Outline

- Anatomy and Development
- Microtia
- Reconstructive Options
  - Autogenous cartilage
  - Tissue expanders
  - Osseo-integrated prosthesis
  - Tissue engineering
  - Alloplastic implants
- Conclusion
Anatomy and Development

Embryology

- Development begins at 5 weeks gestation
- First branchial cleft
  - Dorsal end of first (mandibular) and second (hyoid) branchial arches
  - Six mesenchymal proliferations (Hillocks of His)
  - First arch (hillocks 1-3), second arch (hillocks 4-6)
    - Tragus (1)
    - Helix (2,3)
    - Antihelix (4,5)
    - Lobule (6)
- Starts on lower neck but ascends with mandible development (weeks 8-12), “adult” location by week 20
Anatomy and Development

**Musculature**

- **Intrinsic musculature**
  - Major and minor helixes
  - Tragus
  - Antitragus
  - Transverse
  - Oblique

- **Extrinsic musculature**
  - Anterior auricularis
  - Superior auricularis
  - Posterior auricularis
Anatomy and Development

Blood Supply and Lymphatics

- **Arterial**
  - Superficial temporal
  - Posterior auricular
  - Occipital

- **Venous**
  - Superficial temporal
  - Posterior auricular
  - External jugular
  - Retromandibular veins

- **Lymphatics**
  - Parotid lymph nodes
  - Cervical lymph nodes
Anatomy and Development

Innervation

- Auricle (facial nerve)
  - Temporal branch → anterior and superior auricularis
  - Posterior auricular nerve → posterior auricularis

- Sensory
  - Anterior
    - Auriculotemporal nerve (V₃)
    - Greater auricular nerve (anterior branch)
    - Arnold’s nerve (branch of vagus)
  - Posterior
    - Greater auricular nerve (C3)
    - Lesser occipital nerve (C₂, C₃)
Anatomy and Development

Normal External Ear

- Ear development with age
  - 66% of adult size at birth
  - 85% of adult size at age 3 years
  - 95% of adult size at age 6 years
- Normal height 5.5-6.5cm
- Posterior vertical inclination 5-30°
- Vertical angle parallel or within 15° of nasal dorsum
- Helical rim protrudes 1.5-2.0cm from mastoid with 15-20° protrusion angle

(Bailey, 2006)
Microtia

- Abnormal development of external ear
- Incidence of 0.76-2.35 per 10,000 births
  - Males affected more than females (2.5:1)
  - Higher occurrence in Hispanics, Asians (Japanese), and Native Americans (Navajo, Eskimo)
  - Increased risk with increasing multiparity (four or greater)
- Predilection for the right ear than left
- Family history in less than 15% of cases
Microtia Classification and Grading

- First classification system by Marx (1926)
- Amended by Jarhsdoerfer and Aguilar (1988)
- Further refined and reaffirmed by Aguilar (1996), only auricular malformations
- Additional classification schemes with concomitant congenital aural atresia
  - Altmann (1955)
  - Lapchenko (1967)
  - Gil (1969)
  - Jarhsdoerfer and Aguilar (1988)
Microtia
Classification and Grading (Marx)

- **Normal ear**
- **Grade I**
  - Slightly smaller auricle
  - Mild deformity but can distinguish each part
- **Grade II**
  - 1/2 – 2/3 of normal size
  - Mild deformity but can distinguish each part
- **Grade III**
  - Severe malformation
  - “Peanut ear”
- **Grade IV**
  - (anotia)
## Microtia Classification and Grading (Aguilar)

<table>
<thead>
<tr>
<th>Grade</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>I</td>
<td>Normal ear</td>
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<tr>
<td>II</td>
<td>Slightly smaller auricle (deformities present)</td>
</tr>
<tr>
<td>III</td>
<td>Severe malformation (includes anotia)</td>
</tr>
<tr>
<td>IV</td>
<td>Anotia</td>
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</tbody>
</table>

- **Grade I (normal ear):**
  - Slightly smaller auricle
  - Mild deformity but can distinguish each part

