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ORIGINAL ARTICLE GENERAL RECONSTRUCTION

Current Management of Microtia: A National Survey

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Abstract
Background Microtia reconstruction remains one of the most challenging procedures encountered by the reconstructive surgeon. A national report on the current management of microtia has never been presented before. The purpose of this project was to survey members of the American Society of Plastic Surgeons (ASPS) to identify their preferences and practices and report their opinions regarding issues related to microtia reconstruction.
Methods An anonymous web-based survey consisting of 19 questions was distributed to the members of the ASPS. Questions focused on the management of microtia. The study design was descriptive, using categorical data analysis.
Results Thirty-eight percent of all respondents perform microtia reconstruction; 91 % learned the autogenous cartilage-based reconstruction technique, while only 16 % were exposed to alloplastic reconstruction. Seventy percent of all respondents learned autogenous cartilage-based ear reconstruction exclusively. Fifty percent of respondents who perform microtia reconstruction reported a steep learning curve. In the pediatric patient population, 49 % of microtia surgeons prefer performing the surgery when the patient is between 7 and 10 years of age, while 40 % of microtia surgeons prefer the patient to be 4–6 years of age. Fifty-nine percent of all respondents believe that in 15 years tissue engineering will represent the gold standard of microtia reconstruction.
Conclusion Staged microtia repair using autogenous cartilage remains the heavily favored method of microtia reconstruction among plastic surgeons. Moreover, there is a deficiency in training the newer surgical techniques, such as alloplastic and osseointegrated options. This study also highlights the continuing need to elucidate the optimal timing for microtia repair in the pediatric patient to mitigate the potential psychosocial morbidity well described in the literature.
Level of Evidence V This journal requires that authors assign a level of evidence to each article. For a full description of these Evidence-Based Medicine ratings, please refer to the Table of Contents or the online Instructions to Authors www.springer.com/00266.

Keywords Microtia · Ear reconstruction

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Introduction

Microtia refers to a diverse spectrum of congenital deformities of the external ear that collectively occurs with an incidence of 1–17 per 10,000 [1–3]. Due to the intricate

detail and anatomic complexity of the cartilaginous auricular framework and its intimate relationship with its thin soft tissue envelope, microtia reconstruction remains one of the most challenging procedures encountered by the plastic surgeon. Tanzer [4–6] is credited with initiating the modern era of ear reconstruction in 1959, when he thoroughly detailed the principles of an autologous costal cartilage total ear reconstruction in four stages. Building on the work of Tanzer over the next several decades, the work of Brent [7, 8], Nagata [9–13], Firmin [14, 15], Park [16, 17], and others brought about numerous advances in technique, aesthetic outcome, and patient management.

Although microtia reconstruction using autologous cartilage can result in exceptional results in experienced hands, this technique has its disadvantages as well. The number of surgical procedures, creation of a thicker and less flexible ear, suboptimal ear projection, asymmetry, long operative times, donor-site morbidity, the need for a high level of technical skill associated with a steep learning curve, and inconsistent aesthetic outcomes are some of the shortcomings that have led surgeons to develop alternative or adjuvant techniques to repair the microtic ear. These include the use of tissue expansion, alloplastic implants (e.g., MEDPOR, Porex Surgical, Newnan, GA), and osseointegrated prostheses [18–20]. Autogenous cartilage-based reconstruction currently remains the definitive standard for microtia reconstruction [8, 21, 22]. How well these alternative techniques have been adopted by the plastic surgery community, however, is not well described.

The goal of this study was to survey members of the American Society of Plastic Surgeons (ASPS) to identify the microtia surgeon's practices, preferences, and experiences with ear reconstruction. In addition, our survey sought to investigate the microtia surgeon's opinion on ancillary issues related to ear reconstruction, including the potential for psychosocial morbidity in the pediatric patient population and what the plastic surgery community believes the future holds for the field of microtia reconstruction. To our knowledge, there has never been a comprehensive report on the current surgical management of microtia. It is the authors' great hope that a report of this nature will serve as an insight into the current state of the art, as well as highlight the need for continued advancement and innovation in both the science and the art of ear reconstruction techniques.

