



# Complication Rate of Autologous Cartilage Microtia Reconstruction: A Systematic Review

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**Background:** Autologous cartilage has been widely accepted as the frame material of ear reconstruction for patients with microtia. Although rare, there are multiple complications related with the surgical reconstruction techniques. The authors performed a systematic review of the English literature of microtia reconstruction to determine significant surgical factors that are predictors of postoperative complications.

**Methods:** A PubMed search using the terms “ear reconstruction” and “microtia” was conducted. Articles were screened using predetermined inclusion and exclusion criteria. Data collected included patient characteristics, surgical techniques, the incidence of all kinds of complications, and the specific postoperative morbidity. Patient cohorts were pooled, and the incidence of complications was calculated. Significant predictors such as the use of tissue expander, simultaneously mid-ear reconstruction, with/without skin graft, and different fascia coverage were analyzed by chi-square test.

**Result:** Of 320 articles found, 60 met the inclusion criteria. Totally 9415 patients with microtia were analyzed in this review with 1525 cases with complications. The overall complication incidence is 16.2% in average with a range of 0–72.9%. There was no significant difference when comparing the overall complication rate between with/without preexpansion 2-stage and multiple-stage techniques or with/without mid-ear reconstruction simultaneously.

**Conclusion:** Although there is little agreement in literature regarding risk factors for complications, the authors were able to demonstrate several significant predictors by systematically analyzing 60 articles. Improved knowledge of the incidence of different complications related with various surgical methods can help surgeons provide improved preoperative counseling and take measures to minimize the risk. (*Plast Reconstr Surg Glob Open* 2013;1:e57; doi:10.1097/GOX.0b013e3182aa8784; Published online 18 October 2013.)

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Autologous cartilage has been widely used in ear reconstruction for patients with microtia. According to the latest national survey of American Society of Plastic Surgeons, 91.3% of the plastic surgeons choose autologous cartilage staged reconstruction for patients with microtia.<sup>1</sup> Although low complication rates were reported in the literature, multiple kinds of surgical technique-related complications, both at donor and recipient sites, are

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not uncommon. Little exists in the literature regarding the complication rate of autologous cartilage microtia reconstruction and the related risk factors. In this systemic review, we aim to (1) calculate the kinds and overall rate of complications in autologous ear reconstruction with costal cartilage and (2) identify the complication rate related with certain surgical methods, including fascia type, with/without preexpansion, and surgical stages. Salvage procedures are also listed out for different complications.

## MATERIALS AND METHODS

### Literature Search

A PubMed database search was conducted in March 2013 using the terms “ear reconstruction” and “microtia” as key words to identify studies in the English language published before 2013. The articles were examined, and references were screened for further relevant articles. The search yielded a total of 320 citations. Inclusion criteria were English-language publication, human subjects, ear reconstruction, extractable outcomes on complications, and full-text availability. Exclusion criteria were systematic reviews and meta-analyses, case reports and case series with fewer than 15 patients, and nonrelated with surgery (the method is also provided in other systemic review about fat necrosis in autologous breast reconstruction by Khansa et al<sup>2</sup>). Finally, 260 articles were excluded and 60 articles were reviewed and analyzed (Fig. 1).

### Data Extraction

Two authors, Yu and Huang, were responsible for evaluation of all the articles. When there is disagreement about inclusion and exclusion, the first author

Long will give further evaluation and reached an agreement. The corresponding author Wang assessed the quality and validity of the extracted data finally. For each article, data listed in Table 1 were extracted. The complications according to different surgical methods were listed out and reviewed one by one including with/without expansion, with/without mid-ear reconstruction, stages of operation, and with/without fascia coverage.

The flap types to cover the cartilage frame included nonexpanded or expanded auricular area skin. Methods to cover the postauricular sulcus include temporoparietal fascia or mastoid fascia. Surgical stages vary from 1 stage without expansion, 2 stages with expansion, 2 stages without expansion, or more stages with/without expansion.