- **Grade II (deformities present):**
  - 1/2 – 2/3 of normal size
  - Mild deformity but can distinguish each part

- **Grade III (includes anotia):**
  - Severe malformation
  - “Peanut ear”
Microtia

Considerations

- Association with other congenital abnormalities
  - Cleft palate/lip
  - Cardiac defects
  - Anophthalmia
  - Microphthalmia

- Hearing loss (80-90% conductive hearing loss)
  - Sensorineural hearing loss in 10-15%
  - Can delay additional testing to 6-7 months if nonmicrotic ear passes newborn hearing screen

- Middle ear abnormalities but no direct relation

- Associated facial nerve dysfunction
Microtia Reconstruction

- Reports of first attempts in 1500’s
- Folded mastoid flap by Dieffenbach in mid-1800’s (for traumatic defect)
- Autogenous cartilage by Pierce in 1930’s
  - Tanzer – subcutaneous placement of autologous cartilage graft framework (1959)
  - Modified by Brent in 1970’s
- Cronin – silicone rubber implant (Silastic) (1966)
- Williams – polyethylene implants (Medpor) (1997)
Microtia Reconstruction

- Reconstruction typically delayed until 6 years of age
  - Especially for unilateral cases
  - Sufficient autogenous costal cartilage
  - Psychological factors (i.e. manage postoperative care, school)

- Congenital aural atresia drill-out no earlier than 7 years

- Autogenous cartilage is considered gold standard
  - Brent technique
  - Nagata technique
Microtia Reconstruction

Brent Technique

- Adapted from Tanzer’s six-stage procedure (1959), four-stage procedure (1971)
- Prefer to perform by 6 years of age
- Approximately 60-70% of cases done between 6-10 years
- Four-stage procedure (1974)
  - Develop auricular framework
  - Lobule transposition
  - Auricular framework elevation
  - Tragus formation
- Any otologic surgery follows after reconstruction
Brent Technique
Stage I: Fabricate Auricular Frame

- Template of normal ear (if unilateral) or parent’s ear (if bilateral) on X-ray film
- Decrease size of template by a few millimeters to accommodate for skin cover thickness
- Harvest costal cartilage from ribs 6-8 contralateral to microtic ear
  - Base formed by synchondrosis of ribs 6 and 7
  - Helical rim formed by “floating” rib 8
  - Pieces attached with clear Nylon suture

(Bailey, 2006)
Brent Technique

Stage I: Fabricate Auricular Frame

- Place framework in subcutaneous pocket at posterior and inferior borders of vestige
- Extra cartilage banked with framework or in chest incision
- Two suction drains beneath and near framework
  - Left for five days
  - Avoid complications related to pressure and bolster dressings

(Walton, 2002)
Brent Technique

Stage II: Transpose Lobule

- Performed several months after Stage I completed
- Inferiorly based rotational flap to receive framework

(Bailey, 2006)

(Walton, 2002)

(Shen, 2004)
Incision a few millimeters from helical rim
Dissect over the posterior aspect of the capsule until desired amount of projection achieved
Ear position stabilized with banked cartilage posteriorly beneath frame in fascial pocket
Retroauricular scalp advanced, followed by split-thickness skin graft

(Shen, 2004)
Brent Technique
Stage IV: Construct Tragus

- Composite skin/cartilage graft from anterolateral aspect of contralateral (i.e. normal) conchal vault
- J-shaped incision along posterior tragal margin
- Composite graft inserted into incision to project neotragus and cavitate retrotragal hollow

(Bailey, 2006)
Brent Technique
Stage IV: Construct Tragus

- Shadow of neotragus imitates external auditory canal
- Conchal bowl deepened with subcutaneous tissue excavation
- Adjust for frontal symmetry as needed

(Walton, 2002)
Brent Technique
Preoperative and Postoperative

(Walton, 2002)
Brent Technique
Preoperative and Postoperative

(Thorne, 2001)
Brent Technique

Procedural Modifications

- Laser hair removal of scalp flaps prior to reconstruction
- Create tragus with cartilage framework in Stage I
  - Floating cartilage creates helix
  - Second strut arches around to form antitragus, intertragic notch, and tragus
  - Tip of strut affixed to helical crus of main frame with horizontal mattress suture using clear nylon
Brent Technique

