Surgical Reconstruction of the Neuropathic Foot

I. Introduction
   a. Some Statistics
      i. Diabetes currently affects 366 million people worldwide and is expected to affect 520 million by 2030. (www.idf.org)
      ii. According to the CDC, 25.8 Million Americans (8.3%) have diabetes mellitus and it is on the. (www.diabetes.org)
      iii. 79 Million Americans are “Pre-Diabetic” (www.diabetes.org)
      iv. Amputations:  
         1. 60% of amputations in the United States are due to diabetes  
         2. About 70,000 Amputations/year occur due to diabetes  
         3. The International Diabetes Foundation estimates that 85% of amputations are preventable. (www.idf.org)
   b. Amputations are only part of the problem
      i. 73% of diabetics have hypertension  
      ii. 60% of diabetics will die from a heart attack or stroke  
      iii. Diabetes is the leading cause of Kidney Failure & Dialysis  
      iv. $174 Billion per year on Diabetes
c. Foot and ankle problems in diabetics come from chronic involvement of 3 systems
   i. Peripheral Neuropathy
      1. Sensory nerve loss results in pain and loss of sensation.
         a. Longer nerves are more involved...
         b. Causes “Stocking & Glove” loss of sensation
      2. Motor nerve loss results in weakness, contracture and deformity
      3. Autonomic nerve loss results in:
         a. Drying & cracking of skin (loss of integumentary protection from pathogens)
         b. Poor vasomotor control = Edema & Stasis
   ii. Vascular (Arterial)
      1. Diabetes represents an independent risk factor for large vessel disease
         a. Calcification of vessels is common & may make ABI measurements useless
         b. Small vessel disease is also extremely highly prevalent
         c. Combination can be devastating to wound healing potential
      2. Melton: Reviewed 1073 diabetic patients
         a. 8% with one or more absent pulses
         b. 15% at ten years of diagnosis
         c. 45% at 20 years
         d. Duration of disease and degree of hyperglycemia correlate with the extent of disease present below the popliteal vessels.
iii. Immune
   1. Hyperglycemia impairs macrophage function (phagocytosis)
   2. Ketoacidosis delays migration of lymphocytes and impairs bactericidal function of these cells
   3. Microangiopathy causes decreased tissue perfusion, oxygen levels and delivery of antibiotics

II. Traditional Treatment Models
   a. Casting
      i. Most patients with Neuroarthropathy present in the “Acute phase”.
      ii. Traditionally, treatment has been aimed at getting the patient from the “acute” phase into the “consolidation” phase before severe deformity develops.
      iii. Containment of the foot with a “total contact cast” is often effective.
   b. Accommodative Bracing
      i. Patients with no little or no deformity whose foot is plantigrade typically function well with attention to daily foot care and an off the shelf or custom diabetic insole. These patients also need to be educated in daily foot care.
      ii. Patients with a “stable” rocker deformity may be able to be managed with a custom orthotic with relief posting for the offending prominence.
      iii. More severe deformities and minor instability can be managed with a Charcot Restraint Orthotic Walking boot (CROW Boot).
   c. Traditional Surgical Treatments
      i. Bone Resection of prominences causing ulceration
      ii. Tendo Achilles Lengthening and/or gastrocnemius recession.
III. Limb Salvage vs. Amputation

A. What is necessary for limb salvage?
   a. Adequate vascular supply.
   b. Control of medical comorbidities.
   c. Resolution of Infection.
   d. Creation of a stable plantigrade foot.
   e. Patient compliance with post-operative regimen including bracing.

B. Relative indications for amputation.
   a. Resistant organism causing osteomyelitis.
   b. Poor overall patient health.
      i. Cardiac
      ii. Renal Dialysis
      iii. Glucose Control
      iv. Vascular Disease
   c. Inability of patient to comply with postoperative protocols.

C. What are absolute indications for amputation?
   a. Gangrenous leg
   b. Inadequate bone stock to achieve fusion.
   c. Inadequate soft tissue envelope.
   d. Non-reconstructable vascular disease.
IV. Superconstructs

a. “Superconstruct”\(^2\) – A superconstruct is defined by four factors:

i. Fusion is extended beyond the zone of injury to include joints that are not affected to improve fixation

ii. Bone resection is performed to shorten the extremity to allow for adequate reduction of deformity without undue tension on the soft tissue envelope

iii. The strongest device is used that can be tolerated by the soft tissue envelope

iv. Devices are applied in a position that maximizes mechanical function.

b. Reasoning for “Superconstruct” Methods in Neuroarthropathic Joints

i. A subset of patients exists where gross instability of the neuroarthropathic joints makes management with a bracing and orthotics difficult or impossible.

ii. These patients may benefit from deformity correction with arthrodesis of the foot.

iii. Traditional fixation methods have been fraught with complications including loss of correction, reactivation of the Charcot process.

iv. Reasons for these problems include:\(^3\)

1. Poor Bone Quality

a. “Dissolution” of the neuroarthropathic area occurs due to sympathetic denervation and resultant hyperemia

b. Bone is often osteoporotic to begin with

c. The bone becomes fragmented as part of the neuroarthropathic process.
2. Poor Vascularity
   a. High rate of microvascular disease even when large vessel flow is good
   b. The bone itself may become dysvascular in the neuroarthropathic process
3. Extended Healing Times
   a. Diabetics have poor immune function
   b. Glycosylated tissues have poor healing potential
4. Poor Patient Compliance with restricted weight bearing protocols.\(^4\)
5. Progressive contracture of soft tissue envelope leads to irreducible dislocation.

V. Superconstruct methods attempt to improve initial mechanical stability and improve overall fatigue resistance.

V. Plantar Plating
   a. Schon recognized that application of plates in a plantar location offered multiple mechanical advantages, despite technical difficulties in applying the device in this location.
   b. Schon developed the concept of plantar plating to improve the strength of the construct, noting that the plantar location would improve the intraoperative ability to achieve correction and place the device under tension during weight bearing.
c. In a simulated midfoot fusion model, Marks and colleagues showed that application of the plates plantarly was biomechanically more stable than crossed screws in stiffness and in load to failure.\(^5\)
d. A similar study comparing plantar plate fixation with screw fixation for metatarsal osteotomies yielded similar results.\(^6\)
e. Schon and colleagues reported successful results using this technique in 34 patients who had severe midfoot neuroarthropathic disease.\(^7\)

VI. Locked Plating

a. Locked Plates create a fixed-angle device by rigidly attaching the screw to the plate.

b. Locked Plates have the advantage of significantly improving fixation in osteoporotic bone.\(^8\);\(^9\)

c. No clinical series to date, although anecdotal use reported.
VII. Axial Screw Fixation  
   a. refers to passing long screws through the foot so that the screw lies in the intramedullary canal of the metatarsals distally, and bridges the area of Charcot dissolution.
   
   b. Sammarco 1991 – Calcaneus to 4th MT shaft for lateral column fixation
   
   c. Sammarco and colleagues 2009\textsuperscript{10} - Twenty-two patients were followed for an average 52 months (minimum 2 years’ follow-up). At final follow-up, there were no amputations, and all patients were considered to have successful limb salvage.
   
   d. Assal & Stern 2009\textsuperscript{11} – Medial Column Screw in 15 patients with unstable/ulcerated neuroarthropathic midfoot deformity. 14 with success, 1 amputation.
Reference List


