

Lower Extremity Amputations Secondary to Trauma

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Original Authors: Douglas G. Smith; March 2004; Steven A. Olson; March 2007;
Daniel J. Stinner; 2011; Lisa K. Cannada; 2015



What is an amputation?

“Sometimes the extremities become gangrenous...you must cut off that limb as far as the disease has spread, so that the patient may escape death or greater affliction, greater than the loss of the limb.”

Albucasis, c. A.D. 1000



Kirkup J. Interpretations of Amputation by Society, Patients and Surgeons. In: Kirkup J. A History of Limb Amputation. London: Springer –Verlag, 2007: 96–109

Moving forward

Benjamin Bell (1796)

- **bad compound fractures, extensive lacerations or contusions**



History of lower limb reconstruction after trauma. Wagels M; Rowe D; Senewiratne S; Theile DR. ANZ Journal of Surgery. 83(5):348-53, 2013 May.

Increased use

US Civil War

- **53% amputation rate for severe LE trauma**
- **40% mortality rate associated with amputation**



History of lower limb reconstruction after trauma. Wagels M; Rowe D; Senewiratne S; Theile DR.
ANZ Journal of Surgery. 83(5):348-53, 2013 May.

Debridement

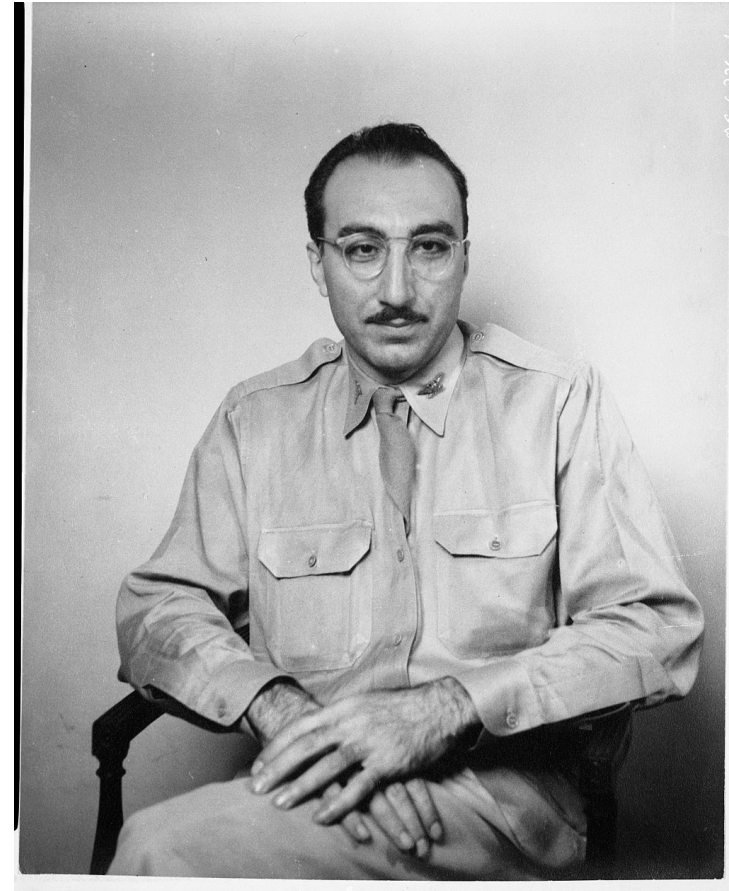
- Described as early as 3000 BC
- Championed by Pierre-Joseph Desault during the French Revolution
- Expanded and mainstreamed by Dominique Jean Larrey
- Modernized by Reyher



Reyher

Modern era

- **Anesthesia**
- **Antisepsis**
- **Antibiotics**
- **Vascular surgery**
- **Debridement**



Battle injuries of the arteries in World War II; an analysis of 2,471 cases. DeBakey ME; Simeone FA. *Annals of Surgery*. 123:534-79, 1946 Apr.

Principles in the management of arterial injuries associated with fracture/dislocations. Sher MH. *Annals of Surgery*. 182(5):630-4, 1975 Nov.

OVERVIEW

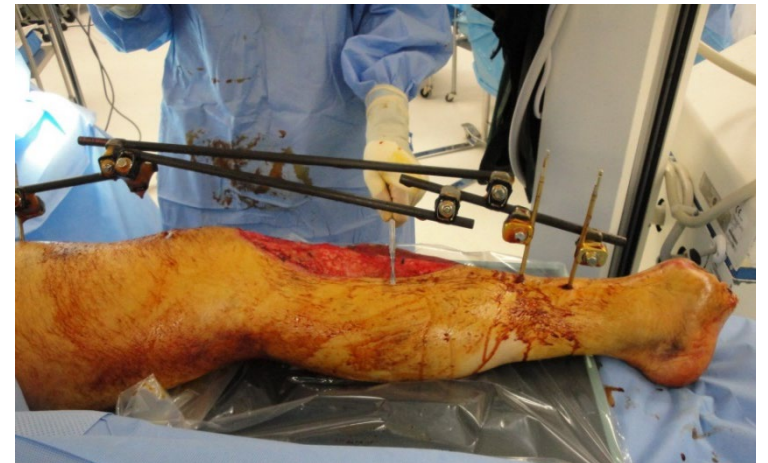
- **Amputation Decisions**
 - Indication
 - Level
- **Amputation Technique**
 - Below Knee Amputation (BKA)
 - Above Knee Amputation (AKA)
 - Knee Disarticulation (KD)
- **Amputation Postop Care**
 - Pain Control
 - Rehab
 - Prosthetic Selection





Who to Amputate?

- Sometimes the answer is obvious
- Other times things are less clear, at least initially



Amputation versus limb salvage

- **Do the outcomes matter if we decide to amputate?**
- **LEAP data**
 - **No difference in Sickness Impact Profile (SIP) in prospective cohort study**
 - **More related directly to educational level of patient**



Bosse MJ, MacKenzie EJ, Kellam JF, et al. An analysis of outcomes of reconstruction or amputation after leg-threatening injuries. *New Engl J Med.* 2002;347:1924-1931

Who to amputate?

- **Scoring system? – none are predictive**
 - **MESS**
 - **NISSS**
 - **Others**
- **Plantar Sensation? - Not helpful as an indication for amputation**



Bosse

Bosse MJ, MacKenzie EJ, Kellam JF, et al. An analysis of outcomes of reconstruction or amputation after leg-threatening injuries. *New Engl J Med.* 2002;347:1924-1931

Bosse MJ, MacKenzie EJ, Kellam JF, et al.. A prospective evaluation of the clinical utility of the lower-extremity injury-severity scores. *JBJS Am.* 2001; 83: 3-14

Who to amputate? Occupation?

- **Civilian-LEAP**
 - **Equivalent**
- **Military-METALS**
 - **Favors Amputation**



Mazurek

The Military Extremity Trauma Amputation/Limb Salvage (METALS) study: outcomes of amputation versus limb salvage following major lower-extremity trauma. Doukas WC; Mazurek MT; et al. JBS (AM) January 16, 2013 - Vol 95(2), p 138-145

Influence of Immediate and Delayed Lower-Limb Amputation Compared with Lower-Limb Salvage on Functional and Mental Health Outcomes Post-Rehabilitation in the U.K. Military. Ladlow P; Phillip R; Coppack R; et al. JBS (AM). 98(23):1996-2005, 2016 Dec 07.

Things to consider

- **Vascularity**
- **Compartment Syndrome**
- **Amount of muscle damage**
- **Ipsilateral associated injuries**



Meta-analysis of prognostic factors for amputation following surgical repair of lower extremity vascular trauma.
Perkins ZB; Yet B; Glasgow S; Cole E; Marsh W; Brohi K; Rasmussen TE; Tai NR.
British Journal of Surgery. 102(5):436-50, 2015 Apr.



Things to consider

Patient resuscitation (Stability?)

- **High ISS-esp. proximal injury**
- **Transfusion requirements**
- **Bilateral injury**
- **Mechanism**

Acute bilateral leg amputation following combat injury in UK servicemen. Penn-Barwell JG; Bennett PM; Kay A; Sargeant ID; Severe Lower Extremity Combat Trauma (SeLECT) Study Group. Injury. 45(7):1105-10, 2014 Jul.



Things to consider

- **Local capability**
 - **Military**
 - Limited blood products
 - Holding capacity
 - Vascular repair
 - **Smaller civilian hospital**
 - Same as above
 - Critical care team?



Healthcare Cost

- **Amputation**
 - Requires less surgery
 - Quicker return to function
- **Limb Salvage**
 - Cheaper
 - More reoperations
 - Lower functional outcome



Health-care costs associated with amputation or reconstruction of a limb-threatening injury. MacKenzie EJ; Jones AS; Bosse MJ; et al. Journal of Bone & Joint Surgery - American Volume. 89(8):1685-92, 2007 Aug.



Financial Cost of Amputation

- **Lost work time**
 - **14-30 months recovery**
- **Patient's Occupation**
 - **Retraining commonly required**
- **50-60% return to work**

Livingston DH, Keenan D, Kim D, Elcavage J, Malangoni MA. Extent of disability following traumatic extremity amputation. *J Trauma* 1994; 37: 495–499.

Early predictors of long-term work disability after major limb trauma. MacKenzie EJ; Bosse MJ; Kellam JF; et al. *JTICC*, 61(3):688-94, 2006 Sep.



Religious Concerns

- **Religious opposition to amputation**
- **Amputated limbs**
 - **burial**



Amputation and Non-Functioning Limb Salvage: Cultural Stigma of Limb Loss. Adi Syazni Muhammed, MBBS
BSc, Ramesh Kumar, MD, FRCS, et al. Bahrain Med Bull 2017; 39(2): 116 – 119



What does the patient want?

- **When in doubt, ask the patient, or the family**
- **Give them the options and the possible outcomes**
- **Guide the discussion**
- **Don't make the decision**



Timing

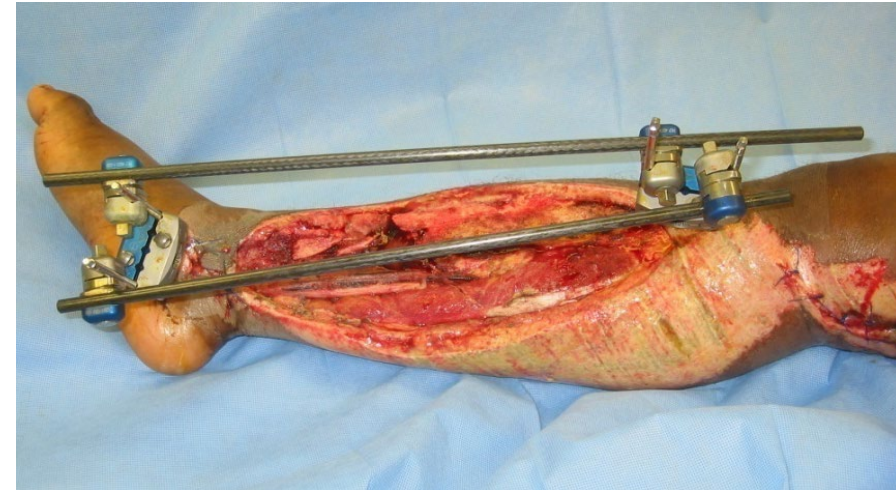
- **Resuscitated patient**
 - **Higher ISS and MESS associated with amputation in theater**
- **Informed patient and family**



Predictors and timing of amputations in military lower extremity trauma with arterial injury. Kauvar DS; Thomas SB; Schechtman DW; Walters TJ. JTACS. 87(1S Suppl 1):S172-S177, 2019 07.

