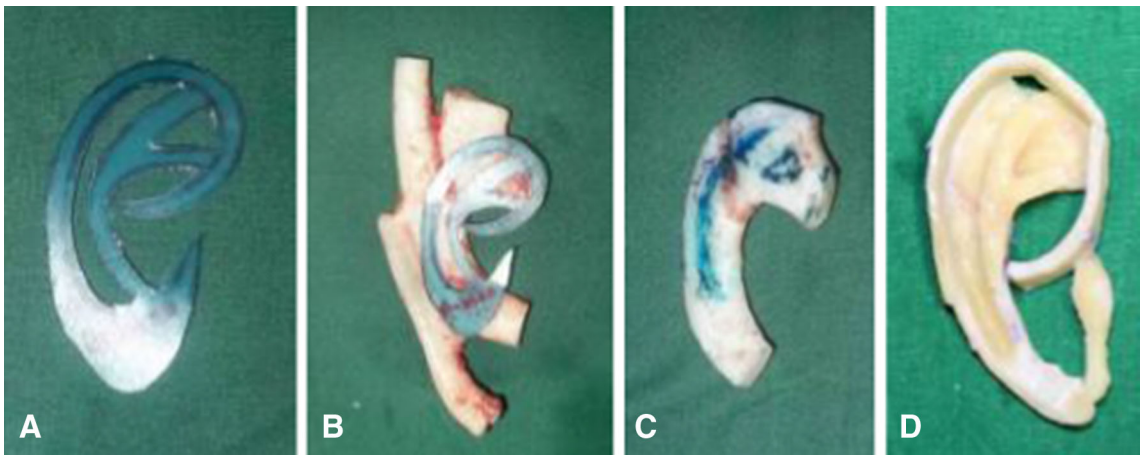

Fig. 2 **a** Surgical template, **b**, **c** preparation of base of the cartilaginous framework from the synchondrosis of the 6th and 7th ribs, **d** Final framework

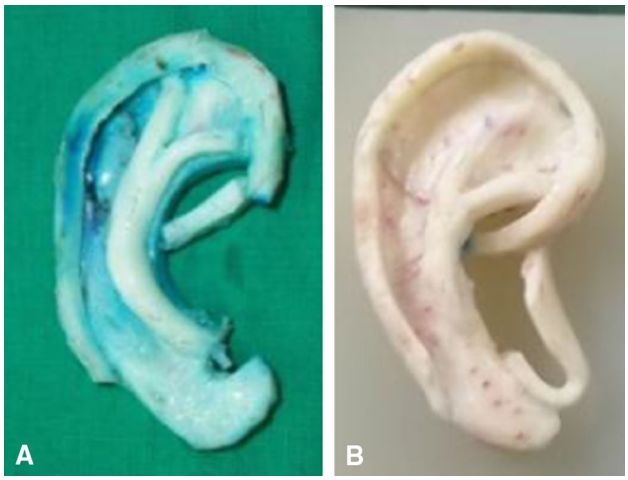

Fig. 3 Carved frameworks. **a** Framework carved early on in series. **b** Framework in the latter half of the series showing improved proportions and definition of the various anatomical components

The Second Stage

Release of the reconstructed ear was performed 12 months following the first stage. A previously stored cartilage block was fixed behind the elevated ear to maintain projection. This was then covered either by a random pattern fascial flap from the mastoid area or a temporoparietal fascia (TPF) flap which in turn was covered by a full thickness skin graft. Later on in the series, the TPF flap became the first choice because of some problems encountered with the mastoid fascia turnover flap. These included occasional graft loss on the posterior aspect of the ear adjacent to the helical rim and also loss of ear projection usually observed after several months. The latter may be related to a combination of the mastoid fascia suboptimal vascularity resulting in cartilage resorption as well as its contraction.

One year after ear reconstruction was accomplished, an aesthetic assessment of the reconstructed ears was carried out by an attending doctor and patients (parents when the patient's age was under 18 years). Five groups of parameters (aspects) were scored: (1) location and size; (2) projection of symmetry (compared with opposite normal ear); (3) appearance of helix, antihelix, triangular fossa, earlobe, conchal and tragus; (4) convolution, thickness and colour match; (5) stability and endurance. Each group of parameters was graded on a 10-point scale. Final results were graded as excellent when each aspect was marked no less than 8, good when one or more aspect was marked 7, fair when one or more aspect was marked 6 and poor when one or more aspect was marked 5 or less.

