Complex Mandibular Reconstruction
Perspectives and State of the "Art"

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Amit Kochhar, MD
(amit.kochhar@med.usc.edu)
Assistant Professor
Division of Facial Plastic and Reconstructive Surgery
USC Caruso Department of Otolaryngology, Head and Neck Surgery

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Disclosures

- I have no financial disclosures

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Objectives

- Anatomy
- Indications for Mandibulectomy
- Mandible Defect Classification
- Preoperative Planning and Goals of Reconstruction
- Historical Perspective
- Current Standard of Care
- Future State of the "Art"

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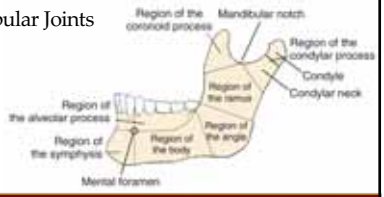
Anatomy – The Bony Mandible

- The strongest Facial Bone
- 1 U shaped horizontal section (Body)
- 2 Vertical Rami
- 2 Temporomandibular Joints



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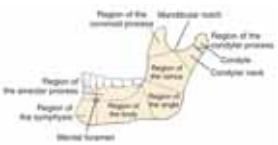
Anatomy – The Bony Mandible

- **Composition**:
  - Dense cortical structure
  - Small core of spongiosa that contains nerves, blood vessels, and lymphatic vessels
- **Alveolar Process**
  - Contains dental sockets to support teeth
  - Changes may occur throughout adult life, especially after dental loss/extractions
- **Mental foramen**
  - Located between the inferior border and upper edge of alveolar process at the level of the second premolar



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Anatomy–The Mandibles Function

- Airway stability
- Speech
- Deglutition
- Mastication
  - Maximal molar occlussal forces of 4346 Newtons
    - ~ 977 pounds
- Shape and contour of the lower face

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Anatomy – Muscular interactions

- Movement is dependent primarily on 2 muscle groups
1. Depressor-Retractor Group
   - Geniohyoid
   - Digastric
2. Elevator Group
   - Masseter
   - Medial Pterygoid
   - Temporalis

❖ Protrusion - Lateral pterygoid

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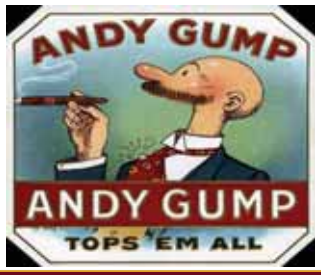
Anatomy – Aesthetic Implications

- The Perils of Mandibular Reconstruction



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The Perils of Mandibular Reconstruction

Roger Ebert

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Indications for Mandibulectomy

- Ablative Surgery for neoplasms of the head and neck
  - Most common indication
  - Benign disease is not typically associated with a soft-tissue oral cavity defect, Malignancy is.
- **Osteoradionecrosis**
- Trauma
- Bisphosphonate-induced osteonecrosis
- Osteomyelitis

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Defect Classifications

- Various Classification Schemes exist though none is widely accepted
  - **Urken**
  - HCL (Boyd et al.)
  - Brown JS

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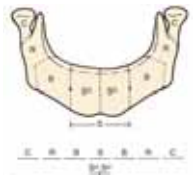
Urken Classification



C – Condyle
R – Ramus
B – Body
S – Total symphysis
SH – Hemisymphysis

- Based on functional considerations caused by detachment of different muscle groups and difficulties with cosmetic restoration
- Only descriptive, does not predict morbidity or suggest a method of reconstruction

Mehta and Deschler. Mandibular Reconstruction in 2004: analysis of different techniques. Curr Opin Otolaryngol Head Neck Surg. 2004 Aug;12(4):288-93.