Delayed Amputation

- **No functional differences between early and delayed amputation**
- **No Psych differences**
- **No pain differences**
- **Increase in complications/LOS**



Influence of Immediate and Delayed Lower-Limb Amputation Compared with Lower-Limb Salvage on Functional and Mental Health Outcomes Post-Rehabilitation in the U.K. Military. Ladlow P; Phillip R; et al. JBJS-AM. 2016, DEC. 98(23):p1996-2005



Early versus delayed amputation in the setting of severe lower extremity trauma. Williams ZF; Bools LM; Adams A; Clancy TV; Hope WW. American Surgeon. 81(6):564-8, 2015 Jun.

Core Curriculum V5

Delayed Amputation

- Infection often the reason for late amputation
- Outcomes similar to early amputation
 - SIP
 - SF-36



The Military Orthopedic Trauma Registry: The potential of a specialty specific process improvement tool. Rivera JC; Greer RM; Spott MA; Johnson AE. J Trauma/Acute Care Surgery. 81(5 Suppl 2):S100-S103, 2016 11.

Functional and psychological outcomes of delayed lower limb amputation following failed lower limb reconstruction. van der Merwe L; Birkholtz F; Tetsworth K; Hohmann E. Injury. 47(8):1756-60, 2016 Aug.

Risk Factors for and Results of Late or Delayed Amputation Following Combat-related Extremity Injuries
CPT Melvin D. Helgeson, MD; MAJ Benjamin K. Potter, MD; et al. Orthopedics. 2010;33(9) **Core Curriculum V5**

Preoperative planning

- **Perioperative pain control**
- **Level selection**
- **Timing of wound closure**





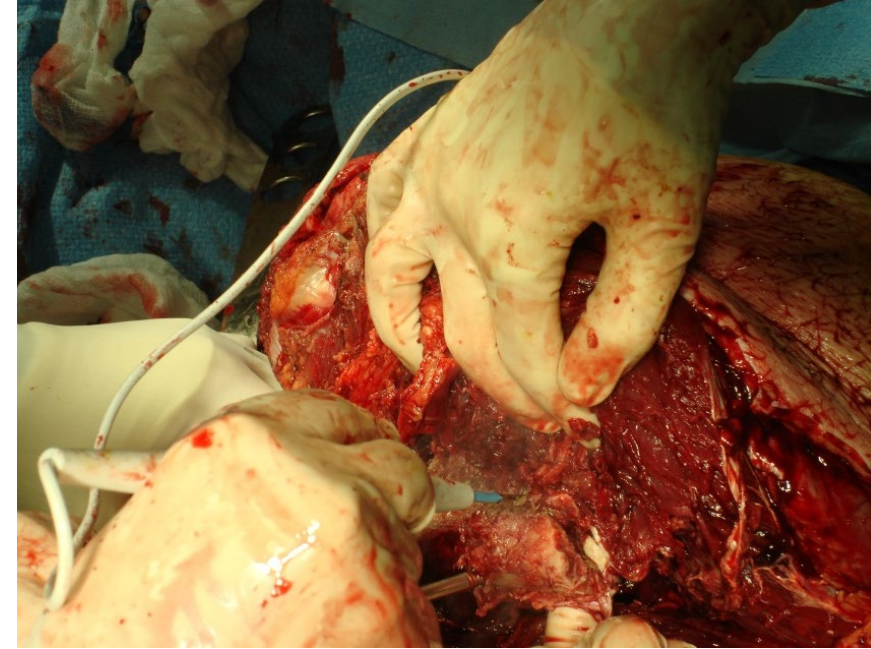
Pain Control

- **Think about it before surgery**
- **Peripheral nerve catheter**
- **Multimodal pain control**
 - **Gabapentin**
 - **NSAID's**

The Use of Prolonged Peripheral Neural Blockade After Lower Extremity Amputation: The Effect on Symptoms Associated with Phantom Limb Syndrome. Borghi, Battista MD +; D'Addabbo, Marco MD et al. *Anesthesia & Analgesia*. 111(5):1308-1315, November 2010.

Debridement

- **Removal of all nonviable tissue**
- **Decrease potential for infection**
- **Leave behind tissue with highest healing potential**
- **Systematic**
- **Repeated (esp higher energy such as blast or crush)**



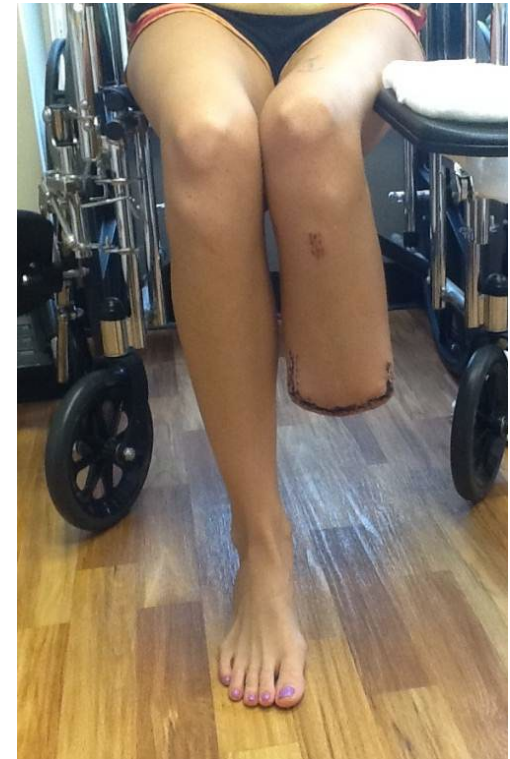
Level Selection

- **Bone length**
- **Skin coverage**
- **Muscle cover/function**



Level Selection (Trans Tibia (TTA) vs Trans Femoral (TFA))

- **No significant functional or outcome differences depending upon the level**
- **No difference in relative energy cost (percent of maximum capacity) for walking**
- **Decreased cadence associated with amputation level**

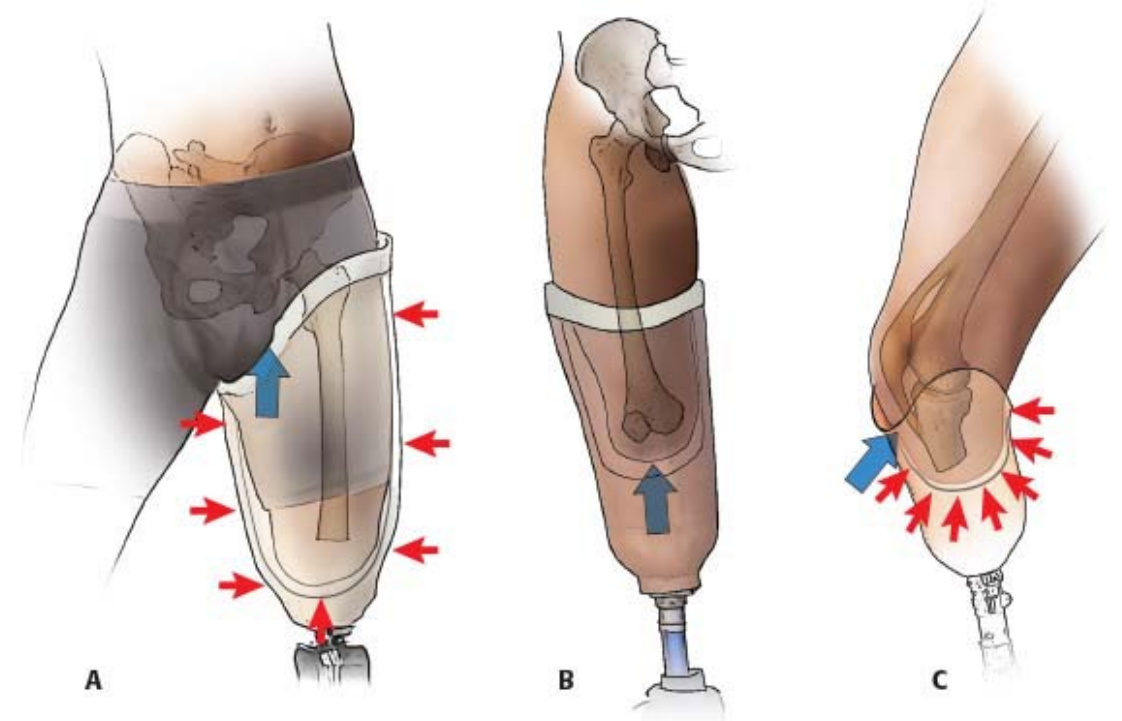


Waters, RL, Perry, J, Antonelli, D, Hislop, H Energy cost of walking of amputees: The influence of level of amputation. *J Bone Joint Surg Am* 1976;58(1):42–46

Goktepe AS, Cakir B, Yilmaz B, et al. Energy expenditure of walking with prostheses: comparison of three amputation levels. *Prosthetics Orthot Int.* 2010;34:31-36

TFA vs Knee Disarticulation (KD)

- **No increase in disability rating**
- **No difference in totally disabled**
- **Psych Issues**
- **No difference in functional outcomes**
- **Decreased pain in KD**



Rockwood and Green 9th ed., Pg 667, Fig 20-1

Characterization of disability following traumatic through knee and transfemoral amputations. Tennent DJ; Polfer EM; Sgromolo NM; Krueger CA; Potter BK. *Injury*. 49(6):1193-1196, 2018 Jun.

Knee Disarticulations Versus Transfemoral Amputations: Functional Outcomes. Polfer EM; Hoyt BW; Bevevino AJ; Forsberg JA; Potter BK. *Journal of Orthopaedic Trauma*. 33(6):308-311, 2019 Jun.

TFA Length

- **No difference in gait or VO2 max with 56% of uninjured limb length as cutoff between short and long TFA**
- **Self selected walking speed slightly faster in longer TFA**

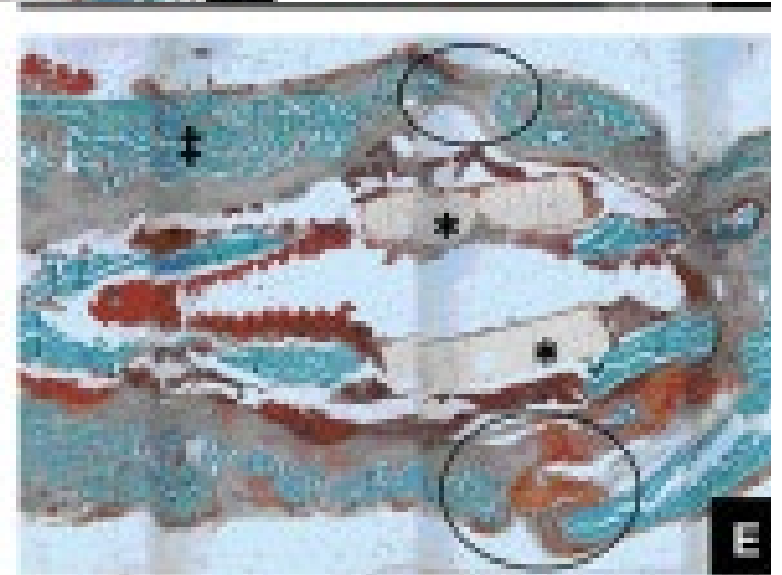
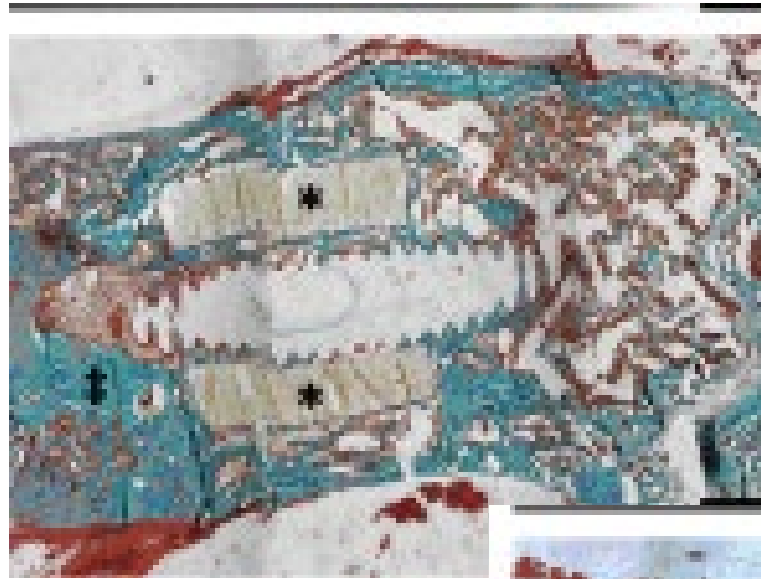