### Data Analysis and Statistics

When 2 or more articles from the same authors of the same institution had overlapping data collection dates, they were assumed to be from the same cohort. When computing the overall rate of complications, the article with the largest number of patients was included and redundant articles from the same institution were excluded. However, some of the redundant articles analyzed distinct predictors of complications, and those were included in the analysis of individual risk factor.

All articles that contained extractable data were analyzed. The data were pooled, and the number of reconstructed ear with complications was calculated according to different surgical methods. Significant predictors, such as the use of tissue expander, simultaneously mid-ear reconstruction, with/without skin graft, and different fascia coverage, were analyzed by chi-square test.

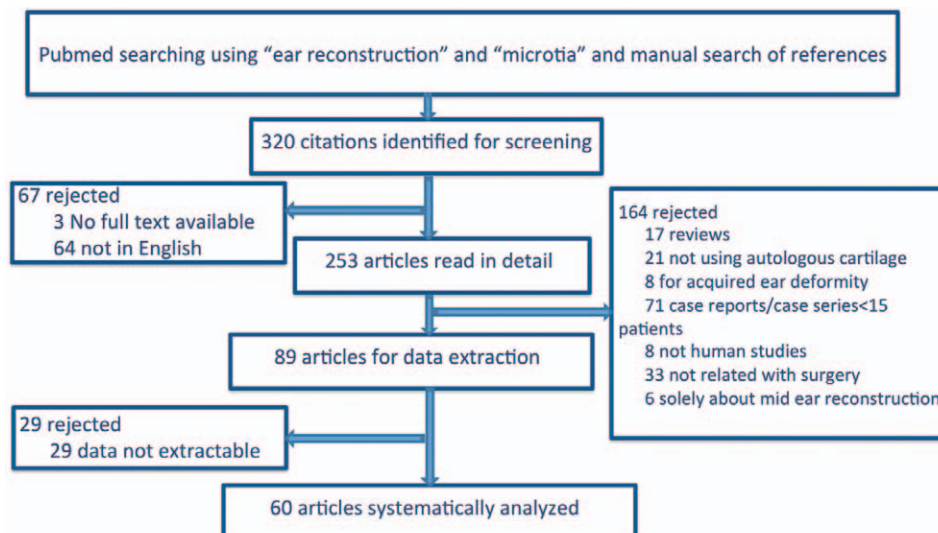


Fig. 1. Study attrition diagram.

**Table 1. Data Extracted from the Article**

Extracted Data
Study characteristics
Authors and institutions
Dates of data collection
Patients characteristics
No. patients
Age of surgery
4–7 years old
8–10 years old
More than 10 years old
Operation stages
Nonexpansion 1-stage reconstruction
Nonexpansion 2-stage reconstruction
Nonexpansion multiple-stage reconstruction
Preexpansion 1-stage reconstruction
Preexpansion 2-stage reconstruction
Preexpansion multiple-stage reconstruction
Frame coverage
Flap with Superficial temporal artery fascia
Flap with postauricular fascia
Flap with no fascia
Mid-ear reconstruction
Simultaneously
Later or not mentioned
Skin graft
With
Without
Accompany symptoms
Present
Absent
Recipient cite injury or surgery history
Positive
Negative
Follow-up time
Side of microtia
Bilateral
Unilateral

## RESULTS

### Complication Rate

Seventeen articles reported the total complication rate,<sup>3–19</sup> and others analyzed the different complications separately. The incidences vary from 0% to 33%. The authors who perform ear reconstruction together with mid-ear reconstruction<sup>17</sup> or using tissue expander during the stages reported higher overall complication rates.<sup>18,19</sup> Among the 253 full-text available English articles, only 21 of them reported using alloplastic material in ear reconstruction. Totally 9415 patients with microtia were analyzed in this review with 1525 cases with complications. The overall complication incidence is 16.2% in average with a range of 0–72.9%, which is comparable to the average complication rate reported by US surgeons as 13.58% with a range of 1–75% according to the national survey published in 2013.<sup>1</sup>

