

**5th Annual
Multidisciplinary Management
of the High Risk Diabetic
Foot Conference**

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Operative Management of Diabetic Foot Ulcers: *Overview*

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Diabetic Foot Ulcers

- Occur in 15% of patients with diabetes
- 85% lower extremity amputations are preceded by a non-healing ulceration
- Wounds accounts for 20% of the costs of caring for persons with diabetes
- Wound care product expenditure is >\$5 billion annually in the US



Appropriate Wound Care

- Moist wound environment
- Offloading pressure
- Protect against infection
- Maintain metabolic control and nutritional status
- Establish level of arterial supply
- Initiate appropriate wound care
- Removal of necrotic or non-viable tissue
- Conduct frequent evaluations with response-directed treatment
- Promote patient education and adherence to therapy



True or False?

- Once a wound heals, recurrence is inevitable
- Neuropathy is the major cause of wounds
- Avoiding lower-limb amputation has little functional significance
- Once a limb has been amputated, the contralateral will also be amputated
- It is difficult to recognize which patients have feet that are prone to developing wounds

Seven Key Questions

- Is the wound infected?
- Is the wound ischemic?
- Is there pressure?
- Is the wound hypoxic?
- Are there nutritional issues?
- Is the patient compliant?
- What is happening at the cellular level?



Surgeries for Treating Wounds in Patients with Diabetes

- Treatment of Ulcers
 - Debridements
- Correction of Deformities
 - Hammertoes
 - Ankle joint equinus
 - Charcot
- Wound closure
 - Flaps and Grafts
 - Closure devices
- Amputation



Procedures should be chosen to correct the underlying problem in the most minimally invasive manner

Diabetic Foot Surgery *Classification*

Class I: Elective

Class II: Prophylactic

Class III: Curative

Class IV: Emergent



*Armstrong and Frykberg,
Diabetic Medicine 2003*

Proactive

- Previous or current ulcer
- prophylactic

Reactive

- Acute soft tissue or bone infection
- Non-reversible ischemia

*Kravitz, McGuire, and Sharma,
Adv Skin & Wound Care 2007*

When to Consider Surgery?

- Failure of conservative treatment -- Ulcers that *cannot* be accommodated and offloaded by footwear, orthoses, or related care
- Therapeutic shoes – recurrence rates of ulcers 28% at 12 months to 100% at 40 months
- Deformity which places limb at risk
 - rigid vs. flexible
- Patient compliance and education concerns
- General medical status



Consider surgery when an aggressive conservative approach fails

Pre-Op Considerations

General Criteria

- Adequate circulation
- Absence of infection
- Superficial ulcer
- Medical control
- Nutritional status
- Compliance

Local Criteria

- Duration
- Functional/structural
- Rigidity
- Location
- Ulceration/infection history



Pre-op Surgical Lower Extremity Physical Exam

Start proximal and work distal

1. Flexion contractures hip and knee
2. Pulses at the ankle
3. Achilles tendon contracture (equinus)
4. Major hindfoot/midfoot deformities
5. Clawtoes
6. Hallux Rigidus or Valgus
7. Joint mobility



Conservative Surgical Approach Versus Non-surgical Management for Diabetic Neuropathic Foot Ulcers: a Randomized Trial

Piaggese et al, *Diab Med*, 15: 412-17, 1998

Prospective, randomized trial

Healing rate in 6 months

Duration of healing time

Prevalence of recurrence

Prevalence of infection



Group A (n=20)

- Non-operative therapy
- Dressing changes
- Offloading

Group B(n=21)

- Operative therapy – removal of ulcer, removal of bone, closure with sutures
- 5 days IV abx

Conservative Surgical Approach Versus Non-surgical Management for Diabetic Neuropathic Foot Ulcers: a Randomized Trial

Piaggese et al, *Diab Med*, 15: 412-17, 1998

	Group A (Non-operative)	Group B (Operative)
Healing Rate	19/24 (79%)	21/22 (95%)
Duration of Healing	129 days	47 days
Recurrence Rate	8/19 (41%)	3/21 (14%) **transfer lesions**
Infection Rate	3/24 (12.5%)	1/22 (4.5%)

- Well vascularized patients
- Lower complications
- Faster healing
- Less recurrence
- Short term follow-up

Modified Resection Arthroplasty for Infected Non-healing Ulcers with Toe Deformity in Diabetic Patients

Kim et al, *Foot & Ankle Intl*, Vol 29, No 5, May 2008

Attempt an alternative therapy for managing toe deformities accompanied by chronic ulcers with and without osteomyelitis

- 52 Patients (57 feet / 72 toes)
- 28 male / 24 female
- Mean age 62

Indications:

Wounds > 6 weeks (mean 12 week duration pre-op)
+/- infection

Surgical Technique

- Digital block
- PIPJ exposed through the wound
- Bone, capsule, tendon and ligaments "massive" debridement
- Bone resected
- K-wire placed
- Infected wounds NOT primarily closed
- Dressing, post-op shoe
- K-wire removed when healed

Modified Resection Arthroplasty for Infected Non-healing Ulcers with Toe Deformity in Diabetic Patients