Slide Picture Reference 1

Bell JC, Wolf EJ, Schnall BL, et al. Transfemoral amputations: is there an effect of residual limb length and orientation on energy expenditure? Clin Orthop Relat Res. 2014;472:3055-3061

Bone Slice Culture

- **Attempt to evaluate residual infection**
- **Used slice of bone at surgery**
- **Guide antibiotic treatment**

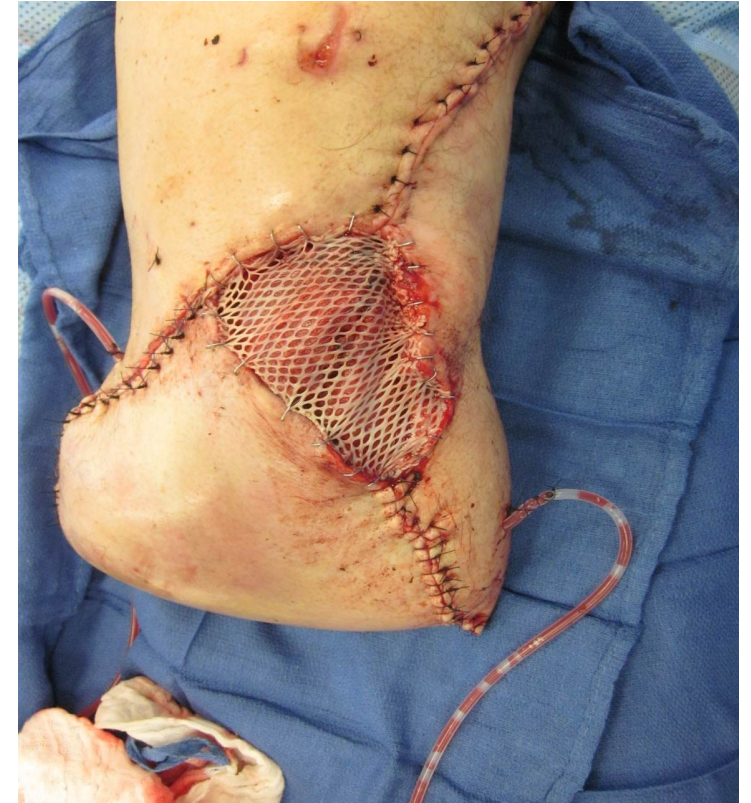


Slide Picture Reference 2

Major amputation of lower extremity: prognostic value of positive bone biopsy cultures. Vaznaisiene D; Beltrand E; Laiskonis AP; Yazdanpanah Y; Migaud H; Senneville E. Orthopaedics & traumatology, surgery & research. 99(1):88-93, 2013 Feb.

Coverage

- STSG ok if muscle below
- Tissue expanders to increase coverage
- Negative pressure wound therapy
- Dermal regenerate
- Free Flap



Use of tissue expansion in revision of unhealed below-knee amputation stumps. Watier E, Georgieu N, Manise O, et al. *Scand J Plast Reconstr Surg Hand Surg*. 2001; 35: 193-196



Application of the orthoplastic reconstructive ladder to preserve lower extremity amputation length.

Fleming ME; O'Daniel A; Bharmal H; Valerio I. *Annals of Plastic Surgery*. 73(2):183-9, 2014 Aug. **Core Curriculum V5**

Coverage in the Zone of Injury

- **LEAP Data**
 - **87 Rotational Flaps**
 - **107 Free Flaps**
 - **Fracture**



Bosse

Filet flap

- **Waste not want not**
 - **Anterior coverage**
 - **Distal coverage**
 - **Heel pad skin**
 - **Increased durability**



Slide Picture Reference 3

Pedicled sensate composite calcaneal flap to achieve full weight-bearing surface in midshaft leg amputations: case report. Livani B; de Castro GF; et al. *Journal of Reconstructive Microsurgery*. 27(1):63-6, 2011 Jan.

Osteocutaneous pedicle flap transfer for salvage of transtibial amputation after severe lower-extremity injury. Vallier HA; Fitzgerald SJ; Beddow ME; Sontich JK; Patterson BM. *JBJS (AM)* Volume. 94(5):447-54, 2012 Mar 07.

Skin Grafting

- **CONS**

- Requires Blood Supply
- Poor flexibility
- Donor Site Issues

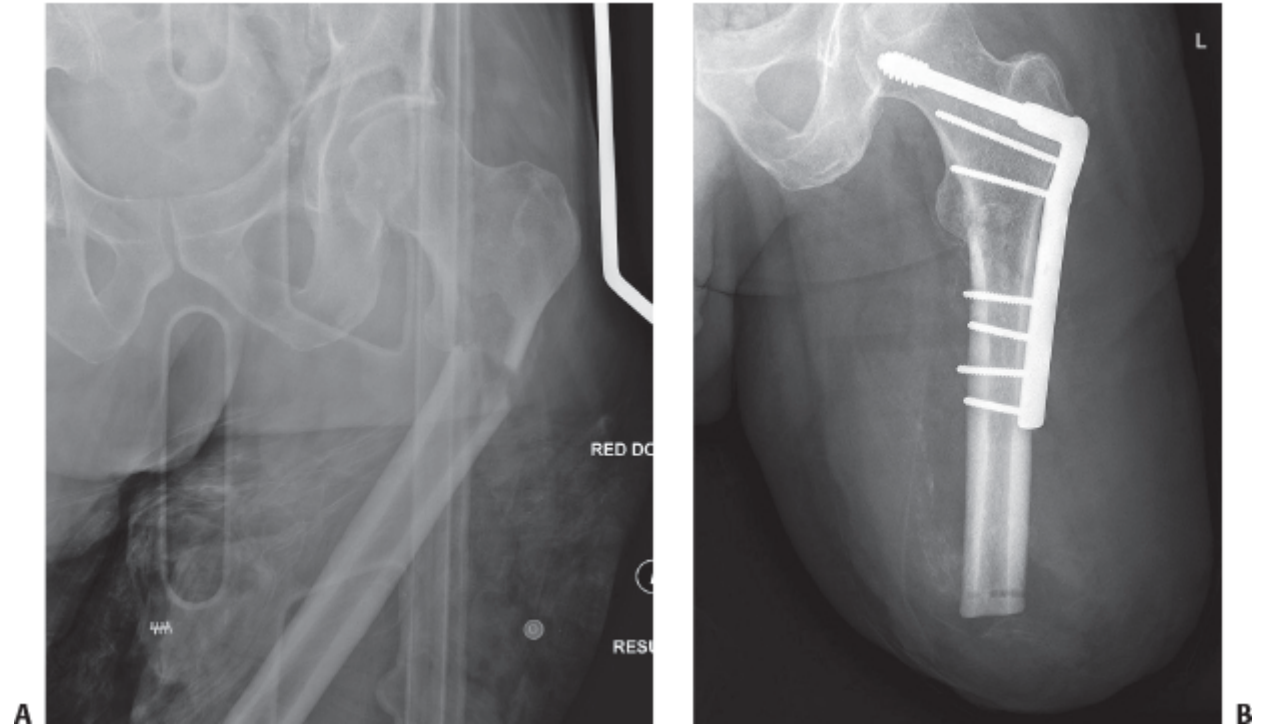
- **PROS**

- Readily available
- Easy to perform



Length Preservation

- **Fix a fracture**
 - **Expect complications**
- **Bone transport**

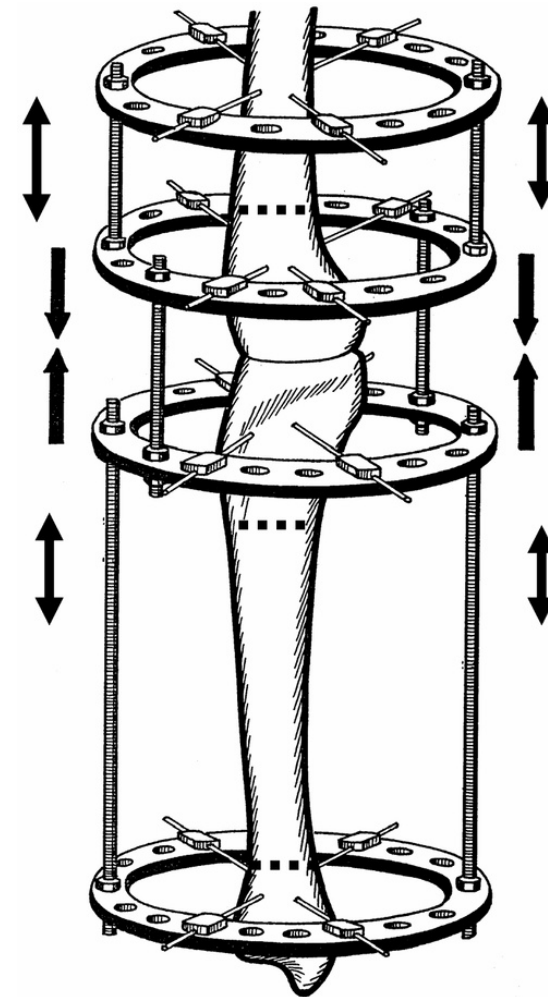


Rockwood and Green 9th ed., Pg 670, Fig 20-5

Gordon WT, O'Brien FP, Strauss JE, et al. Outcomes associated with the internal fixation of long-bone fractures proximal to traumatic amputations. *J Bone Joint Surg Am.* 2010; 92: 2312-2318

Length Preservation

- **Fix a fracture**
 - **Expect complications**
- **Bone Transport**
 - **Expect complications**
 - **Simultaneous soft tissue and bone expansion**
 - **Slow distraction**