Materials and Methods

An anonymous, web-based survey consisting of 19 questions was distributed to 6,103 members of the ASPS. The study design and survey were approved by the institutional review board of Montefiore Medical Center/Albert Einstein College of Medicine (Bronx, NY). The questionnaire was designed so that it could be completed without the need for chart review. Two follow-up requests for participation were sent to nonresponders 2 and 4 weeks after the initial distribution.

Results

Demographics

Over a 6-week period, a total of 334 responses (6 % response rate) were received. Not all questions were answered by each respondent because each respondent had the option to omit any question they did not wish to answer. Of the 334 board-certified members of the ASPS who responded to the survey, 204 (62 %) reported that they do not perform microtia reconstruction and 100 (30 %) stated that they do perform ear reconstruction on a regular basis (Table 1A). Of this latter group, 78 % stated that they operate on one to five patients with microtia per year, while only 8 % reported operating on more than 15 patients per year. Those who perform microtia reconstruction represented a well-distributed cross section of experience, with 42 % having been in practice more than 20 years (Table 1B).

Training and Preferred Method

Approximately 66 % of respondents who perform microtia reconstruction were trained in the independent model of plastic surgery residency training, after completing residencies in general surgery. In terms of fellowship training, 47 % of microtia surgeons completed either a craniofacial or a pediatric plastic surgery fellowship (Table 1C). Respondents were asked to select the method(s) of microtia repair learned and practiced during plastic surgery training and were allowed to select more than one answer. Autogenous cartilage, staged microtia reconstruction was the most common method taught during plastic surgery training, with 91 % of respondents reporting this answer (Table 1D). The vast majority of surveyed plastic surgeons (70 %) were exposed to this method exclusively. By comparison, less than 16 % of respondents were exposed to alloplastic (e.g., MEDPOR) reconstruction and only 8 % had experience with osseointegrated prosthetic reconstruction. A small minority of respondents (6 %) reported not having learned any microtia reconstruction techniques during their residency training. The majority of microtia surgeons (88 %) currently prefer to use autogenous cartilage in a staged reconstruction, while only 8 % prefer alloplastic reconstruction (Table 2A).

Table 1 Microtia surgeon demographics

A. Microtia patients operated on per year	% (n = 334)
Does not perform microtia reconstruction	62.0
1–5	29.8
6–10	4.0
11–15	1.2
More than 15	3.0
B. Microtia surgeon years in practice[a]	% (n = 125)
Less than 5 years	13.6
6–10 years	16.8
11–15 years	16.0
16–20 years	11.2
More than 20 years	42.4
C. Craniofacial/pediatric plastic surgery fellowship training[a]	% (n = 125)
Received fellowship training	47.2
Did not receive fellowship training	52.8
D. Method(s) of microtia reconstruction learned and practiced during plastic surgery training[b]	% (n = 334)
I did not learn/practice any microtia reconstruction techniques	6.2
Autogenous cartilage staged reconstruction	91.3
Alloplastic reconstruction (e.g., MEDPOR)	15.8
Prosthetic reconstruction—adhesive-based	5.9
Prosthetic reconstruction—osseointegrated	7.5

[a] Respondents who do not perform microtia repair were excluded

[b] Respondents were allowed to select more than one answer choice

Table 2 Surgeon preference and comfort level

A. Microtia surgeon's preferred method[a]	% (n = 125)
Autogenous cartilage staged reconstruction	88.0
Alloplastic reconstruction (e.g., MEDPOR)	8.0
Prosthetic reconstruction—adhesive-based	0.0
Prosthetic reconstruction—osseointegrated	1.6
Other	2.4
B. Surgeon-reported comfort level performing microtia repair[a]	% (n = 124)
Very comfortable (5)	49.2
Somewhat comfortable (4)	34.7
Neither comfortable nor uncomfortable (3)	12.1
Somewhat uncomfortable (2)	4.0
Very uncomfortable (1)	0.0

[a] Respondents who do not perform microtia repair were excluded

Preoperative Management, Grade of Microtia, and Operative Stages

Despite a strong overall bias toward cartilage reconstruction, 86 % of microtia surgeons counsel their patients (and/or their parent representatives) on all the available surgical options. Seventy-four percent of microtia surgeons most frequently operate on the lobular-type grade of microtia. Small conchal type (9 %), conchal type (7 %), anotia (6 %), and atypical microtia (4 %) were operated on less frequently. Microtia surgeons who prefer autogenous cartilage-based reconstruction report using on average 3.02 operative stages, while respondents who use alloplastic reconstruction use an average of 2.56 stages. This is a statistically significant difference (p = 0.043).