Result

Complications

In four patients, there was partial skin necrosis in the conchal fossa and antihelix region. Two patients were managed by a transposition flap from the mastoid area which was used to resurface the conchal fossa. There were two cases of infection of framework after skin necrosis resulted in complete loss of framework. There was no loss of any TPF flap and no loss of any covering split thickness skin graft. After a long term, there were wire extrusions in seven cases and these were removed in the outpatient setting without further problems. In five patients, there was some resorption in the lower end of the helical rim. Four patients complained of mild tenderness in the donor site. Following the second stage, 16 patients had significant loss of projection following healing. In 12 of these, the random pattern flap was used, whilst the TPF flap was used in four.

In the pattern of progress, the most dramatic improvement observed was in the quality of the framework carving which was reflected in the detail of the resulting ear (Figs. 4, 5, 6, 7).

Also increasing experience resulted in a more uniform thin skin envelope which adapted better to the cartilage framework. Although the aim was to complete the surgery in two stages, further procedures were required in 4 cases (in addition to the two cases which required local flaps to manage partial skin necrosis described above). These included excisions of skin excess (2 cases), tragus reconstruction (1 case), lobe realignment (1 case). In addition, laser for hair removal on the helical rim was necessary in three cases.

Aesthetic Outcome

The aesthetic outcome was categorised into very good, good, fair and poor. These were judged subjectively by the author and a non-plastic surgeon on the basis of shape, anatomical proportions, thickness and definition. Five cases were graded as poor, 17 fair, 23 good and 8 very good. This demonstrates a downward trend in the cases graded fair and an upward trend in the cases graded very good. Overall reconstruction in the initial cases received a lower grade.

Discussion

A comprehensive understanding of the intrinsic nuances of the auricular architecture is essential to microtia repair, but is no guarantee of a final result. Facial asymmetry, low hair line, absence of auditory meatus and scarring may present additional difficulties [10]. Even the most artistically carved costal cartilage graft can result in a mediocre appearance due to skin thickness, wound healing, and scarring [11]. Limited case availability further compounds a learning curve which was clearly illustrated in this study especially in the carving and assembly of the cartilaginous framework. Complications and/or poor technique results in