Complications of the recipient site include infection and hematoma. Still there are many plastic surgeons who prefer to use the expanded flaps to perform ear reconstruction; thus, in their series, they

reported certain complications related with tissue expander, such as expander leakage or exposure. The donor site also has different kinds of complications, for example, atelectasis and pleural tear. Only 1 article published in 1971 reported a dead case due to the bronchopneumonia after cartilage harvest.<sup>20</sup> Table 2 listed out the overall incidence of different complications separately.

### Operation Methods

Basically, the operation methods could be divided into 2 groups: with or without tissue expansion. (1) Nonexpansion group: Most surgeons preferred 2-stage or multiple-stage ear reconstruction technique with no expansion since the article published by Brent<sup>21</sup> and Nagata.<sup>7</sup> Some articles focused on the donor-site complication<sup>22</sup> or comparison of different fixation material<sup>23</sup> did not provide information of surgical stages. No author reported 1-stage ear reconstruction within the recent 10 years. (2) Tissue expansion group: Chinese surgeons mostly reported their techniques using tissue expander in recent 5 years<sup>24–34</sup> with the expander size varying from 50 to 90 ml. Most authors chose skin graft to reconstruct the postauricular sulcus, the concha, or the mid-ear canal. Only 3 articles using tissue expander declared that skin graft was not used at all.<sup>24,26,35</sup> Authors of twelve articles reported their experiences of simultaneously external and mid-ear reconstruction.<sup>10–12,15,17,27,36–40</sup> Sixteen articles reported the technique of using fascia to cover the framework, including temporoparietal fascia<sup>4,5,7,10,36,41–44</sup> or mastoid fascia.<sup>3,17,25,30,34,45,46</sup> Table 3 is the list of different surgical methods and the overall complication incidence. Figure 2 shows the difference between nonexpansion and expansion technique.

### Other Factors

Age of the first operation varies according to different authors. One early article mentioned the start of the serial ear reconstruction before 4 years old.<sup>47</sup> Most of the others start to perform the surgery at the age older than 7 years in average,<sup>3,4,9,10,12,14,15,18,20,22,24,27,28,31,34–36,39–41,43,45,48–54</sup> which is consistent with the US national survey published in 2013<sup>1</sup> and the international survey on the fourth International Ear Reconstruction Congress in Edinburgh.<sup>55</sup>

The average follow-up time varied from 3 months to 9.5 years. Tanzer<sup>52</sup> published his article in 1978 with an average follow-up time as 9.5 years, which was the longest one among all the articles. Longer follow-up time is correlated with higher incidence of the late complications, such as wire extrusion and chest wall deformity. Ten articles reported

**Table 2. Complications of the Recipient Site**

Complications	Related Articles (n)	Total Cases (n)	Complication Incidence (%)
Complications of the recipient site			
Infection	21	6220	0.9
Hematoma	12	4820	0.32
Grafted skin necrosis	7	585	0.41
Skin envelope necrosis	16	6505	0.16
Frame exposure	16	6019	0.96
Flap venous congestion	3	496	1.61
Cartilage absorption	12	2802	1.28
Wire or suture extrusion	8	4049	1.63
Hypertrophic scar	8	4232	6.29
Unsatisfied final result	16	3626	8.52
Helix broken	2	472	0.42
Asymmetry	3	1405	2.08
Facial nerve injury	2	95	1.05
Complications related with tissue expander			
Expander leakage	1	146	1.37
Expander exposure	2	3367	3.45
Complications of the donor site			
Atelectasis	1	80	8.75
Pleural tear	4	251	12.75
Chest wall deformity	6	342	36.06
Thoracic scoliosis	1	18	22.22
Hypertrophic scar	6	517	5.61

clinical results, with the shortest follow-up time as 3–9 months.<sup>5,10–12,24,26,31,42,49,50</sup>

Several articles summarized the accompany symptoms of the patients with microtia, including first and second branchial arch syndrome, blind external

auditory canal, treacher collins syndrome, lip and palate cleft, and facial dysplasia. Pan et al<sup>29</sup> reported the highest incidence of facial dysplasia as 82.24% in 326 microtia cases.