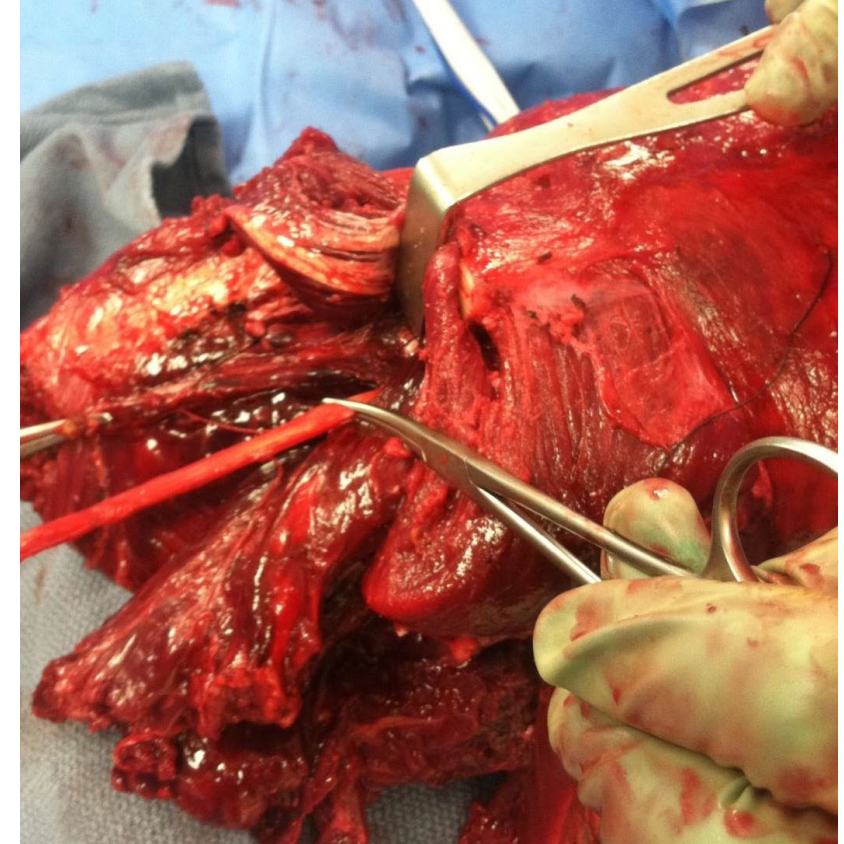


Slide Picture Reference 4

Lengthening of a below knee amputation stump with Ilizarov technique in a patient with a mangled leg. Toon DH; Khan SA; Wong KHY. Chinese Journal of Traumatology. 22(6):364-367, 2019 Dec.

Amputation Technique

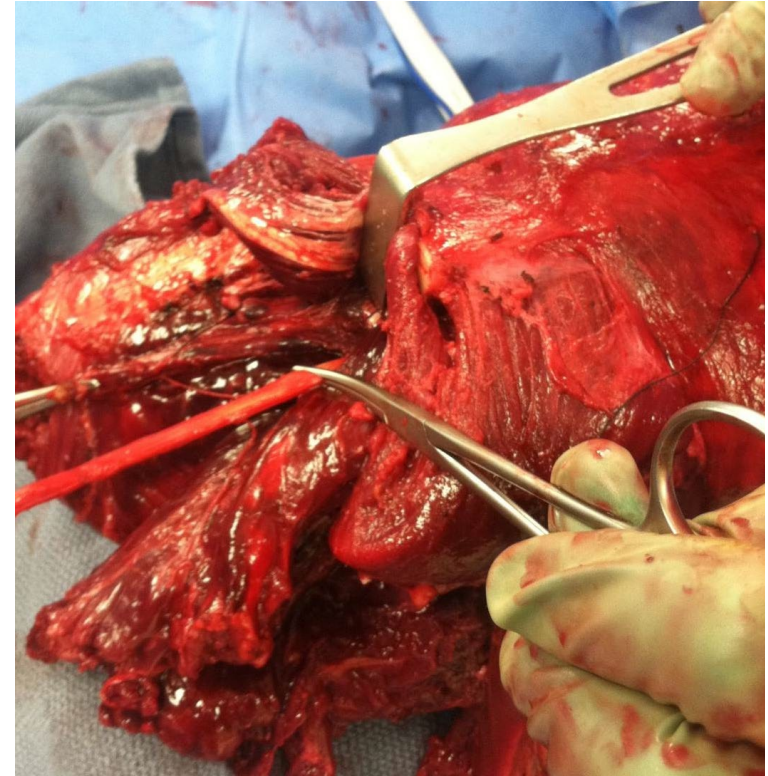
- **Nerve management**
 - **Traction (gentle)**
 - **Local insufflation (maybe)**
 - **Sharp transection (definitely)**
 - **Location (end of flap vs back of knee for sural)**



Proximal sural traction neurectomy during transtibial amputations. Tintle SM; Donohue MA; Shawen S; Forsberg JA; Potter BK. Journal of Orthopaedic Trauma. 26(2):123-6, 2012 Feb

Nerve Management

- **Targeted Nerve Implantation (primary)**
- **Neuroma Excision (revision)**



Does Targeted Nerve Implantation Reduce Neuroma Pain in Amputees? Mitchell A. Pet, MD, Jason H. Ko, MD, Janna L. Friedly, MD, Pierre D. Mourad, PhD, and Douglas G. Smith, MD. Clin Orthop Relat Res. 2014 Oct; 472(10): 2991–3001.

Wound Closure

- **Timing**
- **Drain**



Delayed Closure Is Associated with Decreased Infection Rate in Amputations after Trauma.
Ali Y; Halvorson J; Nunn A; Miller P. American Surgeon. 85(5):501-504, 2019 May 01.

Primary vs delayed primary closure in patients undergoing lower limb amputation following trauma: A randomised control study. Katiyar, AK, Agarwal H, et al; International Wound Journal. 17(2):419-428, April 2020.

Healing adjuncts

- **Topical antibiotics**
- **Incisional wound Negative Pressure Wound Therapy**



Slide Picture Reference 5

Intrawound Antibiotic Powder Decreases Frequency of Deep Infection and Severity of Heterotopic Ossification in Combat Lower Extremity Amputations Pavey, GJ; Formby, PM; et al. CORR: April 2019, 477(4) p 802-810

Incisional Application of Negative Pressure for Nontraumatic Lower Extremity Amputations: A Review Vikas Kotha 1, Elliot Walter 2, Gregory Stimac 3, Paul Kim. Review Surg Technol Int. 2019 May 15;34:49-55.

Postop-General

- Splint
- Elevation
- Rehab
- Early mobility



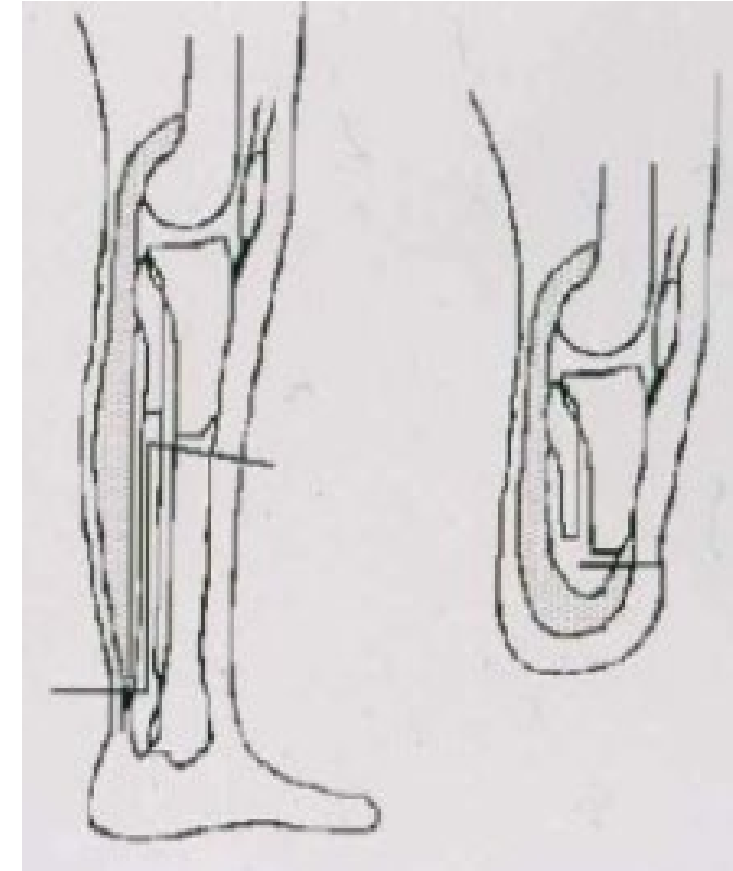
Postoperative dressing and management strategies for transtibial amputations: a critical review. Smith DG; McFarland LV; Sangeorzan BJ; Reiber GE; Czerniecki JM. *Journal of Rehabilitation Research & Development*. 40(3):213-24, 2003 May-Jun.

Clinical Practice Guidelines for the Rehabilitation of Lower Limb Amputation: An Update from the Department of Veterans Affairs and Department of Defense. Webster, Joseph B. MD; Crunkhorn, Andrea DPT; et al; American Journal of Physical Medicine & Rehabilitation. 98(9):820-829, September 2019.

TTA/Below Knee Amputation Technique

- **Ideal Situation**

- **Long posterior flap (Burgess)**
- **At least 2cm longer than the diameter of the leg at planned amputation level**
- **Mark medial and lateral before incision**





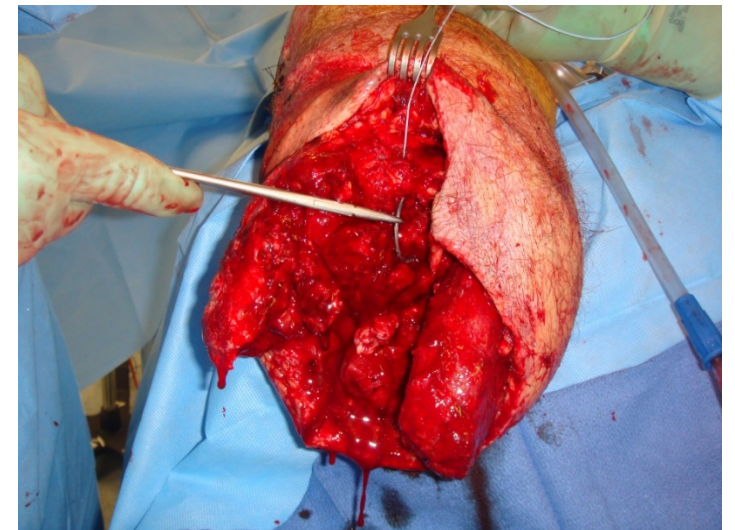
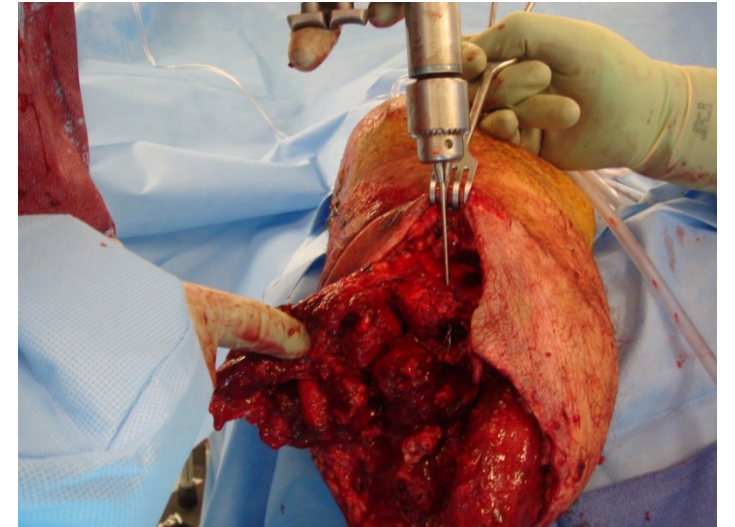
TTA/BKA Technique

- **Cut and bevel tibia**
- **Cut fibula 1-2cm proximal to tibial cut**
- **Ensure no sharp edges**

