Otolaryngology Grand Rounds: Principles of Scalp Reconstruction

Code: ZUTHEG

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Overview
Outline: Scalp Reconstruction

• Case Presentation
• Background
  • History
  • Anatomy
• Preoperative Assessment
• Surgical Technique
• Algorithm for approach to scalp defects
Case Presentation #1

• 69M with h/o BCC of scalp excised 10yr ago
• Presented with recurrent lesion of scalp
  • Location: vertex
  • Bx: BCC
• Also had a soft-tissue occipital scalp mass
  • Pt reported slow growth x4yr
Case Presentation #1

- Intraoperative defect:
  - 9 x 9cm
  - Pericranium intact
- Occipital soft tissue mass
  - 4 x 4 cm
Case Presentation #2

• 64M longstanding history of BCC of R temple
  • 25 years ago: first BCC removed from area
  • 7 years ago: changes to R eye and temple
    • Bx: BCC
    • Resection: negative margins
  • 3 years ago: recurrence
    • Re-excision → positive periosteal/bone margins → XRT

• New progressive vision loss OD (LP only)
  • Loss of R forehead motion

• PMHx:
  • CAD s/p MI with stents, 6-12 EtOH/week, Afib, GERD, HTN
  • BCC removed from L arm and flank ~1mo ago
Case Presentation
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Case Presentation

• Considerations:
  • What is the expected defect?
  • What associated deficits might we encounter?
  • How does his medical history affect our surgical plan?
    • XRT
    • Recent forearm surgery
  • What reconstructive options are available?

• Goals:
  • Eradicate disease
  • Provide coverage for vital structures
  • Optimize aesthetic outcomes
Background: Scalp defects

- Causes of scalp defects
  - Surgical wounds related to skin or other cancers
    - Most common: BCC/SCC of skin
      - Melanoma: less common
    - Risk factors: Sun exposure, age, immunocompromise
  - Trauma
    - Shearing injuries: typically involve loose areolar layer
- Both sources may have associated neurologic deficit
  - Underlying cranial involvement/injury
  - Facial nerve function in specific areas
History
History

- 1696: Augustin Belloste
  - Perforation of bare cranium to facilitate granulation
- 1871: Netolitzky
  - Skin grafting over granulation tissue
- 1908: Robinson
  - Skin grafting over intact periosteum
- 1953: Kazanjian – galeal scoring
- Orticochea:
  - 1967 - four-flap technique
  - 1971 – three-flap technique

“The surgeon must move the cutaneous covering of the skull with the same facility with which a boy peels a banana.” - Orticochea (1975)
**History**

- **1950s-70s: Tissue Expansion**
  - 1957: Neumann - First clinical use of tissue expansion (ear recon)
  - 1978: Radovan - popularizes tissue expansion for scalp
  - 1984: Manders – tissue expansion for extensive scalp defect
- **1976-present: Free tissue transfer**
  - 1976: Miller – replantation of total scalp avulsion
Anatomy
Basic Anatomy of the Scalp

- SCALP
  - Skin
  - SubCutaneous
  - Aponeurosis
  - Loose connective tissue
  - Pericranium

Source: Leedy et al “Reconstruction of Scalp Defects” 2005
Basic Anatomy of the Scalp

- SCALP
  - Skin
  - SubCutaneous
  - Aponeurosis
  - Loose connective tissue
  - Pericranium

Source: Jordan “Reconstruction of Scalp Defects.”
Temporal Anatomy

Source: Papel et al.

Source: Desai et al.
Zones of distensibility

- Defined by thickness of galea
- Tight areas of scalp
  - Thick galea, no underlying muscle
  - Vertex to edge of temporalis
- Loose areas of scalp
  - Thin galea
  - Parietal/occipital areas overlying muscle

Source: Desai et al 2016
Arterial Supply

- ECA system predominates
  - Anteriorly: ICA
- Highly redundant
- Most vessels lie within galea/subcutaneous layer

Source: Desai et al 2016
Sensory Supply

Fig. 3. Scalp vascularity and innervation.