Jiang et al<sup>34</sup> reported the largest case series of using tissue expander in 3332 patients with microtia followed by the report by Zhao et al<sup>39</sup> about 1300 cases that received mid-ear and external ear reconstruction simultaneously. Brent<sup>9</sup> introduced his nonexpanded multiple-staged technique of ear reconstruction for 1200 cases in 1999 and declared there was no complication. The main complications of case series reported by Jiang et al<sup>34</sup> and Zhao et al<sup>39</sup> are listed in Table 4.

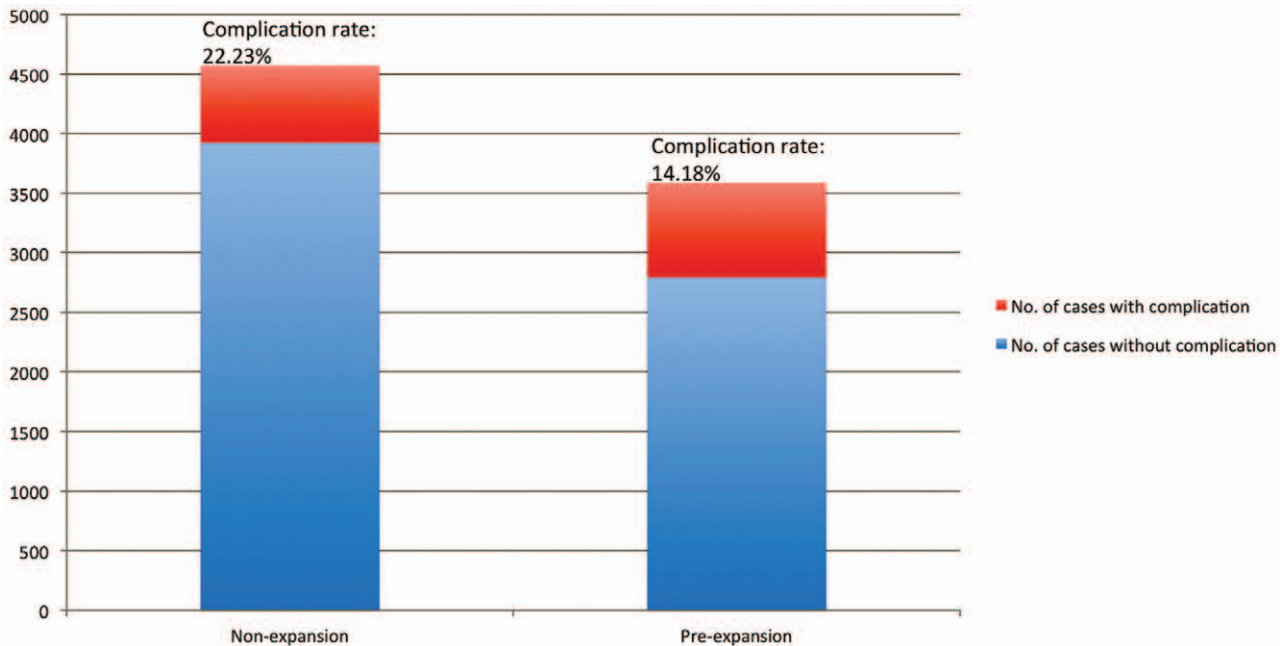
### DISCUSSION

Autologous cartilage staged microtia reconstruction was the most common method according to the literature. Techniques of microtia reconstruction varied among different surgeons. Tissue expander was first reported to be used in ear reconstruction in 1989<sup>41</sup> and 1990<sup>35</sup> and then followed by the only attractable data in the report by Park<sup>18</sup> in 2000. While from 2007 to 2012, doctors from China and only from China published 11 articles that met the inclusion criteria with large case series. Although there were certain complications related with tissue expander, such as expander leakage and exposure, there was no significant difference when comparing the overall complication rate with nonexpan-

