Putting humpty dumpty back together again… is easier with tissue allografts!

Limb Salvage Surgery for Bone Tumors
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Disclosure Information
Edward Cheng, MD
October 6, 2011

- Disclosure of Relevant Financial Relationships
  I have the following financial relationships to disclose:
  - Honoraria from MTF

- Disclosure of Off-Label and/or Investigative Uses
  I will not discuss off-label use and/or investigational use in my presentation.

Objectives
1. To understand the recipient benefits of tissue donation
2. To understand how tissue allografts are used, with or without joint replacements, to surgically reconstruct limbs
3. To appreciate the functional outcome that is facilitated by a tissue allograft
4. To describe the uses of allograft tissue to a donor family

Limb salvage surgery
Trauma – mangled limb
Tumor resection

Age distribution – soft tissue sarcomas
- No particular age distribution for soft tissue sarcoma
- Rhabdomyosarcoma is the most common STS in childhood
- Among all childhood cancers, rhabdomyosarcoma is the most common

Age distribution – bone cancer
- Osteosarcoma is the most common STS in adolescence
- Ewing’s sarcoma is the second most common bone sarcoma
1993 NCI SEER statistics

Pre 1970’s

- Osteosarcoma: routinely treated with amputation

Edward "Ted" Kennedy, Jr.

- 1973
  - "When I was 12-years-old," Ted Jr. says, "I discovered a lump right below my kneecap. When I told my parents about it they took me to a pediatrician who said it was probably just a calcium deposit and to soak it in Epsom salts for a few weeks and come back."
  - But Ted Jr. knew something was drastically wrong. Skateboarding one afternoon, he fell and hit his leg on a curb. "The pain lasted for an abnormal period of time, and I told my parents we’d better check this thing out," he says. The examination revealed a tumor, and a biopsy revealed a malignancy. His leg was amputated above the knee the very next day.

2003

- 80 - 85% pts w/ osteosarcoma, Ewing’s sarcoma, & chondrosarcoma undergo limb salvage surgery after wide excision of their tumor
  
  J Am Acad Orthop Surg 2003

Advances that facilitated limb salvage

- Imaging
  - Anatomic (MRI)
  - Functional (CT-PET)
- earlier diagnosis
- chemotherapy
- Technical
  - intraop imaging, virtual imaging, navigation, RFA
- allografts
  - procurement, donor awareness, processing
- prosthesis design
  - growing expandable prostheses
Radiofrequency ablation

Osteoid osteoma

What we can/cannot replace

• Bone
  – Structural stability
• Joints
• Skin
  – Myocutaneous flaps, local free vascularized
• Arteries
  – Vascular interpositional grafts
• Motor control: muscle – tendon unit
• Veins/lymphatics
• Nerves

Guiding principles – Criteria for limb salvage

• Survivorship should be same with either limb salvage or amputation
  – Primary objective: remove tumor completely
• Local control surgery should not delay adjuvant chemotherapy
• Reconstruction should be reliable and durable enough to provide reasonable QOL
• Function after limb salvage should be similar or better than after amputation

Contraindications

• Infection
• Tumor involving major nerves
• Pathologic fracture
• Biopsy contamination
• Local recurrence

Amputation?
Prosthetic design

Ambrose Pare, c 1575

Reasonable reconstructive option?

Congenital Lymphangiomatosis
Post radiation necrosis, chronic lymphedema

Types of reconstructions

- Dependent upon:
  - Anatomic site
  - Amount of tissue resected
  - Age
  - Joint involvement
  - Patient preferences/functional expectations
  - Surgeon experience
  - Availability of devices/grafts
  - Cultural issues (allografts)

Limb Salvage - diaphysis

Limb Salvage - joint

endoprosthesis

- Pros
  - Faster rehab
  - Available bearings
  - Lower short term complication rate
  - Infection
  - Fracture

- Cons
  - Requires resection of both sides of joint
  - Poor tendon attachment
  - Non-biologic
  - Higher long term complication rate
  - Loosening
  - Wear of bearing/hinge
  - Function declines over time
### allografts

**Pros**
- Superior tendon attachment
- Preserves opposing joint surface
- Function improves over time
- Biologic

**Cons**
- Higher short term complication rate
- Non-union
- Infection
- Less reliable
- Fracture risk
- Limited availability
- Disease transmission

### Allograft – prosthetic composites (APC)

**Pros**
- Superior tendon attachment
- Biologic
- Faster rehab
- Lower fracture risk

**Cons**
- Technically demanding
- Allograft availability
- Expensive
- Difficult to revise
- Disease transmission

### Shoulder joint

- Deltoid intact
  - Osteoarticular or APC glenohumeral reconstruction
- Deltoid absent
  - Tikhoff-Linberg
  - Allograft arthrodesis

### Osteoarticular allograft

Chondrosarcoma

3 yrs post-op

### Tikhoff-Linberg: intercalary scapulo-humeral resection

Tikhoff-Linberg Procedure for Tumors of Scapula and Proximal Humerus

- Allows reattachment of rotator cuff tendons
- Custom length
- Implant provides fixation and strengthens allograft
- Prosthetic articulation better than allograft cartilage articular surface

### Proximal humeral APC

Proximal humeral APC

Allograft
Humeral diaphysis: intercalary allograft

70 F, Ewing’s sarcoma, 6 yrs post-op

Shoulder fusion: allograft arthrodesis

Shoulder fusion: allograft arthrodesis

Distal Radius: osteoarticular allograft

Distal Radius: osteoarticular allograft

Giant Cell Tumor

Proximal Femur - APC

Proximal Femur - APC

Prox Femur: APC

Prox Femur: APC

Giant Cell Tumor

Proximal Femur - APC

Giant Cell Tumor

Femoral diaphysis – intercalary allograft

Femoral diaphysis – intercalary allograft

25 M, osteosarcoma, non-displaced path fx
Distal Femur – rotating hinge knee prosthesis

Rotating hinge knee prosthesis

Distal Femur: osteoarticular allograft

Distal Femur - arthrodesis

Knee arthrodesis

Proximal Tibia OSA

44 M, s/p ACL reconstruction, Leiomyosarcoma

Osteosarcoma, quadriceps excision

gastrocnemius muscle flap
Loose TKA in the allograft… revision to long stem

Van Ness Rotationplasty

- Indications
  - Young child w/ significant growth remaining
  - Intact sciatic nerve
  - Extensive soft tissue resection, eg, path fx
  - Salvage after failed reconstruction

Van Ness Rotationplasty

- Advantages
  - Maintenance of growth
  - Custom tailor limb length
  - Functioning "knee" joint → energy efficient gait
  - Foot is optimal prosthetic bearing stump
  - Avoids soft tissue neuromas, phantom limb pain

Distal femoral osteosarcoma

Rotationplasty – functional outcome

- Austrian study
- 40 pts, 30 > 3 yr f/u
- All independent ambulators
- MSTS evaluation:
  - 68% excellent, 28.5% good, 3.5% fair

## Summary

- Amputation avoidable in most patients
- Medical advances responsible for improvements in limb salvage surgery
- Criteria for limb salvage
- Type of reconstruction
- Anatomical considerations
- What can and cannot be reconstructed
- Rotationplasty

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**Goal:** Surgeons strive to achieve what all the king’s horses and all the king’s men couldn’t do!

*Your role with tissue allografts is crucial and enables this goal!*