Source: Leedy et al. 2005
Lymphatic drainage

- Extensive lymphatic network
  - No nodes in scalp

- Drain to adjacent nodal basins:
  - Parotid
  - Anterior/posterior auricular
  - Occipital
Hair physiology

- Average scalp: more than 100k hairs
- 3 stages:
  - Anagen - growth phase
    - 90-95% of hairs
    - Duration: ~1000 days
  - Catagen - involutional phase
    - 1-2% of hairs
    - Duration: 2-3 weeks
  - Telogen - dormant phase
    - 5-10% of hairs
    - Duration: 2-3 mo

Source: Rompolas et al 2005
Patient Assessment
Patient Assessment

- Overall patient health
  - Able to tolerate general anesthesia?
  - History of/need for radiation
  - Prior surgeries
- Defect size
- Pathology
- Defect location
  - Associated vascular anatomy
  - Distensibility of nearby scalp
  - Hair-bearing or not? Involvement of hairline?
- Involvement of adjacent structures
Associated Pathology

• Location, Location, Location!
  • Intracranial extension of large tumors
    • Bony defects
    • Neurologic involvement – dural defects, CSF leaks
  • Ear involvement
    • Status of TM, need for EAC reconstruction
  • Sinus involvement
    • Frontal obliteration/cranialization
  • Facial nerve involvement/injury
    • Lesions of temporal/frontal scalp

• Associated deficits may need to be addressed prior to/concurrent with reconstruction
Associated Pathology

- **Bony defects**
  - Goals: provide contour, protect brain
  - Monocortical defects:
    - May cause scalp deformity
    - Some may not require additional reconstruction
    - Calcium hydroxyapatite cement for larger defects

- **Full-thickness defects**:
  - Small defects: Calcium hydroxyapatite +/- mesh
  - Larger defects:
    - Split cranial bone, acrylic/titanium mesh

Source: Blackwell “Reconstruction of Cutaneous Malignancies of the Scalp and Lip”
Surgical Approach
Reconstructive ladder – scalp defects

- Secondary intention
- Primary closure
  - VAC-assisted closure
- Skin grafting
- Tissue expansion
- Local flaps
- Regional flaps
- Free tissue transfer
Secondary intention

- Appropriate for:
  - Small defects
  - Bald patients (vertex defects)

- Advantages:
  - No additional procedures

- Disadvantages:
  - Allopecia
  - Requires underlying pericranium/muscle
  - Prolonged healing time
  - Extensive wound care
  - Hypopigmentation
  - Resultant tissue friable
Secondary intention
Skin grafting

- Appropriate for:
  - Defects in non-cosmetic areas
  - Poor medical status
  - Closure of secondary defects
  - Temporary closure for tissue expansion
  - High risk of recurrence

- Disadvantages:
  - Alopecia
  - Requires pericranium/granulation for graft take
  - Friable/thin tissue
  - Not appropriate if post-op XRT expected

- Advantages:
  - Easy, fast
  - Tension-free closure
  - Can close large defects
STSG – wound preparation

• Full-thickness wounds

• Options:
  • Burr down outer table
  • Integra – collagen-GAG wound matrix with silicone outer layer
    • Stimulates granulation formation
    • Can be used as a temporizing measure
  • Other materials
  • Typically wait 3 weeks to allow granulation to form

Source: Jordan “Reconstruction of Scalp Defects”
Skin grafting

Source: Papel et al.
Primary closure

- Appropriate for:
  - Defects <3cm
  - Hair-bearing areas
  - Hairline

- Advantages:
  - Limited alopecia
  - Favorable contour/color match
  - Fast/simple

- Disadvantages:
  - Limited size
  - Requires extensive undermining
  - Dog ears
  - May distort hairline
Primary closure: Technique

• Technique:
  • Ellipse - 3:1 ideal ratio
  • Wide undermining in subgaleal plane
  • Score galea to achieve relaxation
  • Closure:
    • Close galea first (minimize tension)

• Dog ears: may not require revision

Source: Leedy et al.
Local flaps

- Appropriate for:
  - Medium-sized defects
  - Select large defects
  - Medically complex patients

- Advantages:
  - Single-stage
  - Good contour/color match

- Disadvantages:
  - Large incisions/extensive undermining necessary
  - Closure may be under tension
  - Creation of secondary defects
Local flaps: Advancement flaps

- Scalp: minimal distensibility
  - No RSTLs exist in scalp
- Advancement flaps therefore less useful

- Single/double advancement may be useful for:
  - Small defects
  - Temporal defects
Local flaps: Rotational flaps

- Main workhorse for scalp reconstruction
- Technique:
  - Bevel incisions to parallel hair growth
  - Keep in mind vascular anatomy
  - Galeal relaxing incisions
  - Graft secondary defect
- Disadvantage: long incision
  - Length = 4-6x width of defect

