LIMB SALVAGE SURGERY: IMAGING AND COMPLICATIONS

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Limb Salvage Surgery

- Describes surgical techniques that resect and reconstruct a limb with an acceptable oncologic, functional and cosmetic result.

- Today, 70-90% of extremity OGS treated with LSS
Limb Salvage Surgery

- **Indications:**
  - Adequate margins
  - Acceptable functional and cosmetic result

- **Relative contraindications:**
  - Pathologic fracture
  - Neurovascular encasement
  - Poorly placed biopsy tract
Indications:

* Adequate margins
* Acceptable functional and cosmetic result

* Important advancements in Chemo/XRT and surgical techniques

* Advent of accurate imaging techniques for defining extent (MRI)
Basic Noncontrast Sequences

T1

Fluid Sensitive: FS T2 / STIR
Spin Echo T1 weighting:
Most important sequence!
T1-weighted
Differentiate red marrow from tumor:

Red marrow greater signal than skeletal muscle
Differentiate red marrow from tumor:

Red marrow increased signal compared with adjacent Disk
CHEMICAL SHIFT IMAGING

T1 weighted in-phase & opposed-phase gradient echo

Sensitivity=85-95%, Specificity=80-95%

40 y.o. woman with back pain; unsuspected metastatic breast cancer
Limb Salvage Surgery

- **Indications:**
  - Adequate margins
  - Acceptable functional and cosmetic result

- **Relative contraindications:**
  - Pathologic fracture
  - Neurovascular encasement
  - Poorly placed biopsy tract
Outline

- Imaging techniques
- Surgical techniques
- Normal post-operative course
- Complications
Imaging Techniques for LSS

- Radiography
  - Routine in immediate post-op period
    - Documents hardware position
  - Serial radiographs
    - Monitor healing
    - Detect complications
89-y.o. woman with history of right bipolar hemiarthroplasty secondary to destructive lymphoma presenting with progressive pain, swelling, and inability to bear weight.

**PROTRUSION of acetabular component**

**Heterotopic bone**
Imaging Techniques for LSS

- MRI
  - Unparalleled contrast resolution. Therefore, ideal for detecting recurrence.
  - But, limited in presence of metal
Imaging Techniques for LSS

- MDCT
  - Streak artifacts — reduced by metal reduction techniques
- **MDCT**
  - Cross-sectional imaging:
    - Particle disease
## MDCT protocol

### TABLE I: Suggested 64-MDCT Protocols for the Postoperative Evaluation of Patients With Orthopedic Hardware

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Adults</th>
<th>Children and Adolescents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak voltage (kVp)</td>
<td>120–140</td>
<td>100–120</td>
</tr>
<tr>
<td>Tube charge (mA)</td>
<td>250–350</td>
<td>150–200</td>
</tr>
<tr>
<td>Rotation time (s)</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Detector collimation (mm)</td>
<td>0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>Slice thickness (mm)</td>
<td>0.75</td>
<td>0.75</td>
</tr>
<tr>
<td>Pitch</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>IV contrast</td>
<td>Optional</td>
<td>Optional</td>
</tr>
</tbody>
</table>

Imaging Techniques for LSS: MDCT

- Post-processing techniques
  - MPR
  - 3D CT (volume rendering)
Surgical Techniques for LSS

- Tumor excision + wide margin
- Reconstruction of surgical defect
Surgical Techniques for LSS

- Small resection cavity:
  - Autograft

- Large resection cavity (more commonly)
  - Allograft
  - Graft-prosthesis composite
  - Endoprosthesis
Autografts

- Autograft: tissue grafted into a new position in the body of the same individual

- Example: vascularized fibular graft
Often, allografts & endoprostheses are required because of the limited size and shape of autografts.

Potential for donor site morbidity.
Allografts

- Allograft: tissue obtained from a donor of the same species, but with a different genotype from the recipient.
- Typically, fresh deep-frozen cadaver grafts.
- Restore size and shape of original bone after tumor resection.
### Table 2: Advantages and Disadvantages of Allografts

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>The possibility of supporting mechanical loads and attaching host ligaments and muscles to the allografts</td>
<td>Host-donor junction complications due to lack of vascular supply</td>
</tr>
<tr>
<td>Grafts are readily available from tissue banks and can be matched to the size of the resected bone</td>
<td>Negative effects on the strength and elastic modulus of the graft due to processing techniques</td>
</tr>
<tr>
<td>Potential of allografts over synthetic materials for progressive incorporation into the host</td>
<td>Possible disease transmission</td>
</tr>
<tr>
<td>The possibility of supporting mechanical loads and attaching host ligaments and muscles to the allografts</td>
<td>Significant complication rate for infection, nonunion, late fractures, and progressive arthritis</td>
</tr>
</tbody>
</table>