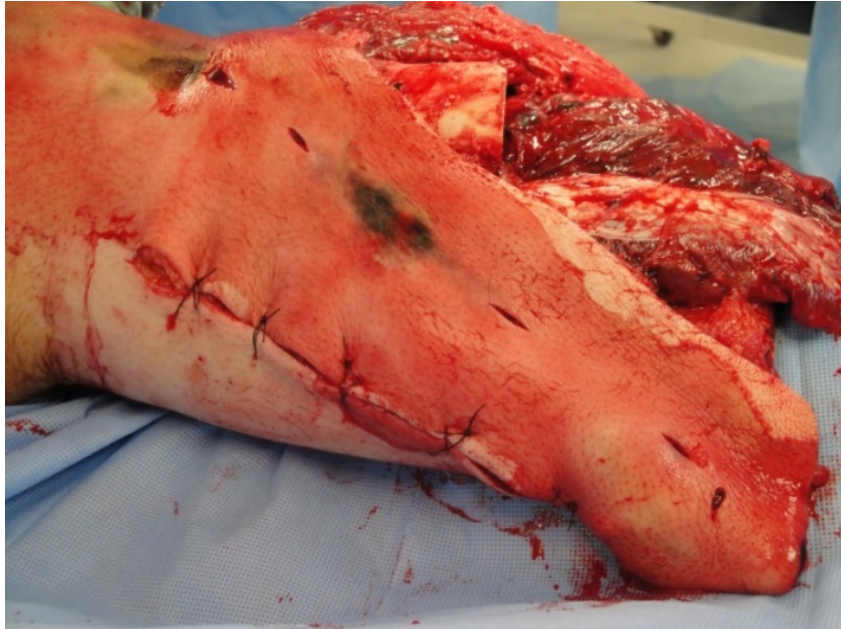
Talving, P., Varga, S., & Lee, J. (2015). Lower extremity amputations. In D. Demetriades, K. Inaba, & G. Velmahos (Eds.), *Atlas of Surgical Techniques in Trauma* (pp. 314-322). Cambridge: Cambridge University Press.

TTA/BKA Technique

- **Myodesis of gastroc or gastroc soleus to tibia**
 - Drill holes in tibia
 - Large braided polyester suture
 - Secure muscle to tibia
 - Padding
 - Function



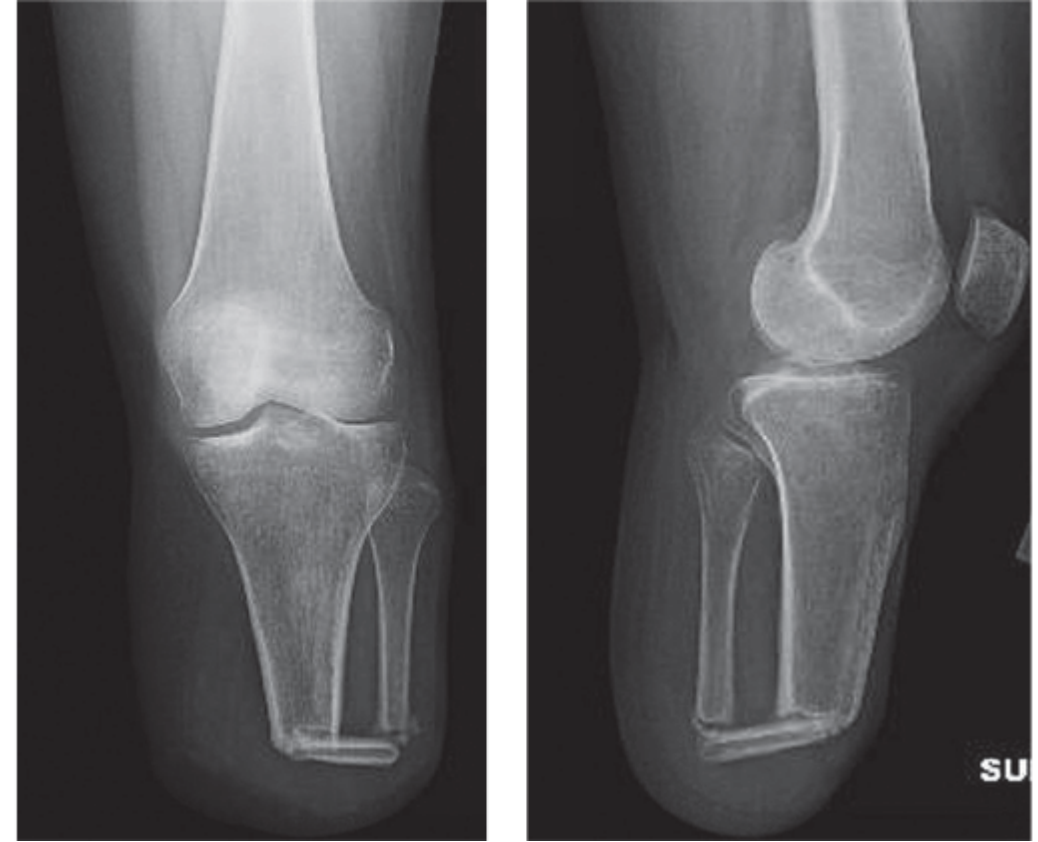
The reality



Design of skin flaps for skew flap below-knee amputation. (Modified from Robinson K. Vascular surgical techniques. Philadelphia: WB Saunders, 1989.)

To Ertl or not to Ertl?

- **Bone bridging transtibial amputation**
- **Bone or bone and periosteal hinge swung onto tibia from fibula**
- **An Osteoplasty Originated in 1920's by Janos Ertl**



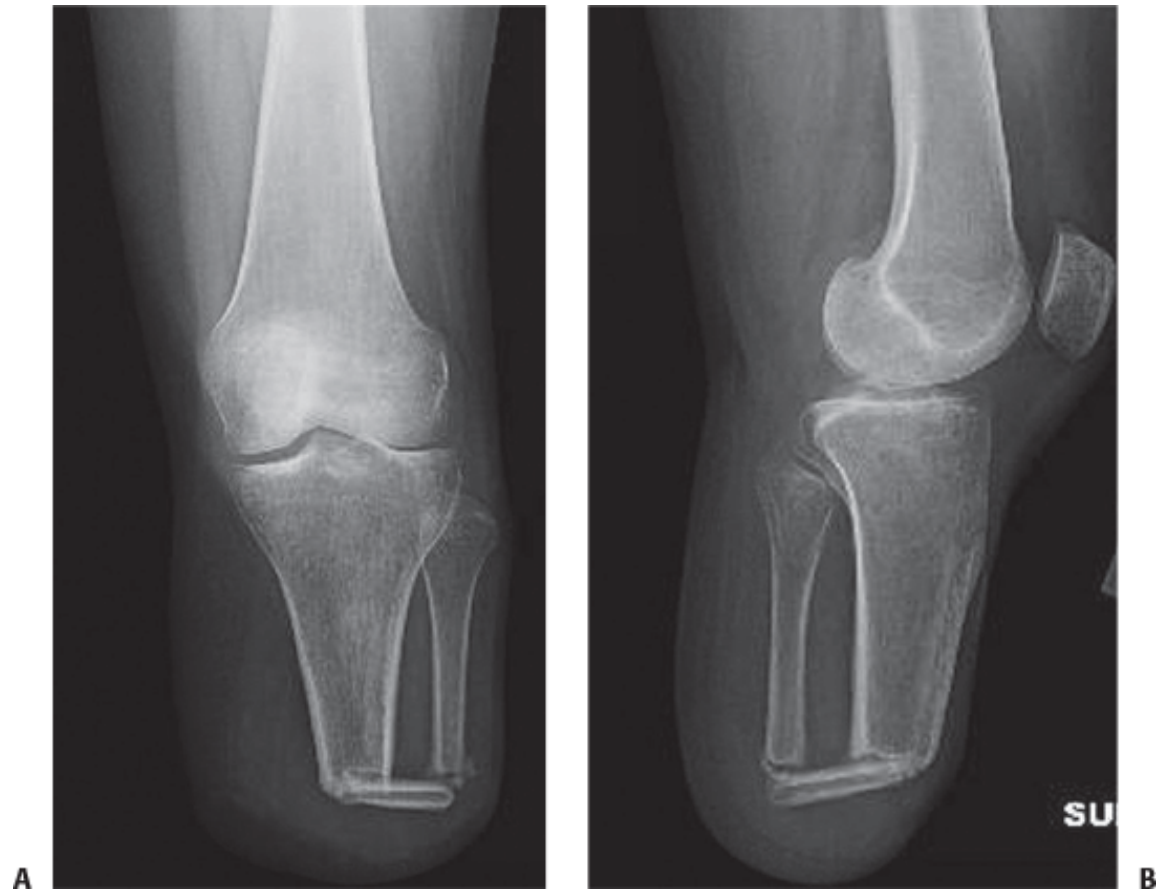
Rockwood and Green 9th ed., Pg 675, Fig 20-8

Traumatic and Trauma-Related Amputations: Part I: General Principles and Lower-Extremity Amputations.
Tintle, LT Scott M. MD; Keeling, CDR John J. MD; et al. JBJS (AM). 92(17):2852-2868, December 1, 2010

Do Patients With Bone Bridge Amputations Have Improved Gait Compared With Patients With Traditional Amputations? Kingsbury T, Thesing N, Collins JD, Carney J, Wyatt M, CORR. 2014 Oct; 472(10): 3036–3043.

Ertl Osteoplasty

- **No clinical benefit**
- **Increased operative time**
- **Biomechanical and anecdotal support**



Rockwood and Green 9th ed., Pg 675, Fig 20-8

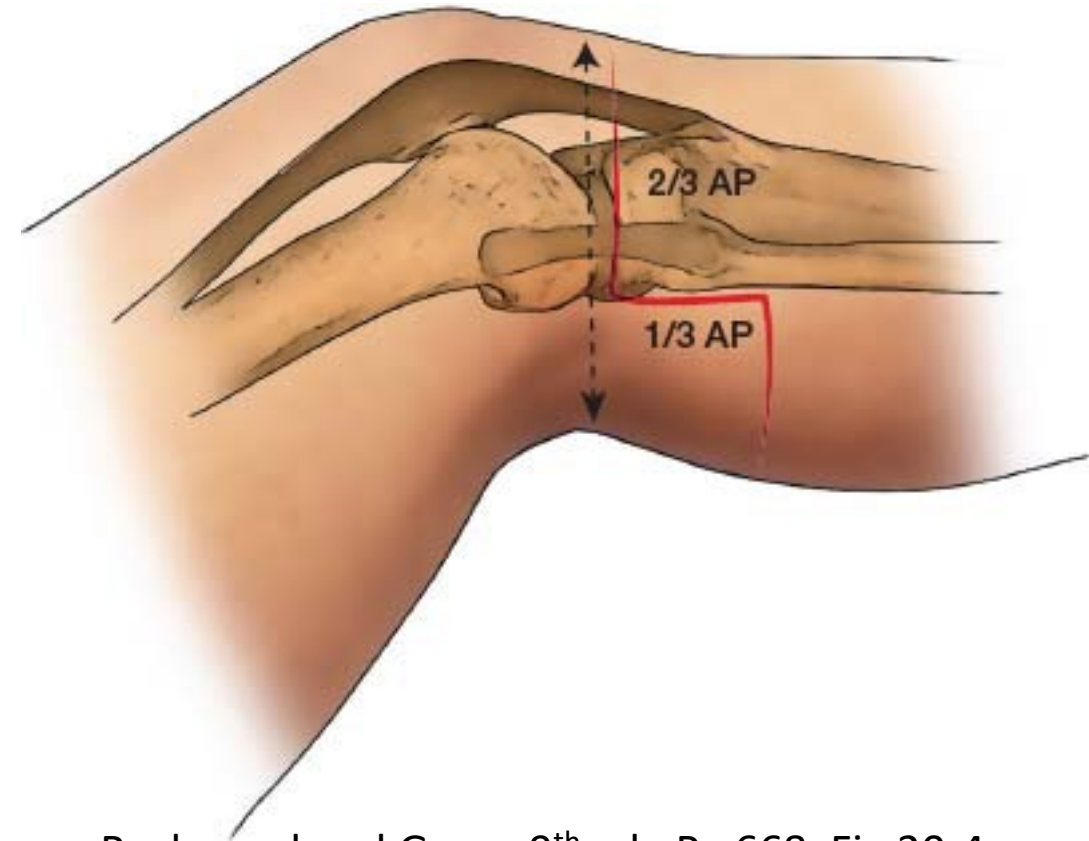
Comparison of functional outcomes following bridge synostosis with non-bone-bridging transtibial combat-related amputations. Keeling JJ; Shawen SB; et al. JBJS (AM) 95(10):888-93, 2013 May 15.