Complications

The most common complications in microtia reconstruction, as reported by this sample of surgeons, are skin necrosis, extrusion of sutures, extrusion of framework, resorption of framework, flap failure, hematoma, infection, and chest wall donor site morbidity. In this study, complications were considered collectively rather than specifically. Respondents reported an average complication rate of 13.58 % [± 9.63 % (SD), 95 % confidence interval (CI) = 0−32.44], with a range of 1–75%. No statistically significant difference was noted in complication rates for surgeons who prefer autogenic reconstructions versus alloplastic reconstructions (p = 0.207).

Comfort Level and Issues with Preferred Microtia Repair Technique

The majority of microtia surgeons feel comfortable performing microtia reconstruction, with nearly half of respondents reporting that they feel very comfortable (Table 2B). Microtia surgeons report a steep learning curve in mastering microtia reconstruction techniques and a lack of consistency in results (Table 3A).

Timing of Surgery, Delayed Surgery, and Psychosocial Morbidity in the Pediatric Patient

More than half of the respondents prefer to wait until their patients are at least 7 years of age, whereas 34 % prefer to operate when the child is 4–6 years old. Only 10 % of surgeons wait until the pediatric patient is older than 10 (Table 3B). There is agreement among most microtia surgeons (72 %) that aesthetic outcomes are better in older patients (Table 3C). Fifty-six percent of microtia surgeons believe that there is a potential for greater psychosocial morbidity with delayed microtia reconstruction (Table 3D).

Outcomes

In general, microtia surgeons report good aesthetic results, with respondents reporting an average of 3.9 on a scale of 1

Table 3 Surgeon-reported opinions on microtia reconstruction

A. Surgeon issue(s)with microtia reconstruction[a,b]	% (n = 125)
None	11.2
Steep learning curve	49.6
Poor aesthetic outcome	26.4
Lack of consistency	36.8
High complication rate	6.4
Other	12.0
B. Preferred timing of microtia repair for pediatric patient[a]	% (n = 125)
Less than 4 years old	1.6
4–6 years old	33.6
7–10 years old	55.2
More than 10 years old	9.6
C. Agree/disagree: better aesthetic outcome with delayed microtia reconstruction in pediatric patient[a]	% (n = 123)
Strongly agree (5)	30.1
Somewhat agree (4)	41.5
Neither agree nor disagree (3)	18.7
Somewhat disagree (2)	6.5
Strongly disagree (1)	3.3
D. Agree/disagree: potential for greater psychosocial morbidity with delayed microtia repair in pediatric patient[a]	% (n = 124)
Strong agree (5)	13.7
Somewhat agree (4)	42.7
Neither agree nor disagree (3)	21.8
Somewhat disagree (2)	16.9
Strongly disagree (1)	4.8

[a] Respondents who do not perform microtia repair were excluded

[b] Respondents were allowed to select more than one answer choice

Table 4 Surgeon-reported aesthetic outcome of microtia repairs[a]

	% (n = 123)
Very good (5)	21.1
Good (4)	45.5
Fair (3)	31.7
Poor (2)	2
Failure (1)	0

[a] Respondents who do not perform microtia repair were excluded

(failure) to 5 (very good) (Table 4). The majority of surgeons surveyed (69 %) believe that creating an aesthetically pleasing ear is the most important outcome of microtia reconstruction in the pediatric patient, while 20 % believe the most important outcome is the potential to minimize future psychosocial morbidity (Table 5).