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Preoperative Planning & Goals of Reconstruction

- The best functional AND aesthetic results occur with immediate mandible reconstruction
- Delayed reconstruction results in scarring and fibrosis of the remaining bone and soft tissue
  - proper placement of the reconstructed bone becomes difficult or even *impossible*

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Preoperative Planning

- **General considerations:**
  - The localization and latitude of bony and soft tissue defect
  - Thorough evaluation of a patient's facial anatomy
  - Age
  - Dental status

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Preoperative Planning (cont)

- **Contraindications to mandibular surgery/reconstruction**
  - Active infection
  - Thinning of mandible bone stock
  - Bleeding disorders
  - Unrealistic expectations
  - A history of radiation
  - Significant comorbidities incompatible with surgery

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Goals of Mandibular Reconstruction

- Accurate assessment of *potential* defect and understanding of functional deficits
- **Restoration of Form and Function**
  1. Restore Bony Contour of Native Mandible (Form)
  2. Maintenance of the Airway (Function)
  3. Restoration of Mastication (Function)
  4. Restoration of Deglutition (Function)
  5. Restoration of Articulation (Function)
  6. Potential Restoration of Dentition (Function)
     - Cost vs Benefit

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Techniques for Mandibular Reconstruction

1. Alloplastic materials (with or without bone)
2. Avascular/Free bone grafts
3. Pedicled bone flaps
4. Free vascularized tissue
   1. Soft tissue + plating
   2. Oteocutaneous/osteomyocutaneous flaps

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Alloplastic vs. Free Bone Grafts

- Titanium bone plates and screws are most common
- Indicated in patients with poor performance status
- Excellent for short term but high risk of extrusion over long term
- Innovation in self-drilling, self-tapping screws and locking miniplates assists in microvascular reconstruction

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Metal Reconstruction bars

- Short term - significant improvement
- Long term – Complications > 30% with vascularized tissue.
  - Plate extrusion
  - Plate fracture
  - Screw loosening
  - Not to be used with radiation

Boyd et al. 2012. Removal of Exposed Titanium Reconstruction Plate After Mandibular Reconstruction With a Free Fibula Osteocutaneous Flap.

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Free bone grafts

- Initially reported by Bardenheuer in 1881
- Numerous techniques were developed in the 20th century.
- Harvested from the scull, rib, ilium, tibia, fibula, scapula, humerus, radius, and metatarsal bones.
- Best for reconstruction of small (<3cm) in a setting of a benign disease.
  - **Some authors claim they can harvest up to 8 cm of bone from the iliac crest.**
  - Most guidelines recommend no more than 6cm as failure reaches 50%, for defects larger than 4cm

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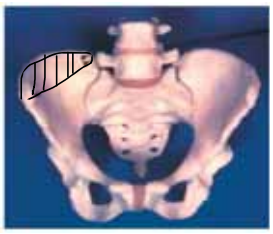
Free bone grafts - Iliac Crest



Dr. Uttam Sinha

Urken, Mark L.. Atlas of Regional and Free Flaps for Head and Neck Reconstruction. 2011. Wolters Kluwer Health.

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Pedicled Flaps

- Including the **trapezius and pectoralis osteomyocutaneous flaps**
- Advantages
  - Adjacent to the head
  - Same operating field
- Drawbacks
  - Available bone is limited
  - Osseous components have poor blood supply
- Generally not recommended as primary methods of mandible reconstruction

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Free tissue (non-osteocutaneous)

- 1976 - Panje and Baker introduce successful oral cavity reconstruction with free groin transfer
- The vertical rectus flap, forearm flap, or the anterior lateral thigh (ALT) flaps commonly used
- Reserved for lateral defects
- Provides soft-tissue coverage for a reconstruction plate in patients who are poor candidates for an Osteocutaneous free flap
- Major Disadvantage:
  - High risk of infection, exposed hardware and ultimate flap failure.

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Free Osteocutaneous Tissue Transfer

- 1975 – Taylor et al. report the successful transfer of the vascularized fibular bone flap for reconstruction of an open fracture of the lower extremity
- 1979 – Taylor, Sanders and Mayou identified the iliac crest bone as viable for free tissue transer
- 1983 – Chen and Yan – First to perform fibular osteocutaneous tissue transfer

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Free Osteocutaneous Tissue Transfer

- Iliac Crest Free Flap
- Radial Forearm Osteocutaneous Free Flap
- Scapular Free Flap
- Serratus-Rib Free Flap
- Fibular Free Flap

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Iliac Crest Free Flap

 Urken, Mark L.. Atlas of Regional and Free Flaps for Head and Neck Reconstruction. 2011. Wolters Kluwer Health.