Biomechanical analysis of curb ascent in persons with Ertl and non-Ertl transtibial amputations.

Ferris AE; Christiansen CL; Heise GD; Hahn D; Smith JD. Prosthetics & Orthotics International. 44(1):36-43, 2020 Feb.

Knee Disarticulation/Through Knee Amputation

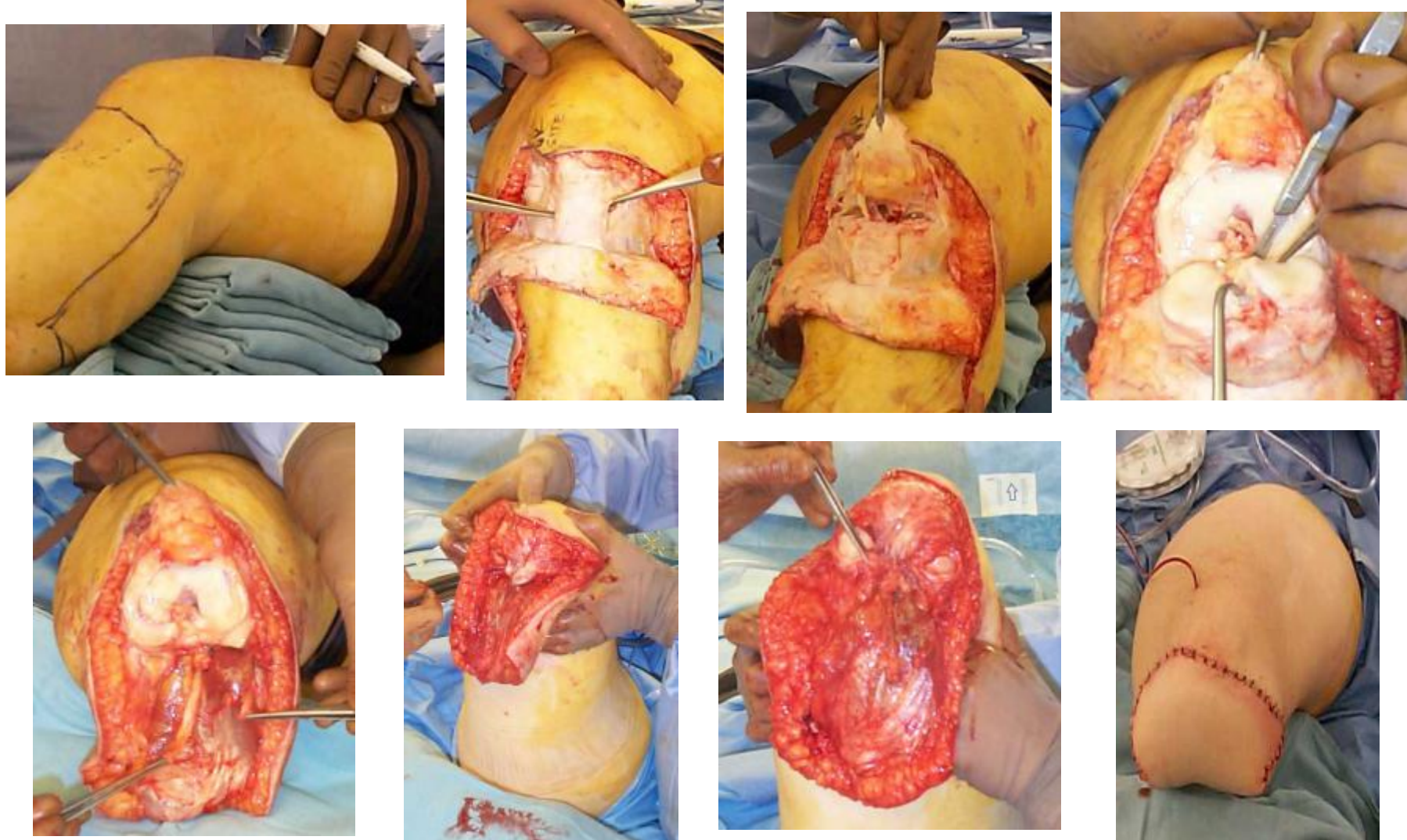
- **Anterior and posterior flaps**
 - **Gastroc coverage**
- **Preserve Adductor insertion**
- **Suture patella over bone end**
- **Myodesis of quad to hamstring**
- **Need adequate soft tissue coverage**



Rockwood and Green 9th ed., Pg 668, Fig 20-4

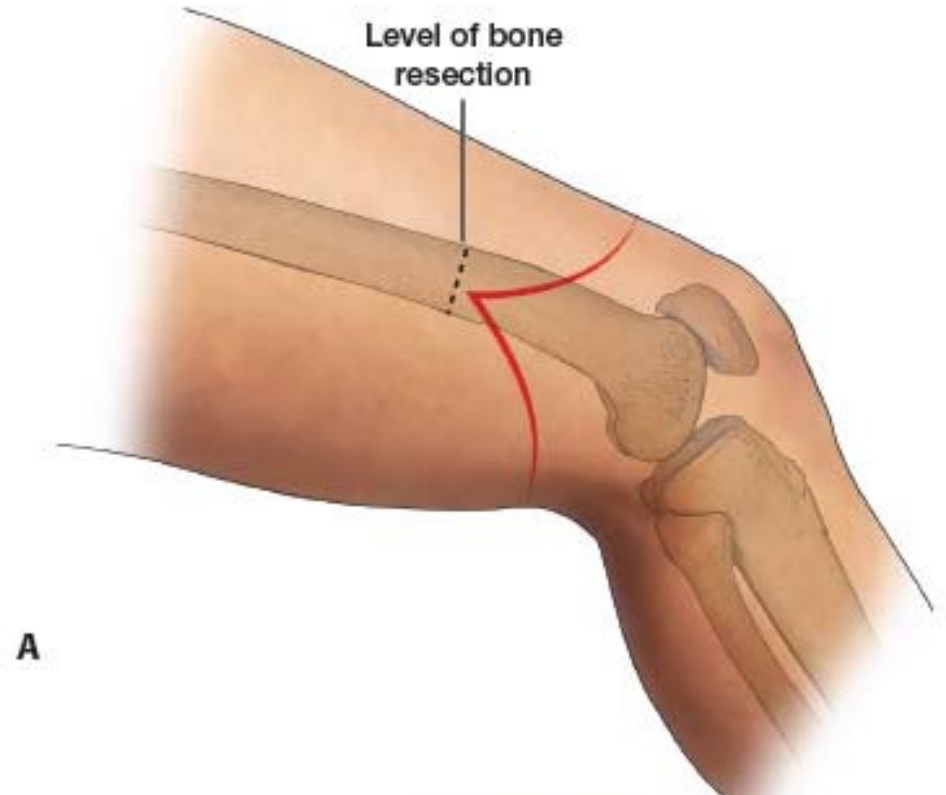
Through Knee Amputation: Technique Modifications and Surgical Outcomes. Frank P Albino,¹ Rachel Seidel,¹ Benjamin J Brown,¹ Charles G Crone,² and Christopher E Attinger. Arch Plast Surg. 2014 Sep; 41(5): 562–570.

Posterior Flap Technique



TFA/Above Knee Amputation Technique

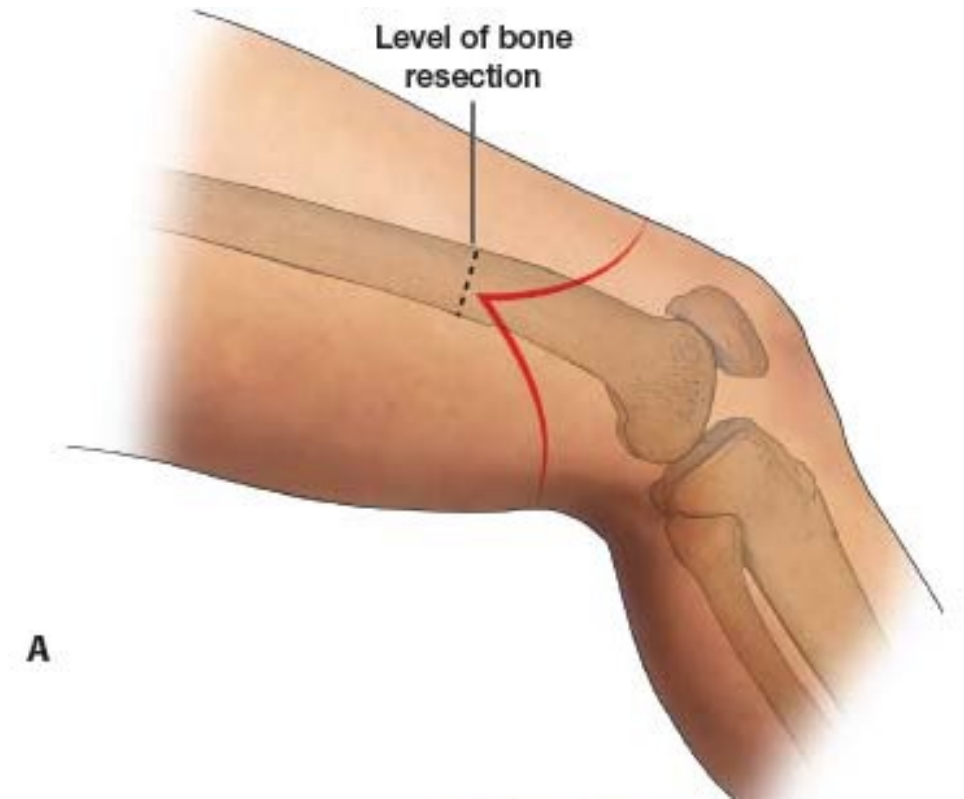
- **Flaps anterior and posterior**
 - 1cm longer than $\frac{1}{2}$ diameter
- **Sharp dissection to bone laterally, anterior, and posterior**
- **Medially careful isolation and elevation of adductor magnus insertion**