Table 5 Surgeon-reported importance of microtia reconstruction outcomes in pediatric patient

	% (n = 231)		
	Most important	Somewhat important	Least important
The potential to minimize future psychosocial morbidity	20.0	40.9	39.1
Creating an aesthetically pleasing ear for the patient	69.4	25.2	5.4
Having minimal complications	18.9	41.4	39.6

Table 6 Surgeon opinion: gold standard of microtia repair in 15 years

	% (n = 277)
Autogenous cartilage reconstruction	29.2
Alloplastic reconstruction (e.g., MEDPOR)	5.4
Prosthetics	6.1
Tissue engineering	56.3
Other	2.9

Future of Microtia Reconstruction

Fifty-six percent of all respondents believe that a method that uses tissue engineering will represent the gold standard of microtia reconstruction in 15 years (Table 6). Twenty-nine percent believe that autogenous cartilage reconstruction will remain the favored approach.

Discussion

Fundamentally, the field of ear reconstruction has seen tremendous advancement since 1597, when Tagliacozzi described the use of a pedicled arm flap to reconstruct a monk's ear. Dieffenbach's utilization of a folded mastoid flap to repair an acquired auricular defect in the mid-19th century marked a step closer toward the current principle in microtia reconstruction of using local flaps to cover an ear framework [23, 24]. Until the mid-20th century, however, when Tanzer introduced the plastic surgery community to autologous costal cartilage-based ear reconstruction, total ear reconstruction had remained an elusive goal and was considered impossible by most plastic surgeons [4, 6, 20]. While there is no doubt that the work of Brent [7, 8], Nagata [9–13], Firmin [14, 15], Park [16, 17], and others has significantly advanced the field of microtia reconstruction, this study clearly demonstrates that there has been a general lack of evolution in microtia surgery over the past decade or longer since the experiences of these surgeons have been reported.

A limitation to this study was the low response rate, which was likely due to the rarity of the subject matter, in addition to the low number of plastic surgeons who perform microtia repair. Nonetheless, this study shows not only that autologous cartilage-based ear reconstruction remains the predominantly taught and preferred surgical technique, but also that there is a great deficiency in the training of newer surgical techniques such as alloplastic and osseointegrated methods. These techniques were developed to address the major shortcomings of autologous techniques by providing a more consistent aesthetic result, avoiding donor-site morbidity, decreasing the number of reconstructive stages, shortening surgical time, allowing reconstruction in younger patients, and reducing the slope of the steep learning curve associated with autologous cartilage methods [18, 20].

Thorne et al. [25] provided a list of relative indications for osseointegrated prosthetic microtia reconstruction, including (1) failed autogenous reconstruction, (2) severe soft-tissue/skeletal hypoplasia, and (3) a low or unfavorable hairline [18, 25]. However, the need for implant replacement every 2–5 years, questionable implant stability, and the fact that the placement of osseointegrated implants hampers future attempts at autologous reconstruction may explain why this surgical approach has not been well incorporated into plastic surgery training and practice [18]. One must then question why alloplastic ear reconstruction has not been more widely adopted.

Cronin and Ohmori [26, 27] described excellent initial aesthetic results using a silicone framework, but long-term follow-up revealed an unacceptably high failure rate from implant exposure [20]. This led to the abandonment of the use of silicone for ear reconstruction. Reinisch [28] has advocated the use of porous polyethylene. Porous polyethylene causes minimal tissue reaction, and its porous quality allows soft-tissue ingrowth, which theoretically provides for greater incorporation and stability. Unfortunately, initial results from the use of porous polyethylene implants demonstrated an exposure rate similar to that of silicone constructs [29, 30]. However, the use of a temporoparietal fascia flap to envelop the porous polyethylene implant has resulted in a significant reduction in the exposure rate associated with this product [31, 32]. Although the initial failures of alloplastic ear reconstruction likely deterred its wide acceptance by microtia surgeons, this technique appears promising as an alternative to autologous microtia reconstruction. As technical improvements and improved long-term safety and aesthetic outcomes continue to be reported, this technique may be more incorporated more into plastic surgery training and practice.