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Iliac Crest Osteocutaneous Free flap

- It was at one time, the "workhorse"
- Arterial supply is based on Deep Circumflex Iliac Artery (DCIA)
- Provides a large quantity of bicortical bone with height comparable to native dentate mandible
- Contoured to fit most segmental mandibular defects
- Can also harvest internal oblique muscle
- Reduced lower extremity donor morbidity

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Iliac Crest Free Flap

 Motemadi et al. The Journal of craniofacial surgery. 2012

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Iliac Crest - Disadvantages

- Bone lacks segmental perforators
- Vessels are generally short and of small diameter
- Skin Island Unreliable and often provides too much bulk
- Donor Site Morbidity
  - Numbness to Anterior Hip Region
  - Complications include Hernia of the internal oblique muscle
- **Today, the indications for use of the ilium are limited. Best indication is a short lateral or hemimandible segment not requiring mucosal lining replacement.**

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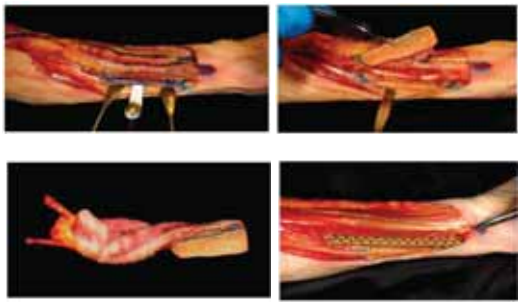
Radial Forearm Osteocutaneous Flap



 Urken, Mark L.. Atlas of Regional and Free Flaps for Head and Neck Reconstruction. 2011. Wolters Kluwer Health.

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Radial Forearm Osteocutaneous Flap

Advantages

- RFFF has the best quality skin island;
  - thin, pliable, and abundant
- The vascular pedicle is long, large-diameter, capable of reaching contralateral neck.
- Skin island is ideal for resurfacing a large mucosal defects.
- **Most common indication** - boney defect limited to the ramus and the proximal body with large associated intraoral soft-tissue defect.

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Radial Forearm Osteocutaneous Flap

Disadvantages

- **Bone stock is poor when compared with other choices**
- Must carefully split radius during harvest to prevent postoperative fracture (Debatable based on shape)
- Length of bone is short, ~10 cm
- **Cannot** perform of osteointegrated implants
- Relatively contraindicated for most anterior defects due to inadequate soft tissue and bone volume

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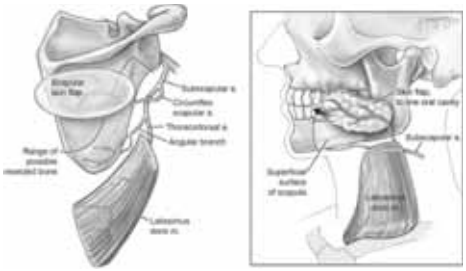
Scapula Free Flap



 M. Bak et al. / Oral Oncology 46 (2010) 71–76

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Scapular Free Flap

- Based on Circumflex Scapular Artery and Vein
  - Large caliber, long vessels
- Preferred by some for geriatric patients due to ability to ambulate early after surgical resection

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Scapular Free Flap

Advantages

- Up to 14 cm of bone that can be osteotomized
- Large, well vascularized skin island
- Good choice for "through and through" defects involving facial skin, bone, and mucosa
- Accepts osseointegrated dental implants
- Useful in setting of salvage surgery after Chemo/XRT failure
  - Can include latissmus dorsi muscle to cover major vasculature in the neck

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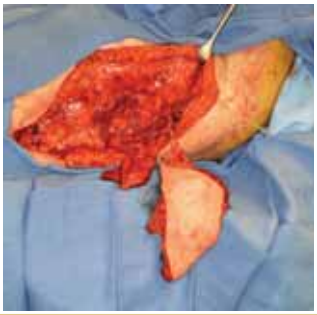
Scapular Free Flap - Harvest