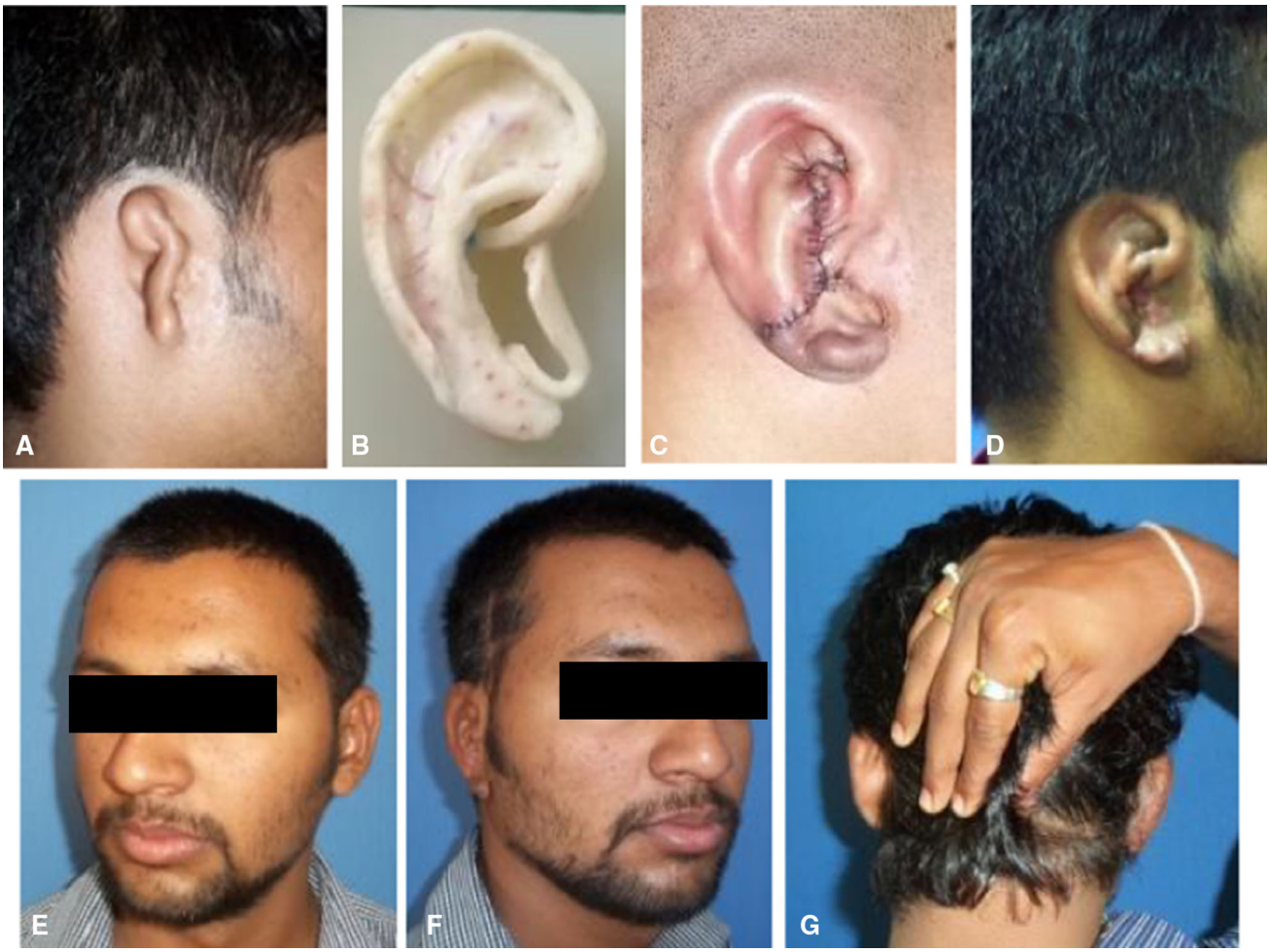

Fig. 4 **a** Pre-op, **b** framework, **c** post-op, **d** 3 months post-op, **e**, **f** comparison between normal and reconstructed ear after elevation of ear. **g** Projection of reconstructed ear