Critique

- High number of stages
  - Operative morbidity
  - Increased cost

- Aesthetic result of tragal reconstruction

- Lack of definition to conchal bowl, intertragic notch, and antitragal contour

- Hyperpigmentation of skin grafts to conchal bowl

- Effacement of postauricular sulcus after elevating framework results in decreased projection
  - Caused by contraction of skin grafts
  - Minimize with thicker skin grafts (prefer full-thickness) or advancing postauricular skin to depth of sulcus and grafting only posterior ear
Microtia Reconstruction
Nagata Technique

- Two-stage technique introduced in 1993
- Technical refinements dependent on type of microtia
  - Lobular
  - Small concha
  - Conchal
  - Anotia
  - Low hairline
- Reconstruction begins at age 10 years and at least 60cm chest circumference
Nagata Technique
Stage I

- Roughly encompasses first three Brent stages
  - Rib cartilage framework with tragal component housed in subcutaneous pocket
  - Lobule transposition
- Framework assembled with fine-gauge wire sutures
- Three “floors” correspond to three different elevations of frame
  - Base – cymba, cavum conchae
  - Second level – crus helicis, fossa triangularis, scapha
  - Top level – helix, antihelix, tragus, antitragus

(Walton, 2002)
Nagata Technique

Stage 1

- Ipsilateral costal cartilage of ribs 6-9
  - Base – 6th and 7th costal cartilages
  - Helix and crus helicis – 8th costal cartilage
  - Superior and inferior crus and antihelix – 9th costal cartilage
  - Remaining structures carved from residual cartilage

- Most, if not all, perichondrium left intact

(Walton, 2002)
Nagata Technique

Stage I

- Anterior lobule/tragal incision with removal of 2mm circular portion of skin

- “W”-shaped posterior lobule incision
  - Increases surface area to cover cartilage construct
  - Allows lobule transposition
  - Flaps undermined and reapproximated to form cup of intertragal notch

(Walton, 2002)
Nagata Technique
Stage I

- Cartilage framework inserted and positioned
- Posterior flap advanced to anterior flap
- Inverted dog-ear formed from 2mm circular skin defect creates incisura intertragica
- Reassembling flaps in Z-plasty fashion transposes lobule
- Bolsters secured with mattress sutures and left in place for 2 weeks

Walton, 2002

Excessive skin inverted to form pseudoacoustic meatus
Nagata Technique
Stage II

- Six months after Stage I
- Crescent-shaped piece of costal cartilage
  - Harvested from fifth rib
  - Wedged into position to elevate framework
  - Serves as posterior conchal wall

(Walton, 2002)
Nagata Technique
Stage II

- Temporoparietal fascial flap
  - Raised through new scalp incision
  - Tunneled subcutaneously to cover:
    - Posterior aspect of cartilage graft
    - Reconstructed auricle
    - Mastoid surface

- Retroauricular skin advanced followed by split-thickness skin graft
  - Ultra-delicate
  - Freehand harvest from occipital scalp
Nagata Technique
Preoperative and Postoperative

Stage I Completed

(Walton, 2002)
Nagata Technique
Preoperative and Postoperative

Stage II Completed

(Walton, 2002)
Nagata Technique

Critique

- Provides a deeper and more natural conchal bowl (no need to excavate subcutaneous tissue)
- High rate of peri-lobular flap necrosis (14%) from vascular compromise
- More cartilage harvested
  - Significant anterior chest wall deformity
  - Thicker ears
- High extrusion rate of cartilage framework from wire sutures (8%)
- Frontal symmetry not addressed, would require third stage
Autogenous Cartilage Graft Risks and Benefits