Allograft: Types

- Intercalary Allograft
- Osteoarticular Allograft
- Graft-prosthesis Composites
Intercalary Allograft

- Tumor of diaphysis or metadiaphysis

Intercalary graft:
Preserves ends of bone

Combined with fibular graft to augment healing
2 years later: complete healing of allograft-host junction
**Allografts: Chronology of healing**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Timeline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Osseous density</td>
<td>Maximum at 15 weeks and gradually decreases to baseline levels at 100 weeks; diminished magnitude may indicate failure</td>
</tr>
<tr>
<td>Periosteal reaction</td>
<td>Maximum at 40 weeks after surgery; delayed peak may indicate failure</td>
</tr>
<tr>
<td>Callus formation at the host-donor junction site</td>
<td>Maximum at 40 weeks after surgery; diminished magnitude may indicate failure</td>
</tr>
<tr>
<td>Soft-tissue swelling</td>
<td>Maximum at 15–20 weeks after surgery; increased magnitude may indicate complications</td>
</tr>
<tr>
<td>Osseous union</td>
<td>Variable at 20–182 weeks after surgery</td>
</tr>
</tbody>
</table>

Intercalary allograft: Complications

- Delayed union/nonunion
- Infection
- Fracture

Nonunion
For reconstruction of one side of a joint

Accurate anatomic matching of size and shape between the host defect and the graft optimizes the functional life of the graft.
Osteoarticular allografts

- Or, replacement of location where prosthesis not readily available (ex: radius)
## Osteoarticular allografts

**TABLE 4: Chronology of Healing of Osteoarticular Allografts**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Timeline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Osseous density</td>
<td>Remains increased first 25 weeks after surgery, after which a gradual decrease may be observed with stabilization at approximately 2 years after surgery</td>
</tr>
<tr>
<td>Periosteal reaction</td>
<td>Maximum at 62–87 weeks after surgery</td>
</tr>
<tr>
<td>Callus formation at the host-donor junction site</td>
<td>Maximum at 60–80 weeks after surgery</td>
</tr>
<tr>
<td>Soft tissue swelling</td>
<td>Maximum at 15–25 weeks after surgery</td>
</tr>
<tr>
<td>Bone resorption</td>
<td>Pronounced and increasing until 7–10 weeks after surgery</td>
</tr>
<tr>
<td>Osseous union</td>
<td>Maximum at 40–50 weeks after surgery</td>
</tr>
<tr>
<td>Joint space narrowing</td>
<td>Beginning to occur 3–4 years after surgery</td>
</tr>
</tbody>
</table>

Osteoarticular allografts: Complications

- Delayed union/nonunion
- Bone graft fractures
- Infection
- Cartilage degeneration
- Joint instability

*up to 70% complication*


Allograft does not need to be perfectly size-matched to the host bone.

Allografts provide tendinous attachments for reconstructions of the extensor mechanism in the knee, the rotator cuff in the shoulder, or the abductor muscles in the hip.
Prosthesis cemented into segmental allograft
Graft–prosthesis Composites: Complications

- Bone graft fracture
- Nonunion
- Infection

Fracture
Endoprosthesis

- Megaprosthesis: large metallic device designed to replace the excised length of bone and the adjacent joint
Modular endoprostheses for limb salvage surgery permit reconstruction of a wide variety of defects using standard components, as opposed to expensive custom implants.

Prostheses are assembled intra-operatively and provide flexibility for the margin of tumor resection.

May be expanded when used for reconstruction in skeletally immature patients.
Saddle prosthesis: (Periacetabular tumors)

- Establishes a stable and mobile articulation between the femur and a partially resected pelvis.
Pelvic chondrosarcoma
For diaphyseal lesions that extend proximally to the lesser trochanter and distally to the distal diaphysis-metaphysis junction.
Skeletally immature: Extendable prosthesis

- Maintenance of limb length after resection
- Cope with child’s functional/recreational demands
12y.o. OGS

- Expandable part of the stem
- Expansion mechanism
- Axial pin fixing femoral and tibial components
- Tibial component

- Expansion mechanism
- Axial pin fixing femoral and tibial components
- Femoral component
- Tibial component
Endoprosthesis: Complications

- Infection
- Implant dislocation
- Mechanical failure
- Aseptic loosening
- Instability
- Tumor progression/recurrence
Aseptic loosening
Aseptic loosening?
Recurrence
Recurrence
Recurrence
Conclusion

- Limb salvage surgery: the standard of care for sarcomas
- Reviewed surgical techniques
- Post-surgical imaging: important to management
Thank you!

Questions?

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