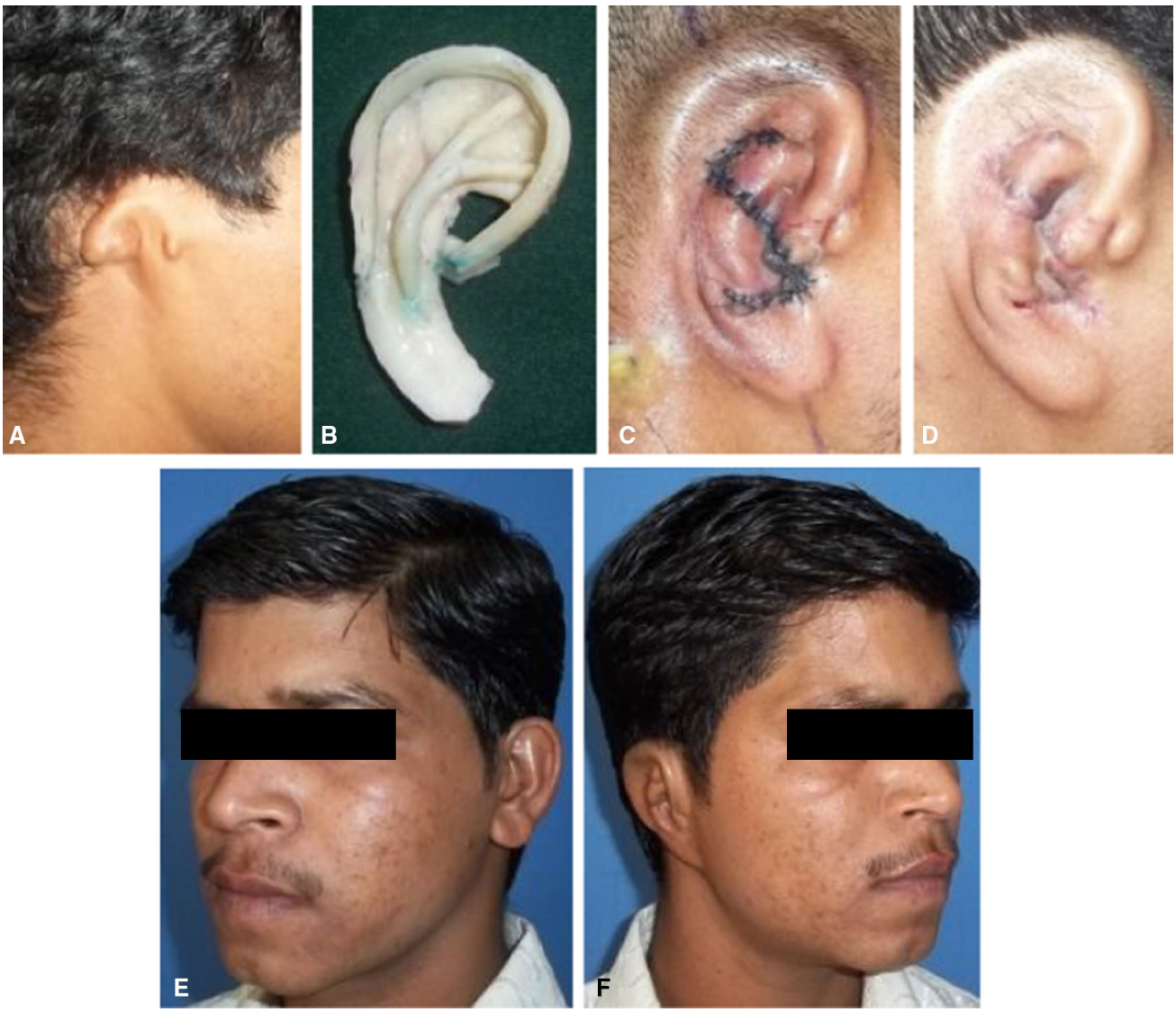

Fig. 5 **a** Pre-op, **b** framework, **c** post-op, **d** 3 months post-op. **e**, **f** Comparison between normal and reconstructed ear after elevation of ear

a situation which is extremely difficult to rectify since the outcome of autologous ear reconstruction is very dependent on high-quality non-scarred skin.

A number of prominent surgeons worldwide have brought ear reconstruction to new standards of excellence. Tanzer was the first to establish that consistent good results can be achieved with costal cartilage [8, 12]. Brent described it as 'a unique marrying of science and art' and has attained outstanding results with a four-stage technique [8, 13, 14]. Nagata popularised a two-stage technique [8, 15–20] demonstrating meticulous approach with an excellent outcome. Firmin reported a large series comparing both techniques [3, 8] and more recently described a two-stage approach based on an alternative surgical classification [8, 21]. Firmin has recently described a new surgical classification [8, 21] in which most cases involve direct transposition of the lobe and utilising the superior skin only (type 2a).

An adequate skin envelope of good quality is critical for successful ear reconstruction. The skin must be supple, thin, and well vascularised to drape over the numerous convolutions of the framework to render adequate definition. Careful intraoperative dissection with preservation of the subdermal plexus and approximation of the skin flaps to the underlying cartilage framework are imperative for an uncomplicated, successful outcome [1]. In this series, cases were treated using the Firmin approach to the skin. The main reason for this was it is easier to design and apply. The main drawback is that it provides less skin to cover the framework. Because of the tension and lack of subcutaneous pedicle, this appeared to increase the risk of skin compromise in the conchal fossa. It was noted, however,