Advantages
- Native tissue
- Less infection
- Potential for 5% growth with time

Disadvantages
- Cartilage may warp or resorb with time
- Framework extrusion with skin flap necrosis
- Cartilage donor effects
  - Pneumothorax
  - Atelectasis
  - Chest wall deformity/scarring
- Low hairline
  - Aesthetics
  - Thicker skin with less contour
  - Inflammation/infection
Other Reconstructive Options

- Single-stage reconstruction
- Tissue expanders
- Osseo-integrated prosthesis
- Tissue engineering
- Alloplastic implant
  - Silastic
  - Medpor
Other Reconstructive Options

Single-Stage Reconstruction

- Used predominantly for partial defects (i.e. superior helix or lobule)
- Total ear reconstruction usually entails:
  - Skin flaps
  - Fascial flaps
  - External stents
- Results not comparable to multiple-staged procedures
- Two-flap, single-stage procedure has been converted to a three-stage one (Park, 1997 and 2000)
Other Reconstructive Options

Tissue Expanders

- Hata and Umeda (2000)
  - Reconstruct auricle in single stage without skin graft
  - Good skin texture and match
  - Skin innervation preserved

- Park (2000)
  - First Stage
    - Expand skin and fascial layers
    - Cartilage framework sandwiched between both layers
    - Skin graft over fascial layer
  - Second Stage
    - Remove cartilage and shape structures from framework
    - May need skin graft to posterior surface of frame

(Yang, 2009)
Other Reconstructive Options

Tissue Expanders

- Pain
- Not well tolerated in young children
- Insertion of expander is a procedure; number of stages not truly reduced
- Fibrous capsule formation around expander may marginalize contouring results

(Yang, 2009)
At least 3mm of bone to secure implant

Indications for use:
- Severe soft-tissue or skeletal hypoplasia
- Poor local tissue
  - Cancer
  - Radiation
  - Failed autogenous reconstruction
- High operative risk factors

Prosthesis changes
- Approximately 2-5 years with ultraviolet degradation
- Multiple prosthesis for seasonal skin tones

(Tollefson, 2006)
Other Reconstructive Options

Osseo-Integrated Prosthesis

Advantages
- Single, less involved procedure
- Best cosmetic outcome
- No resorption
- Minimal infection
  - Inflammation around anchoring pins
  - Mechanical trauma to pins
  - Tissue overgrowth

Disadvantages
- Repeat procedures ($2,000-7000 per prosthesis)
- “Mr. Potato Head” social stigma (i.e. if ear falls off)
- Precludes future autogenous reconstruction
Other Reconstructive Options
Tissue Engineering

- Potential to offer autogenous cartilage without morbidity from rib harvest
- Prefabricated framework
  - Taut pressure from overlying skin can deform frame
  - Firm alloplastic frames can withstand pressure but extrude
  - Difficult to match size and shape of normal ear
  - Requires replication of numerous human chondrocytes to create adequate framework
  - Bovine chondrocytes grown in vitro transplanted onto synthetic ear-shaped biodegradable scaffold
  - Scaffold implanted into immunocompetent mouse
  - New cartilage formation with human ear shape after 12 weeks
Other Reconstructive Options

Tissue Engineering

- Human-sized auricle with hydrogel scaffold in pigs (Kamil, 2004)
- Grow chondrocytes on perforated pure gold ear mold (Kamil, 2004)
- Harvest chondrocytes from microtic human ears in mouse model (Kamil, 2004)
Silicone implant investigated by Cronin (1966) and Ohmori (1978)

- Promising results initially
- Disappointing long-term outcomes
  - Implant extrusion/resorption secondary to skin flap erosion/necrosis
  - Minor trauma or abrasions can cause implant failure
  - May occur years after operation
- Salvage can be done with local skin and fascial flaps
- Use has since been abandoned
Other Reconstructive Options

Medpor Alloplastic Implant

- Prefabricated porous polyethylene auricular implant
- Excellent biocompatibility, stability, tissue integration, and resistance to infection
  - Minimal tissue reaction
  - Pore size 150µm allows soft-tissue ingrowth improves stability
  - Can be bent when heated to 82-100°C, carved to shape, or affixed to other pieces with cautery