**Table 3. Operation Stages and Overall Complication Incidence**

Surgical Methods	Related Articles (n)	Total Cases (n)	Publication Year Range	Complication Incidence (%)	P
Operation stages and overall complication incidence					
1 stage	4	110	1983–2002	0.87	—
Nonexpansion 2 stages	17	2746	1993–2012	14.45	—
Preexpansion 2 stages	2	3332	2008	15.1	NS (with nonexpansion 2 stages)
Nonexpansion multiple stages	15	829	1971–2010	13.75	NS (with preexpansion 2 stages and nonexpansion 2 stages)
Preexpansion multiple stages	12	2615	1989–2012	7.11	—
No skin graft in ear reconstruction					
Preexpansion multiple stages	3	95	1990, 2011	28.42	0.0007
Simultaneously mid-ear reconstruction					
Nonexpansion multiple-staged reconstruction with skin graft	12	2158	1996–2012	26.14	—
Ear reconstruction with fascia coverage					
Temporoparietal fascia	9	331	1989–2011	16.62	NS (with nonexpansion 2 stages and nonexpansion multiple stages)
Mastoid fascia	7	4350	1983–2010	13.49	NS (with temporoparietal fascia)

NS, not significant.



**Fig. 2.** Complication rate of nonexpansion and preexpanded group.

sion 2-stage or multiple-stage techniques. The price of local produced tissue expander in China is about 40–50 dollars, which is cheap and has the advantages of creating adequate skin to cover the frame, and probably, it is the main reason of its wide acceptance by both the Chinese plastic surgeons and patients despite the time-consuming expansion technique. It is noticeable that the 3 articles mentioned using tissue expander with no skin graft in relatively small case series had significant higher complication rate when compared with the other groups ( $P = 0.0007$ ).

Mid-ear reconstruction is also related with certain complications, for example, facial nerve injury and postatresiaplasty infection. However, the overall complication incidence of simultaneously mid-ear reconstruction has no significant difference when compared with the other groups (Table 3). It is still controversial whether it is necessary to perform mid-ear reconstruction for unilateral microtia.<sup>55</sup> According to the 11 articles that reported the experience of simultaneously external and mid-ear reconstruction, most of the patients gained an improvement in hearing over 20–30 dB pure-tone average.<sup>10–12,15,17,27,36–40</sup> According to the result, if performed with fewer operation stages and lower complication rate, simultaneously mid-ear reconstruction could be an option for microtia patients with indications including radiologic evidence of the inner ear and audiometric evidence of cochlear function.

Brent<sup>21</sup> and Nagata<sup>7</sup> reported their technique of microtia reconstruction separated in different surgical stages. There is no significant difference between

the complication rate of 2-stage and multiple-stage microtia reconstruction without tissue expansion (Table 3). However, when using tissue expander, the overall complication incidence is much lower in the multiple-stage group than in the other groups. The main shortcomings of tissue expansion technique are the complications related with expander and the delayed extraction of the expanded flap. According to the data, tissue expansion did not increase the overall complication rate. Thus, the possible reason of the low complication incidence in this group is that the multiple stages help to avoid the delayed extraction but remain the advantage of creating more skin envelope with tissue expansion, which will finally result in better coverage of the frame and satisfied contour of the reconstructed ear.

Different surgeons use different material to fix the framework. Eight articles reported the wire extrusion rate, ranging from 0.3% to 25%.<sup>23,28,30,34,42,52,56,57</sup> The follow-up time of these publications vary from 1 to 9.5 years. Not surprisingly, the article reported highest wire extrusion accident (25%) also had the longest follow-up time,<sup>52</sup> but it was also the earliest article to report this complication. With the technical development in fixation material and surgical method, the incidence has dropped down dramatically. Sakamoto et al<sup>23</sup> compared different material in cartilage frame fixation and found lowest complication rate with absorbable sutures.