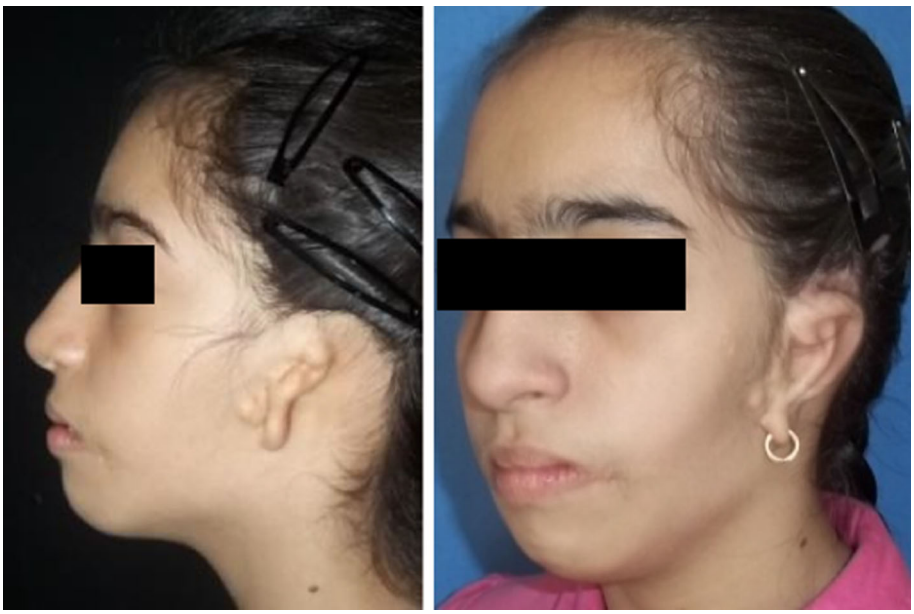

Fig. 6 Ear reconstruction in hemifacial microsomia associated with microtia

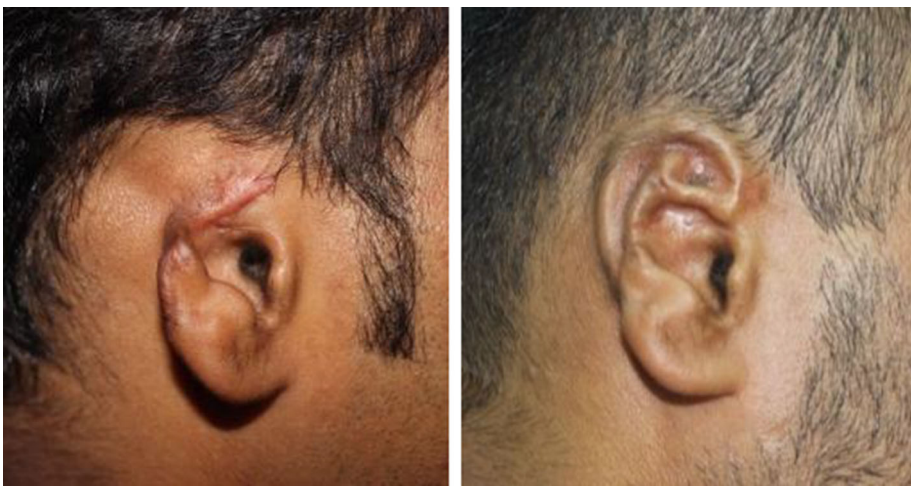

Fig. 7 Ear reconstruction after traumatic amputation of upper half of ear

that in four cases using the Firmin technique there was partial skin necrosis in the conchal fossa. The absence of a subcutaneous pedicle as well as a smaller skin envelope to cover the framework, resulting in more tension, may have contributed to this.

The most dramatic improvement through the series was in the carving of the cartilaginous framework (Figs. 4, 5, 6, 7). This was manifested in improvement in the anatomical proportions and attaining much better definition. The carved cartilage was very accurately reflected in the final ear shape and the improvement in aesthetic outcome observed was primarily due to the refinement of the framework. However, improved utilisation of the skin (thickness and distribution) was also a significant contributor. It is highly recommended that aspiring ear surgeons practice carving on models before embarking on real live cases.

There was a relatively low level of complications in this series. Complications can be minimised by a very cautious and respectful approach to the dissection of the skin pocket. This requires careful and meticulous tissue handling, absolute haemostasis and very precise application of dressing. It is also advisable for new surgeons to be more vigilant about the skin vascularity post-operatively and to inspect the ear on the first post-operative day if there is any concern as the continuous suction can exacerbate the problem. The suction drains may occasionally need to be clamped temporarily to improve the skin blood supply.

The creation of a post-auricular sulcus and achieving adequate projection (the second stage) presents a challenge to the ear surgeon because of the scar contracture that can occur. The most important step is to secure an accurately carved piece of cartilage behind the reconstructed ear. This then has to be covered by vascularised fascia prior to

grafting. The turnover mastoid fascial flap is less invasive than the TPF flap and for that reason it was initially chosen. A number of complications were encountered using the mastoid fascia which includes loss of projection. The TPF provided a superior vascularised layer and it became the standard technique later on in the series. One of the main problems with the TPF flap is the alopecia around the scar which can be minimised cutting parallel with the hair follicles.