- Lobule transposition can be performed after three months

- Bone-anchored hearing aid can be placed concurrently (Romo, 2006 and 2009)
Less extrusion rates compared to silicone with use of temporoparietal fascial (TPF) flap to cover framework
- Lower 2/3 inserted in to skin pocket
- Upper portion covered with TPF and skin graft
- Flap must be water-tight

Soft tissue flaps to treat early implant exposure from flap ischemia
- If exposure is less than 1cm
- If tissue integration is seen

Good short-term results (2-year) but long-term results still lacking

Other Reconstructive Options
- Medpor Alloplastic Implant

(Tollefson, 2006)
Dr. John Reinisch’s Five Main Advantages

- Good projection and definition
- Decreased reconstruction time
- No scarring from costal cartilage harvest
- Can perform in younger children (3-4 years)
- Shorter learning curve than autogenous cartilage graft

Other Reconstructive Options

Medpor Alloplastic Implant
Other Reconstructive Options
Medpor Alloplastic Implant

Advantages
- Improved cosmetic result compared to autogenous cartilage graft
- No resorption
- Low extrusion rate

Disadvantages
- Not native tissue
- Infection risk with any cut
- Sensitive to trauma and direct contact

TPF Flap
- Y-shaped incision
- Full-thickness skin graft over top 1/3 of Medpor
- Small vacuum drain

(Romo, 2009)
Medpor Alloplastic Implant
First Stage Reconstruction

Superficial temporal arteries identified with Doppler

Scalp incisions
- Made to avoid junctions over arteries
- Perpendicular to direction of hair growth

Template marked for implant position

Subcutaneous pedicle for blood supply to skin over future conchal bowl

Long and wide TPF flap is needed to cover the entire implant

(Reinish, 1998)
Medpor Alloplastic Implant
First Stage Reconstruction

Skine exposure flaps over fascia reapproximated to protect tissue

Lobule mobilized and opened to fit over implant rim

Postauricular skin harvested from contralateral ear

(Reinish, 1998)
Medpor Alloplastic Implant
First Stage Reconstruction

- Abdominal skin graft to cover harvest site
- Antibiotic-covered bolster to cover the graft site
Medpor Alloplastic Implant
First Stage Reconstruction

- Medpor pieces soaked in betadine
- Placed inside 60mL syringe
- Betadine suctioned against finger to drive betadine into pores
Medpor Alloplastic Implant
First Stage Reconstruction

- Medpor pieces affixed with electrocautery or non-absorbable suture
- TPF flap lifted with enough to cover the entire implant
Medpor Alloplastic Implant
First Stage Reconstruction

- TPF flap draped over implant
- Two drains, one placed right under implant
  - TPF flap must be watertight
  - Skin flap will press against TPF and implant if truly tight

(Reinish, 1998)
**Medpor Alloplastic Implant**

First Stage Reconstruction

- Abdominal skin flap placed posteriorly
- Contralateral postauricular skin flap placed anteriorly
- Trim flaps as needed to keep abdominal flap behind helical rim

(Renish, 1998)
Medpor Alloplastic Implant
Second Stage Reconstruction

Excess tissue removed

Anteriorly based flap made near tragus
Medpor Alloplastic Implant
Second Stage Reconstruction

- Part of parotid gland removed to make room for conchal bowl
- Anterior flap sutured over itself to make tragus

(Reinish, 1998)
Medpor Alloplastic Implant
Preoperative

(Courtesy of Dr. Athre)
Medpor Alloplastic Implant
Intraoperative

(Courtesy of Dr. Athre)
Medpor Alloplastic Implant
Postoperative

(Courtesy of Dr. Athre)
Conclusion

- Microtia can be associated with other congenital abnormalities and adverse psychosocial effects
- Surgical intervention can be delayed until the child is older
- Reconstruction with autogenous cartilage graft is the gold standard
- Alloplastic implants provide improved cosmetic results with less staged procedures


Tanzer RC. Total reconstruction of the external ear. Plast Reconstr Surg 1959;23:1.