Source: Jordan “Reconstruction of Scalp Defects”
Local flaps: Rotational flaps

Source: Leedy et al.
Local flaps: Rotational flaps

- Multiple rotation flaps
  - Distributes tension over scalp
  - Smaller flaps required
  - May allow recruitment from more elastic areas
  - Disadvantage: more incisions

- Examples:
  - O-Z flap
  - Pinwheel flap

Source: Jordan “Reconstruction of Scalp Defects”
Local flaps: Rotational flaps

- **Multiple rotation flaps**
  - Distributes tension over scalp
  - Smaller flaps required
  - May allow recruitment from more elastic areas
  - Disadvantage: more incisions

- **Examples:**
  - O→Z flap
    - Defects <5cm, vertex
  - Pinwheel flap

Source: Jordan “Reconstruction of Scalp Defects”
Local flaps: Rotational flaps

• **Multiple rotation flaps**
  - Distributes tension over scalp
  - Smaller flaps required
  - May allow recruitment from more elastic areas
  - Disadvantage: more incisions

• **Examples:**
  - O-Z flap
  - Pinwheel flap

Source: Desai et al.
Local flaps: Rotational flaps

Pre-op

1wk Post

2wk Post

6wk Post

6mo Post
Local flaps: Orticochea flap

- Described by Miguel Orticochea in 1968
  - Initially 4-flap technique
  - Revised to 3-flap technique in 1972

- Technique: Multiple transposition flap
  - 2 lateral flaps: STA
  - 1 posterior flap: occipital
  - Galeal releasing incisions

- Can be used on defects up to 9x12cm
- Provides hair-bearing tissue

Source: Orticochea M. “Flaps of the Cutaneous Covering of the Skull.”
Local flaps: Orticochea flap

Source: Leedy et al.
Local flaps: Orticochea flap

Source: Orticochea M. “Flaps of the Cutaneous Covering of the Skull.”
Local flaps: Visor flap

- Described by Hwang et al.

- Technique: Bipedicled advancement flap
  - V-V donor site
  - May allow for closure at both primary and donor site.
  - Defect size: 3-50 cm²
Tissue expansion

- Appropriate for:
  - Hair-bearing scalp
  - Larger defects
  - Non-malignant processes
  - Compliant patients

- Advantages:
  - Good contour/color match
  - Recruits hair-bearing tissue
  - Versatile

- Disadvantages:
  - Duration of expansion
  - Multiple procedures
  - Disfigurement during expansion
  - Risk of infection/extrusion
  - May require grafting for temporary coverage
Tissue expansion

• Long-term tissue expansion
  • Relies on biologic creep
  • Duration:
    • Begin inflation 2 weeks after implantation
    • Inflation: 4-8 weeks
    • Areas with thin skin require slower expansion
  • Inflate until overlying skin is indurated or until patient discomfort
    • If blanching occurs, deflate slightly

• Intraoperative tissue expansion
  • Relies on mechanical creep
  • Inflate until pale/indurated
  • Deflate after 3min, repeat

Source: Papel et al
Tissue expansion

Net tissue effect:
- Blood flow - increases
- Dermis - thins, increased fibroblasts
- Epidermis - thickens, increased mitotic activity
- Fat - thins up to 50%
- Muscle - decreased mass, maintains function

Source: Leedy et al
Tissue expansion

Source: Papel et al
Tissue expansion

Can replace defects up to 50% of scalp

Galeal scoring - may decrease
- Expansion time
- Patient discomfort

Expander base = 2.5x width of defect
- Net gain by shape:
  - Round: 25%
  - Crescent: 32%
  - Rectangle: 38%
Regional flaps

• Ideal for:
  • Occipital/temporal defects
  • h/o XRT
  • TPF flap: can provide tissue for grafting

• Common flaps used:
  • Trapezius
  • Lattisimus dorsi
  • Temporoparietal

• Disadvantages:
  • Donor site morbidity
  • Not hair-bearing

3/29/17
Free Tissue Transfer

- **Ideal for:**
  - Extensive defects
  - History of XRT
  - Defects involving skull/dura
  - Chronic infection

- **Advantages:**
  - Robust coverage
  - High success rate

- **Disadvantages:**
  - Long operative time, hospital stay
  - Donor site morbidity
  - Not hair-bearing, color/contour mismatch
Free Tissue Transfer