Rockwood and Green 9th ed., Pg 670, Fig 20-6

TFA/AKA Technique

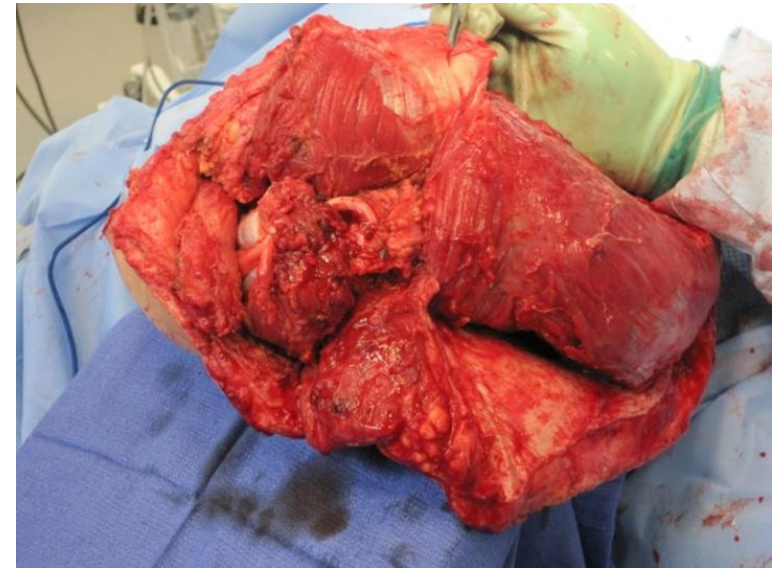
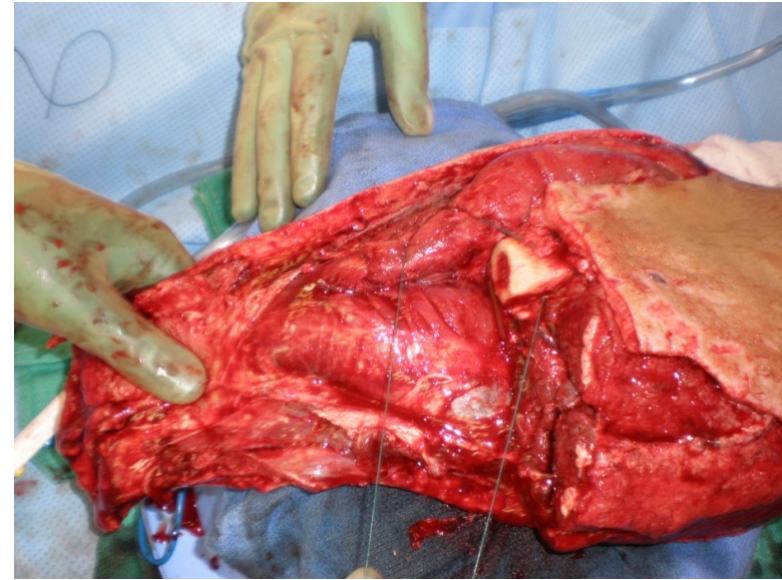
- **Bone cut 12-15cm proximal to knee center of rotation**
 - **15cm above knee center of rotation Allows for a rotator**

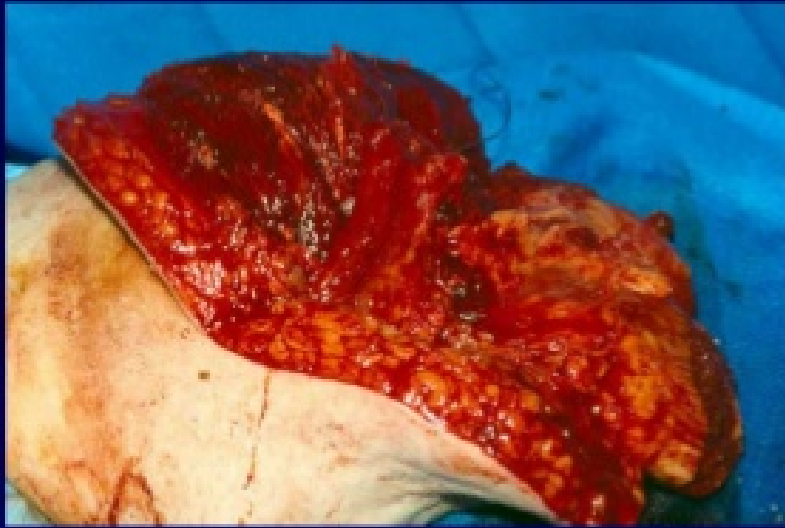
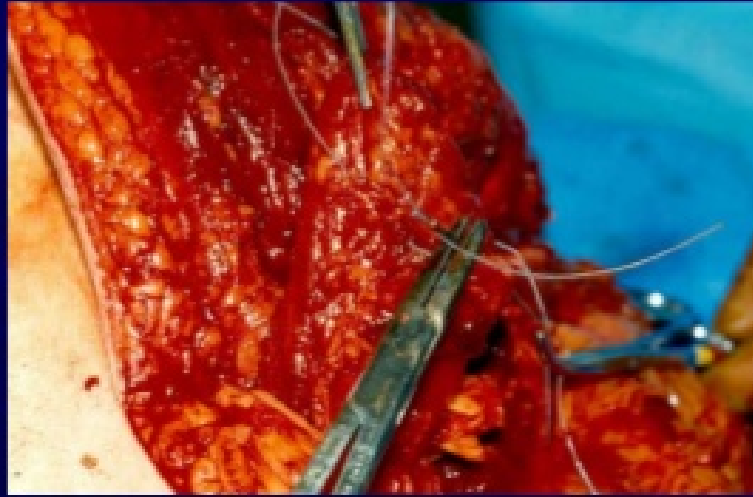


Rockwood and Green 9th ed., Pg 670, Fig 20-6

Myodesis

- **Posterolateral drill holes**
- **Secure adductor lateral**
- **Suture Quadriceps posterior**
- **Add hamstring**



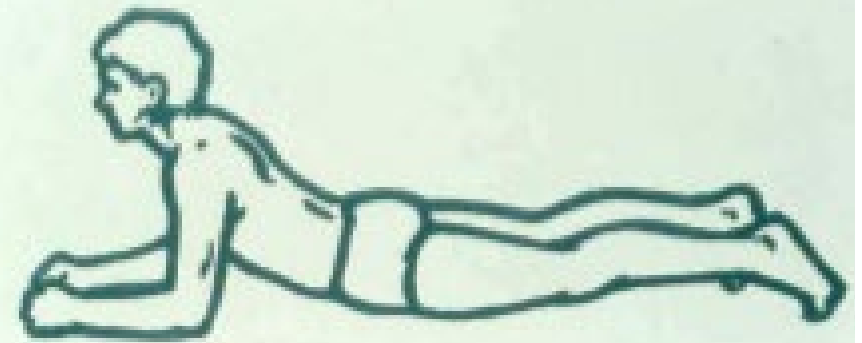


Postop Care

- **Splint for protection**
 - Hip spica wrap
- **Drain**
- **Elevation**
- **Tummy time**



Prone on Elbows



Outcomes

- **Low Back Pain**
- **Bone Mineral Density**
- **Hypertension**
- **Pain**
- **Prosthetic Wear**



General Outcomes-Transtibial

- **75% able to ambulate with prosthesis**
- **24% Reoperation rate**
- **2% Conversion to TFA**



Outcomes after 294 transtibial amputations with the posterior myocutaneous flap. Brown BJ; Iorio ML; et al. Int J of Lower Extremity Wounds. 13(1):33-40, 2014 Mar.



Reoperation after combat-related major lower extremity amputations. Tittle SM; Shawen SB; et al. Journal of Orthopaedic Trauma. 28(4):232-7, 2014 Apr.

General Outcomes-Transfemoral

- **SF-36 scores worse than BKA**
- **Equivalent 500m walking**
- **Increased prosthetic use and decreased pain vs KD/TKA**

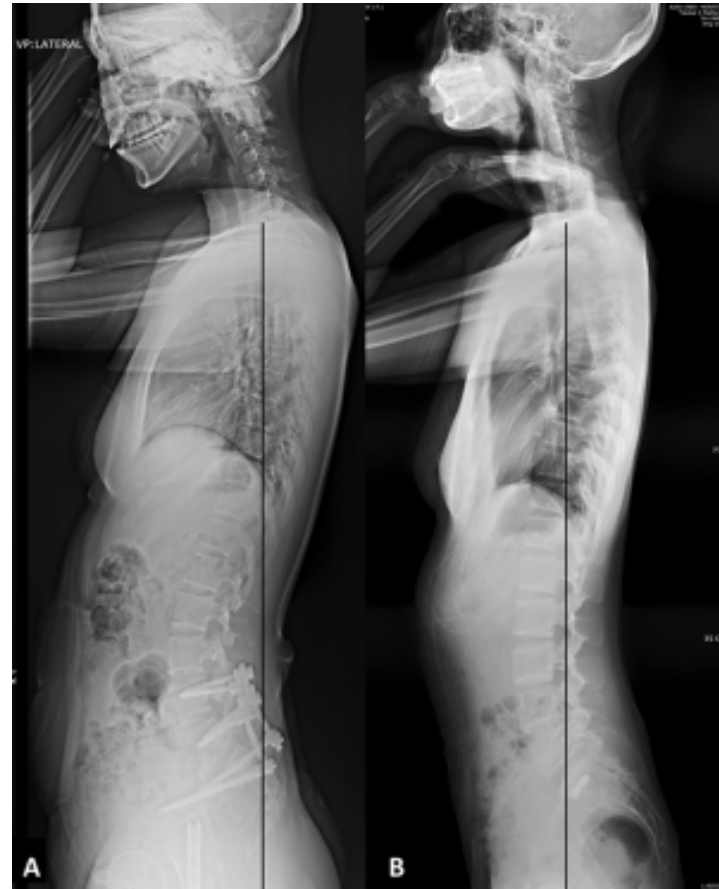


Outcomes in lower limb amputation following trauma: A systematic review and meta-analysis

Author links open overlay panel Jowan G. Penn-Barwell¹. Injury Volume 42, Issue 12, Dec 2011, Pg 1474-1479

Low Back Pain

- **Exceedingly Common**
- **May improve with PT**
- **Gait/Prosthetic fitting???**



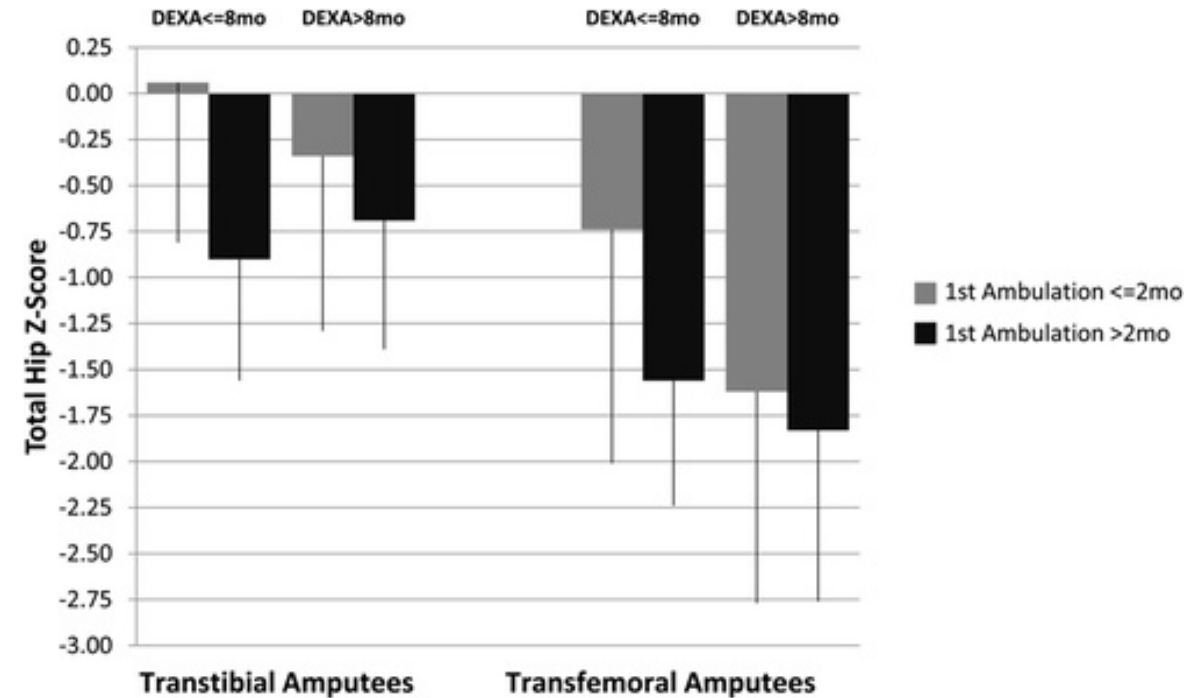
Slide Picture Reference 6

Chronic low back pain in individuals with lower-limb amputation. Kusljagic A; Kapidzic-Durakovic S; Kudumovic Z; Cickusic A. *Bosnian Journal of Basic Medical Sciences*. 6(2):67-70, 2006 May.