Chest wall deformity can range from minor deformities to the development of scoliosis. The incidence ranged from 6.25% to 50%.<sup>22,26,33,47,52</sup> Most of

**Table 4. Complications of the 2 Largest Case Series**

Reference	Surgical Methods	Total Cases (n)	Infection	Flap Necrosis	Frame Exposure	Expander Exposure	Cartilage Absorption	Hematoma	Wire Extrusion	Auricular Hypertrophic Scar	Asymmetry	Unsatisfied Contour
Jiang et al <sup>34</sup>	Preexpansion 2 stages Nonexpansion with mid-ear reconstruction	3332	20	28	8	111		116	10	210		
Zhao et al <sup>39</sup>			1	15	15 (same cases with flap necrosis)							280
							2					

the articles did not provide the incidence of chest wall deformity as one of the complications, possibly due to the short follow-up period. Some authors reported their technique of reducing the amount of cartilage harvested or the maintenance of perichondrium to avoid future chest wall deformity.<sup>28,58</sup> It is a noticeable problem as there was possibility of thoracic scoliosis after cartilage harvest according to the article by Ohara et al<sup>22</sup>

Eight articles reported auricular hypertrophic scar after microtia reconstruction. All of these articles are from Asian countries,<sup>17,29,30,34,51,56,59,60</sup> which is consistent with the high occurrence of hypertrophic scar and keloid in Asian population. It was also reported by these authors that scar resection and skin graft could help to solve the auricular hypertrophic scar. Instead, authors of the 6 articles reported chest wall hypertrophic scar after cartilage harvest are from the United States,<sup>37,52</sup> Colombia,<sup>38</sup> Canada,<sup>47</sup> and China.<sup>28,50</sup> Local injection was the main way to resolve the chest wall hypertrophic scar according to these reports.

Twelve articles reported the technique in treating complications. The salvage procedures included local flap coverage<sup>34,49</sup> or temporoparietal fascia transfer and skin graft<sup>41,46,54</sup> for frame exposure, cartilage removal,<sup>39,48</sup> or expander removal<sup>18,27,43</sup> due to infection and wire or suture removal after exposure.<sup>34,52,54</sup> Using temporoparietal fascia in the first stage of microtia reconstruction is controversial as it is a useful salvage procedure to cover the exposed cartilage frame. The overall complication incidence of using temporoparietal fascia to cover the postauricular sulcus has no significant difference when compared with the mastoid fascia group, nonexpansion 2-stage, and multiple-stage groups.

The review has some limitations. First, all the case numbers are counted as the number of patients instead of the number of reconstructed ears. As most articles reported the complications number of patients, we extracted the data of total cases in the same way. The included 60 articles totally involved 9415 patients, and there were 30 articles that mentioned the case number of unilateral or bilateral reconstruction; among these series, there were 931 bilateral reconstruction cases. Simply counting the bilateral cases as 1 patient may increase the overall complication incidence. Second, only 3 articles mentioned 86 patients with previous surgery or injury history of the recipient cite,<sup>20,44,52</sup> which is also a factor related with high complication incidence but difficult to analyze due to the lack of data in other articles. Third, the variation of mean follow-up time may produce bias in the result as early and late complications happened at different period post operation. Also publishing

bias could be one of the factors that influence the statistic results as some of the articles only provided refinements of previous techniques, which may not fully mirror the complication rate.

## CONCLUSIONS

There is significant variability in the literature regarding complication rates in autologous cartilage ear reconstruction of patients with microtia. By providing a comprehensive review of different complications with different surgical techniques, this study could help plastic surgeons adequately take measures to minimize the complication rates in their future operations.

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