 Images Courtesy of Dr. Daniel Kwon

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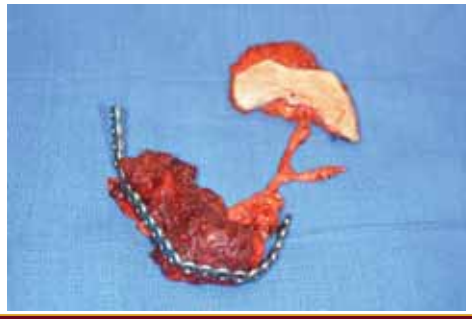
Scapular Free Flap - Inset



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Scapular Free Flap - Inset

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Logistic Limitations of Scapula Flap

- Cannot harvest while resection is taking place
- Requires repositioning during surgery (supine to LLD)
- Must use valuable ischemia time to close donor site.
- Vessels may be easily tangled

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Serratus Rib (Lat Dorsi Muscle)

- Based on the subscapular system
  - Circumflex Scapular Artery and Vein
  - Thoracodorsal Artery and Vein
  - Serratus anterior Artery and Vein
  - Includes the latissimus dorsi myocutaneous skin paddle and rib for bone
- Similar indications to Scapula
  - Patients who have poor leg vessel vascularity

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Serratus Rib (Lat Dorsi Muscle)

- Advantages
  - Can be harvested simultaneously with ablation
  - Long pedicle can reach contralateral neck
- Disadvantages
  - Easy to tangle vessels
  - Technically more challenging
  - Risk of pneumothorax
  - Will not take implants

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Defect

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Serratus Rib (Lat Dorsi Muscle) - Flap Design

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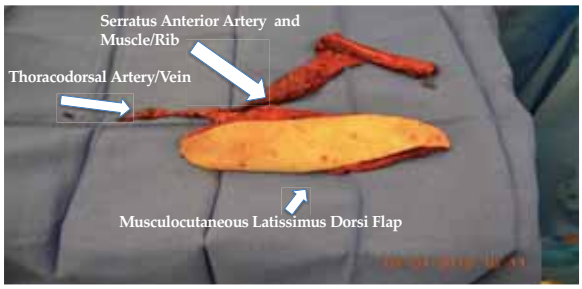
Harvested Flap - Serratus Rib (Lat Dorsi Muscle)



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Flap Inset

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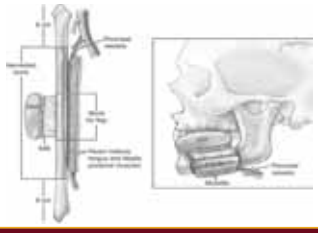
Osteocutaneous free flap

- Fibula Free Flap is currently the donor site of choice for most patients



 M. Bak et al. / Oral Oncology 46 (2010) 71–76

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Fibula Free Flap

- Based on the Peroneal Artery and Veins
- Well vascularized long donor bone (>25cm)
- Only donor site that allows reconstruction of TOTAL mandibular defects
- Large vessels, Long vascular pedicle
- Bony strength permits good screw fixation and solid reconstruction

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Fibula Free Flap

- Can be shaped with multiple segmental osteotomies
- Stable bicortical osseointegrated dental implant fixation is possible
- Thin, pliable overlying skin
- Simultaneous cancer resection and harvesting of flap possible

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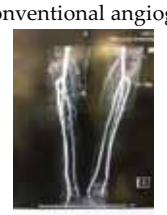
Fibula Free Flap

- Evaluation of lower extremity vasculature, recommended to assess disease precluding transfer
- MR angiography recommended and has replaced conventional angiography



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Fibula Free Flap Design

 M. Bak et al. / Oral Oncology 46 (2010) 71–76

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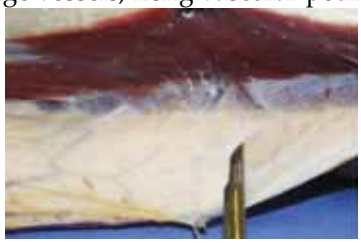
Fibula Free Flap Harvest

- Thin, pliable overlying skin
- Large vessels, Long vascular pedicle



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Fibula Free Flap Inset

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Fibula Free Flap - Limitations