- **Common donor sites:**
  - Latissimus Dorsi
  - Anterolateral thigh
  - Radial forearm

- **Common recipient vessels:**
  - Facial vessels
  - STA/STV
Free tissue transfer – ALTFF

Source: Desai et al
Free tissue transfer - RFFF
Free tissue transfer – Latissimus Dorsi + STSG
Free tissue transfer – Total scalp defect
Algorithm for approach to defects
Figure 6. Algorithm for the Reconstruction of Various Scalp Defects

Scalp defect size:
- Small (<9 cm²)
  - Frontal, temporoparietal, occipital
  - Vertex
- Medium (9 to 30 cm²)
  - Frontal, temporoparietal, occipital
  - Vertex
- Large (>30 cm²)
  - Frontal, vertex
  - Temporoparietal, occipital
  - Total scalp

Defect location:
- Frontal, temporoparietal, occipital
- Vertex

Radiation history:
- No
- Yes

Hairline distortion?
- Yes
- No

Hairline:
- Yes
- No

Ideal reconstruction:
- Local flap
- Primary closure
- Primary closure, "pinwheel" or 0→Z flap
- Free tissue transfer
- Tissue expansion
- Local flap
- Skin graft (bald patient), large rotational flap
- Free tissue transfer
- Tissue expansion
- Orhtocochial flap
- Free tissue transfer
- Tissue expansion
- Free tissue transfer, consider regional flap
- Free tissue transfer

Algorithm for the reconstruction of various scalp defects based on size and location. See the section Algorithmic Approach to Defect for further details.

aIdeal reconstruction refers to the surgical option that could achieve an optimal functional and aesthetic outcome; however, often that reconstructive option may not be feasible.
bLocal flaps include advancement, rotation, and transposition flaps.
Small defects (<9cm²)

- Considerations:
  - Location
  - Involvement of hairline

- Reconstructive options:
  - Primary closure
  - Local flaps

Source: Desai et al
Medium defects (9-30cm²)

• Considerations:
  • Location
  • History of/need for XRT
  • Involvement of hairline

• Reconstructive options:
  • Local flaps
  • Tissue expansion
  • Free tissue transfer (XRT)
Large defects (>30cm²)

Considerations:
- Location
- History of/need for XRT
- Involvement of hairline

Reconstructive options:
- Orticochea flap
- Tissue expansion
- Free tissue transfer
- Regional flap

Total scalp:
- Free tissue transfer
Case Presentations
Case Presentation #1

- Considerations:
  - 9 x 9cm vertex defect
  - Bald area of scalp
  - 4 x 4 cm occipital mass
  - Recurrent tumor – may require XRT
Case Presentation #1

• Reconstruction: O-Z
  • Wide undermining
  • Galeal scoring
  • Resection of subcutaneous mass
    • “Tissue expander”
Case Presentation #1

- Reconstruction: O-Z
  - Wide undermining
  - Galeal scoring
  - Resection of subcutaneous mass
    - “Tissue expander”
Case Presentation #1
Case Presentation #1
Case Presentation #2
Case Presentation #2

- Extensive defect involving:
  - R orbit/maxilla
  - R ethmoid/maxillary/frontal sinuses
  - Inner and outer table of skull
  - Resection of dura

- Reconstruction: Left ALTFF
  - Musculocutaneous free flap
  - Anastamosis: R ECA and EJ

- Cranial/Orbital reconstruction
  - Dura-Matrix synthetic dura
  - Titanium mesh cranioplasty
  - Titanium mesh orbital reconstruction
  - Frontal sinus obliteration
Case Presentation #2

- Successes of reconstruction:
  - Good contour
  - Coverage of defect
  - Tension-free closure
  - Single-stage
  - Minimal distortion of hairline

- Drawbacks:
  - Poor color-match
  - Hair-bearing donor tissue

- Ultimately, noted to have recurrence along suture line
Case Presentation #2

- Re-resection
  - Partial removal of previous flap
- Right ALTFF
  - Anastamosis: contralateral facial vessels
Conclusions: Scalp reconstruction

- May run the gamut of reconstructive ladder
- Anticipation of associated pathology/defects is paramount
  - “Load the Boat”
- Key considerations in reconstruction:
  - Defect size, location
  - Involvement of hairline
  - History of/anticipation of XRT
References

Thank you!

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