Conclusion

This series clearly shows that there is a steep learning curve to microtia reconstruction. Such a learning curve is unavoidable; however, it is important that its steepness is curtailed. Before undertaking costal cartilage reconstruction surgeons should gain an in-depth understanding of the techniques and the principles involved. It is important that these cases are not treated on an occasional basis by interested surgeons as it is unlikely that good results will be achieved. A suboptimal outcome is disastrous to the patient and extremely difficult to rectify. Thus it is recommended that ear reconstruction is only performed where there is a steady stream of cases. This series demonstrates that with the appropriate training and case availability it is possible to attain good results without engaging in a prolonged learning curve at the expense of the patient.

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References

1. Cho BC, Kim JY, Byun JS (2007) Two-stage reconstruction of the auricle in congenital microtia using autogenous costal cartilage. J Plast Reconstr Aesthet Surg 60:998–1006
2. Dashan Y, Haiyue J, Qinghua Y, Bo P, Lin L, Tailing W, Yanmei W, Xiao Q, Hongxing Z (2008) Technical innovations in ear reconstruction using a skin expander with autogenous cartilage grafts. J Plast Reconstr Aesthet Surg 61:59–69
3. Firmin F (1998) Ear reconstruction in cases of typical microtia. Personal experience based on 352 microtic ear corrections. Scand J Plast Reconstr Surg Hand Surg 32:35–47
4. Joseph L, Leach JL Jr, Jordan JA, Karla Brown KR, Biavati MJ (1999) Techniques for improving ear definition in microtia reconstruction. Int J Pediatr Otorhinolaryngol 48:39–46
5. DellaCroce FJ, Green S, Aguilar EF 3rd (2001) Framework growth after reconstruction for microtia: is it real and what are the implications? Plast Reconstr Surg 108:1479–1484
6. Brent B (1999) Technical advances in ear reconstruction with autologous costal cartilage grafts: personal experience with 1200 cases. Plast Reconstr Surg 104:319–334
7. Harris PA, Ladhani K, Das-Gupta R, Gault DT (1999) Reconstruction of acquired sub-total ear defects with autologous costal cartilage. Br J Plast Surg 52:268–275
8. Sabbag W (2011) Early experience in microtia reconstruction: the first 100 case. J Plast Reconstr Aesthet Surg 64:452–458
9. Suutarla S, Rautio J, Klockars T (2009) The learning curve in microtia surgery. Facial Plast Surg 25:164–168
10. Kobus K, Szczyt M, Latkowski I, Wojcicki P (2002) Reconstruction of the auricle. BrJ Plast Surg. 55:645–651
11. Tollefson TT (2006) Advances in treatment of microtia. Curr Opin Otolaryngol Head Neck Surg 14:412–422
12. Tanzer RC (1978) Microtia- a long term follow up of 44 reconstructed auricles. Plast Reconstr Surg 61:161–166
13. Brent B (1980) The correction of microtia with autologous cartilage graft: I. The classic deformity. Plast Reconstr Surg 66:1–12
14. Brent B (1999) Technical advances in ear reconstruction with autogenous rib cartilage graft: personal experience with 1200 cases. Plast Reconstr Surg 104:319–334
15. Nagata S (1993) A new method of total reconstruction of the auricle in microtia. Plast Reconstr Surg 92:187–201
16. Nagata S (1994) Secondary reconstruction for unfavourable microtia results utilizing temproparietal and innominate fascia flaps. Plast Reconstr Surg 94:254–265
17. Nagata S (1994) 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 93:221–230
18. Nagata S (1994) Modification of the stages in total reconstruction of the auricle: part II. Grafting the three-dimensional costal cartilage framework for concha-type microtia. Plast Reconstr Surg 93:231–242
19. Nagata S (1994) Modification of the stages in total reconstruction of the auricle: part III. Grafting the three-dimensional costal cartilage framework for small concha-type microtia. Plast Reconstr Surg 93:243–253
20. Nagata S (1994) Modification of the stages in total reconstruction of the auricle: part IV. Ear elevation for the constructed auricle. Plast Reconstr Surg 93:254–266
21. Firmin F (2001) La reconstruction auriculaire en cas de microtie. Principes, methods et classification. Ann Chir Plast Esthet 46:447–466