Incidence of Overuse Musculoskeletal Injuries in Military Service Members With Traumatic Lower Limb Amputation. Farrokhi S; Mazzone B; et al. *Archives of Physical Medicine & Rehabilitation*. 99(2):348-354.e1, 2018 02.

Bone Mineral Density

- **Decreased**
- **Level Association**
- **Bilaterality**
- **Time to weight bearing**



Slide Picture Reference 7



Bone mineral density loss after combat-related lower extremity amputation. Flint JH; Wade AM; Stocker DJ; Pasquina PF; Howard RS; Potter BK. Journal of Orthopaedic Trauma. 28(4):238-44, 2014 Apr.

Hypertension

- **Present in amputees**
- **Questionable association**
 - **Cardiovascular Disease (CVD)**
 - **Mortality**



Increased peripheral vascular resistance in male patients with traumatic lower limb amputation: one piece of the cardiovascular risk puzzle. Paula-Ribeiro, M; Garcia, MMN; et al. Blood Pressure Monitoring. 20(6):341-345, December 2015.

Heterotopic Ossification

- **Common in blast injury**
- **Amputation within zone of injury**
- **Partial excision**
- **Early removal (6 months)**



Slide Picture Reference 8

Heterotopic ossification in high-energy wartime extremity injuries: prevalence and risk factors. Forsberg JA, Pepek JM, et al. J Bone Joint Surg Am. 2009;91:1084-1091

What risk factors predict recurrence of heterotopic ossification after excision in combat-related amputations? Pavey GJ, Polfer EM, Nappo KE, Tintle SM, Forsberg JA, Potter BK. Clin Orthop Relat Res. 2015;473:2814-2824



Pain

- **Exceedingly Common**
 - **Phantom pain**
 - **Residual Limb**
 - **Neuropathic**

Phantom Limb Pain: A Review. Luo, Yong PhD, MD; Anderson, Thomas A. PhD, MD International Anesthesiology Clinics. 54(2):121-139, Spring 2016.

Benchmarking Residual Limb Pain and Phantom Limb Pain in Amputees through a Patient-reported Outcomes Survey. Mioton, Lauren M. MD *; Dumanian, Gregory A. MD *; et al. Plastic and Reconstructive Surgery 8(7):e2977, July 2020.

Pain Control

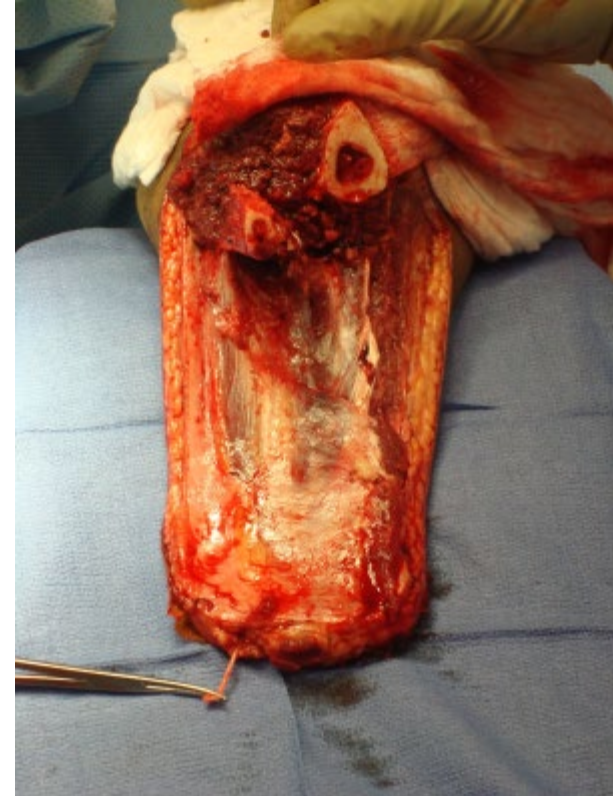
- **Peripheral nerve catheter**
- **Multimodal pain control**
- **Multidisciplinary approach**
- **Cognitive/Behavioral**



The Use of Prolonged Peripheral Neural Blockade After Lower Extremity Amputation: The Effect on Symptoms Associated with Phantom Limb Syndrome. Borghi, B; D'Addabbo, M; et al. *Anesthesia & Analgesia*. 111(5):1308-1315, November 2010.

Neuropathic Pain

- Neuroma Excision
- Targeted Muscle Reinnervation



Slide Picture Reference 9

Ducic I, Mesbahi AN, Attinger CE, et al. The role of peripheral nerve surgery in the treatment of chronic pain associated with amputation stumps. *Plast Reconstr Surg.* 2008;121:908-914

Targeted Muscle Reinnervation for Transradial Amputation: Description of Operative Technique. E Morgan, BK Potter, J Souza, S Tittle *Techniques in Hand & Upper Extremity Surgery.* 20(4):166–171, DECEMBER 2016

Targeted Muscle Reinnervation Technique in Below-Knee Amputation Bowen, J. Byers M.D., M.S.; Ruter, Daniel B.S.; Wee, Corinne M.D.; West, Julie M.S., P.A.-C.; Valerio, Ian L. M.D., M.S., M.B.A. *Plastic and Reconstructive Surgery:* January 2019 - Volume 143 - Issue 1 - p 309-312

Osseointegration

- **Skeletal Fixation**
- **Percutaneous prosthetic interface**
- **Avoids socket fitting issues**



Rockwood and Green 9th ed., Pg 675, Fig 20-7

Walking ability and quality of life in subjects with transfemoral amputation: a comparison of osseointegration with socket prostheses. Van de Meent H; Hopman MT; Frolke JP. Arch of Physical Medicine & Rehabilitation. 94(11):2174-8, 2013 Nov.

Osseointegrated prosthesis for patients with an amputation. Frölke, J.P.M., Leijendekkers, R.A. & van de Meent, H. Unfallchirurg 120, 293–299 (2017).

Osseointegration

- **How do they do?**
 - **Significant improvement over Socket TFA**
 - **55% reoperation rate**
 - **100% superficial infection rate**



Rockwood and Green 9th ed., Pg 573, Fig 17-6

Bone-anchored prostheses in patients with traumatic bilateral transfemoral amputations: rehabilitation description and outcome in 12 cases treated with the OPRA implant system. Hagberg K. Disability & Rehab Asst Technology. 14(4):346-353, 2019 05.

Keeping Clean

- **Derma clean is recommended for cleaning gel liners and the skin**
- **Mild neutral soaps can be used also**
- **Recommend only washing the residual limb once daily**





Other Lower Extremity Amputations

• **Midfoot Amputation**

- Trans metatarsal or Lisfranc disarticulation level, plantar based flap is best
- Needs an Achilles lengthening to prevent equinus
- Inadequate lever arm for walking so poor for active person

• **Hindfoot Amputation**

- Chopart, or Boyd
- Develops equinus
- Poor walking lever arm – a propulsive gait
- Associated with ankle fusion does give stable platform but not propulsive

Other Lower Extremity Amputations

• Ankle Disarticulation (Syme's)

- End bearing with few complications
- Requires healthy skin over heel
- Must protect posterior tibial artery as provides blood to posterior flap
- Malleoli removed and heel pad sutured to anterior tibia
- Need a dynamic responsive foot prosthesis

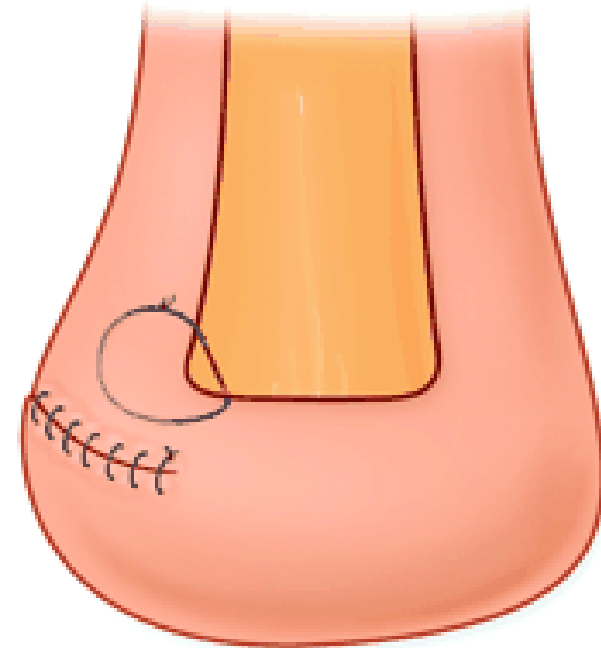


Syme's Amputation

- Pitfall: heel pad migration
 - Anchor heel pad to anterior tibia
 - Excise subchondral bone – scar
 - Consider temporary pin stabilization
 - Tenodesis of Achilles to posterior tibia

Smith DG, et al. Achilles tendon tenodesis to prevent heel pad migration in the Syme's amputation. *Foot Ankle Int.* 1994;15:14-7.

- Very functional level
 - Easier suspension of socket but fewer prosthetic options than TTA



Other Lower Extremity Amputations

- **Ray amputations – metatarsal and corresponding toe**
 - 5th no disability
 - Central ray – wound healing problems
 - 1st ray decreases medial column stability
 - Narrow foot, forefoot equinus, shoe fitting problems
 - “tennis racket” incision around base of toe
- **Toes**
 - Better tolerated, little functional loss
 - Usually isolated
 - Commonly for diabetic infections
 - Plantar based incision if possible
 - Retain proximal phalanx if 2nd toe amputated as spacer to prevent Hallux drift

Team

- Meet the patient prior
- Previous amputees
- Come to hospital, rehab, clinic



Communication

- **Realistic Expectations of Life Changes**
- **Simple questions**
- **Reassurance**
- **How long until prosthesis?**
- **Can I have the best?**



Summary

- **Whole patient approach**
- **Team**
- **Limb Salvage vs. Amputation is a Marathon, not a Sprint**

SLIDE PICTURE REFERENCES

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8. Slide 60: Evans, K. , Forsberg, J. , Potter, B. , Hawksworth, J. , Brown, T. , Andersen, R. , Dunne, J. , Tadaki, D. , Elster, E. & (2012). Inflammatory Cytokine and Chemokine Expression is Associated With Heterotopic Ossification in High-Energy Penetrating War Injuries. *Journal of Orthopaedic Trauma*, 26 (11), e204-e213
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