- **Donor site morbidity:**
  - Delayed wound healing and skin graft loss
  - Peroneal tendon exposure
  - Knee/Ankle instability – Required to leave 6-8cm of bone
  - Pseudocompartment syndrome
- **Contraindications**
  - **Peripheral vascular disease**, venous insufficiency, previous deep vein thrombosis, congenital absence of lower leg vessels (rarely)
  - **Poor skin quality:** Obesity, stasis and ischemia
  - **Previous lower limb trauma:** Fractures, vascular injury

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State of the Art Mandibular Reconstruction

- Virtual Surgical Planning (VSP) with 3 Dimensional Cutting Guides

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VSP with 3 D Cutting Guides

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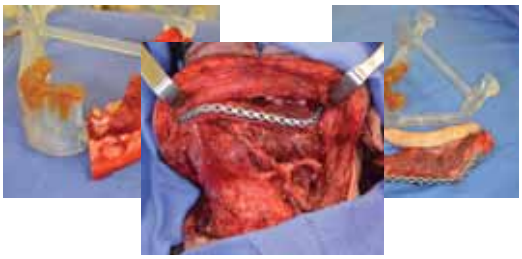
VSP with 3 D Cutting Guides



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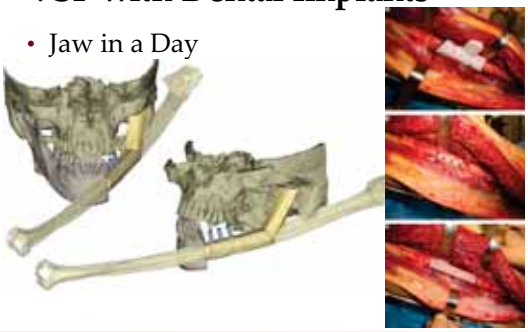
VSP with Dental Implants

- Jaw in a Day



 D.Pauchet J.,L.Pigot F.Chabolle C., A.Bach. Prefabricated fibula free flap with dental implants for mandibular reconstruction. European Annals of Otorhinolaryngology, Head and Neck Diseases. 2018

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VSP with Dental Implants

Disadvantages

- Very expensive
- Few insurances cover
- Requires oral

Surgery

- Not be practical for all

Patients

- Must consider life expectancy

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VSP vs Traditional Non-cutting guide Method

- 25 studies included in a Systematic Review
  - 12 VSP only
  - 13 Compared Traditional to VSP
  - 241 VSP patients and 214 traditional patients available for meta-analysis.

Findings in favor of VSP

- Significant reduction in operative time by 44.64 minutes
- Mean trend toward shorter hospital admission
- No statistical difference between cohorts for major or minor complications (odds ratio, 1.03; 95% CI, 0.46–2.31; $P = 0.95$)
- Did not perform cost comparison

 Barr, M et al. Virtual Surgical Planning for Mandibular Reconstruction With the Fibula Free Flap: A Systematic Review and Meta-analysis. Ann Plast Surg. 2020 Jan;84(1):117-122.

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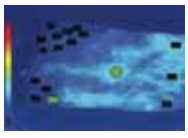
Mega Fibula Skin Paddle

- Improving fibula free flap soft tissue viability with Indocyanine Green Angiography (SPY ELITE ®)
  - Before ICGA – 33% skin necrosis rate
  - After ICGA – 8% skin necrosis rate
- Best used for larger skin paddles, X>200cm^2



 Beckler A. et al. Assessment of Fibula Flap Skin Perfusion in Patients Undergoing Oromandibular Reconstruction. JAMA FPRS. 2016. Nov-Dec;17(6):422-6.

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Mega Fibula Skin Paddle



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Conclusion

- Mandibular Reconstruction poses both functional and aesthetic challenges in head and neck reconstruction
- Several options exist, each with its own risks and benefits
- Metallic prostheses alone in tumor reconstruction are not recommended
- Free tissue transfer has been proven to be the most beneficial
- The fibula and Scapula free flaps have become the workhorses of mandible reconstruction
- But, there continues to be opportunities for improvement

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