One particular advantage of alloplastic reconstruction is that the learning curve associated with it might not be as steep compared to that associated with autologous reconstruction, as reported in the literature and now also confirmed by our study [19]. However, regardless of preferred technique, the relative rare incidence of microtia leads to restricted case availability for young surgeons. Our data reveal that greater annual experience with microtia reconstruction and greater overall surgical experience positively correlate with comfort level and surgeon-reported aesthetic outcome. An interesting future study may include a comparison of surgeon-reported aesthetic outcomes to aesthetic outcomes evaluated by independent aesthetic reviewers and/or patients. Higher complication rates and unsatisfactory outcomes tend to occur earlier in the career of a microtia surgeon [19, 33]. Low surgical volume may explain why the number of surgeons with a high level of skill or experience in ear reconstruction is limited.

The optimal timing of surgery in the pediatric microtia patient has long been a controversial topic. Our results show that more than half of microtia surgeons prefer to wait until the patient is at least 7 years of age. Considering that the auricle is 85 % of its adult size by age 3 and 95 % of its adult size by 6 years of age, Brent and others have recommended performing microtia reconstruction between the ages of 4 and 6 to lessen the potential psychosocial burden of having an obvious physical deformity when the child begins school [20, 34, 35]. Many surgeons, however, may delay surgery until the child is 10 years old or has a chest circumference at the level of the xiphoid of at least 60 cm to ensure the availability of an adequate amount of costal cartilage. Many also believe that aesthetic results are improved in this older age group [9–15, 20, 35]. This tendency is supported by our data, which show that 72 % of microtia surgeons believe that delaying surgery yields a better aesthetic outcome. Our finding that most surgeons rank the creation of an aesthetically pleasing ear for the child as the most important outcome additionally supports the preference to wait until the child is older before performing surgery. Yet one must balance the aesthetic benefits of delayed repair with the potential negative psychological issues associated with the burden of carrying a significant physical deformity through the early school years [36]. Children may develop self-awareness of their facial deformities as early as 3–4 years of age [37, 38]. Jiamei et al. [32] looked at mood disorders in children with microtia using a child behavior checklist (CBCL), one of the most widely used measures in child psychology, and found a tendency for the prevalence of mood disorders, including depression, interpersonal sensitivity/social difficulties, and hostility/aggression, to increase with age in patients who have not had reconstructive surgery. It is difficult for the microtia surgeon to reconcile the fact that while early surgery might be psychosocially advantageous, an autologous cartilage-based reconstruction is best

delayed until later in the first decade of life. Use of an alloplastic framework eliminates this conflict: reconstruction may occur at an earlier age because the size of the child's costal cartilage is irrelevant [18].

This study shows that the plastic surgery community has great hope for tissue engineering to become a relevant option for microtia repair. While the advances made in this regard have been quite remarkable, ear reconstruction using a tissue-engineered framework will likely not be a clinically applicable solution for some time. Nonetheless, several studies have shown the astounding promise of such an approach. Cao et al. [39] successfully transplanted bovine chondrocytes, grown in vitro, onto a synthetic biodegradable ear scaffold that was implanted under the skin of an immunocompetent mouse. Kamil et al. [40] constructed ear-shaped cartilage with gold molds in a bovine model, and Neumeister et al. [41] has successfully generated vascularized ears using a tissue-engineering approach. This research, along with advances in computer imaging techniques as well as design and manufacturing capabilities, must be aggressively pursued. Such innovation can lead to the development of an ideal microtia repair method that will yield consistent and excellent aesthetic results through early intervention and with minimal associated morbidity.

In conclusion, this study provides a comprehensive review of the current practices, preferences, and issues in microtia reconstruction. In general, the most common approaches to microtia repair have remained stable over the past few decades. While there have been great advances in autogenous cartilage ear reconstruction, now is the time to invest in innovative science and research that may usher in a new era of ear reconstruction based on tissue-engineering principles. This study has also highlighted the crucial importance of understanding the psychosocial issues involved when managing patients born with microtia, especially when considering the optimal timing of surgery in the child. These findings underscore a fundamental principle in plastic surgery as described by Dr. Milton Edgerton: treating psychological suffering is the heart of the plastic surgeon's work [42]. It is our hope that this work provides some insight that will improve the overall care we can provide to our microtia patients.

Conflict of interest The authors have no conflict of interest to disclose.

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