Kim et al, *Foot & Ankle Intl*, Vol 29, No 5, May 2008

Results

- 68/72 procedures had + cultures
- Mean wound healing time 26 days
- 12 toes required re-operation
- 3 cases required amputation
- No claw toe recurrence at follow-up (mean 28 months)



Outpatient Percutaneous Flexor Tenotomies for Management of Diabetic Claw Toe Deformities with Ulcers: A Preliminary Report

Tamir et al, *Can J Surg*, Vol 51, No 1, February 2008

Retrospective review of outpatient percutaneous flexor tenotomies in diabetic patients with claw toes and ulceration

Inclusion Criteria

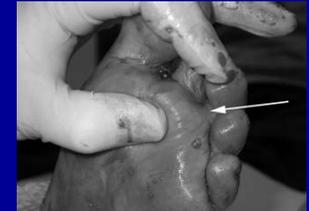
Mild to moderate rigidity
Distal ulceration

Exclusion Criteria

Absence of pulses
Cellulitis

Surgical Technique

- Digital block
- DF Ankle, pressure to plantar met head
- Puncture under middle phalanx
- Tendon cut
- Osteoclasis for more rigid deformity
- Pressure dressing
- WBAT in regular shoes



Outpatient Percutaneous Flexor Tenotomies for Management of Diabetic Claw Toe Deformities with Ulcers: A Preliminary Report

Tamir et al, *Can J Surg*, Vol 51, No 1, February 2008

Results

34 toes in 14 patients

8 male / 6 female

24 ulcers / 10 at risk

3 Osteomyelitis

Average duration of
ulceration 11
months

Mean f/u 13 months

- Ulcers without osteo healed within 3 weeks
- Ulcers with osteo healed within 8 weeks
- No complications
- No recurrence
- No hyperextension deformities seen

Clinical Efficacy of the First Metatarsalphalangeal Joint Arthroplasty as a Curative Procedure for Hallux Interphalangeal Joint Wounds in Patients With Diabetes

Armstrong et al, *Diabetes Care*, Vol 26, No 12, Dec 2003



Case control study to evaluate the complications and outcomes of 1st MPJ arthroplasty compared to standard, non-surgical management of hallux IPJ wounds

Clinical Efficacy of the First Metatarsalphalangeal Joint Arthroplasty as a Curative Procedure for Hallux Interphalangeal Joint Wounds in Patients With Diabetes

Armstrong et al, *Diabetes Care*, Vol 26, No 12, Dec 2003

- 21 Surgical patients underwent Keller type arthroplasty
- 20 age, sex-matched patients receiving standard non-surgical care
- 6 month f/u

Results

Ulcer healing

24 days vs. 67 days

Ulcer recurrence

5% vs. 35%

Infection

40% vs. 38%

Amputation

10% vs. 5%

Metatarsal Head Resection for Diabetic Foot Ulcers

Griffiths et al, *Arch Surg* 1990; 125; 832-835

Retrospective review of diabetic patients who underwent metatarsal head resections for recalcitrant diabetic foot ulcerations

34 met head resections
on 25 patients in 32
operations

Mean age 58

19 males / 6 female

Indications

- Non healing ulcers (22)
- Infected ulcers (5)
- Transfer lesions (3)
- Ulcerations after amputations (2)
- Painful callus (2)

Metatarsal Head Resection for Diabetic Foot Ulcers

Griffiths et al, *Arch Surg* 1990; 125; 832-835

- Mean time of ulceration pre-op = **9.0 months**
- Mean f/u 13.8 months
- Mean time for ulcer healing post-op = **2.4 months**
- No recurrence in same area
- 3 transfer lesions were re-operated



Efficacy of Fifth Metatarsal Head Resection for Treatment of Chronic Diabetic Foot Ulceration

Armstrong et al, *JAPMA* 2005

Retrospective cohort study to evaluate outcomes of operative versus non-operative treatment of ulcerations sub 5th metatarsal head in people with diabetes



22 patients underwent 5th met head excision

18 patients received standard non-operative care

6 month f/u

Duration to healing

5.8 weeks vs 8.7 weeks

Reulceration rates

4.5% vs. 28%

Infection rates

18% vs. 22%

Amputation rates

4.5% vs. 12%

Partial Calcanectomy in the Treatment of Recalcitrant Heel Ulcerations

Randall et al, JAPMA 95(4); 335-341, 2005

Literature Review

148 cases since 1931

89% healing rates

DM and PVD

Incisional approaches



Retrospective review 8 patients underwent partial calcanectomy for chronic non-healing ulcerations

8 patients / 9 feet

7/9 (78%) healed without recurrence

2 failures: PVD / Improper post-op offloading

Ambulatory status unchanged post-op

Surgical Management of the Charcot Foot

- 1-4% of the diabetic population
- M=F
- Average age of developing Charcot is 40
- 30% may be bilateral
- Complications

Indications for Surgery

- Unstable deformity not amenable to bracing
- Deformity with current non healing ulceration
- Deformity with potential for recurrent ulceration

Surgical Procedures

- Exostectomy
- Arthrodesis
 - Midfoot, Hindfoot, Ankle



Achilles Tendon Lengthening

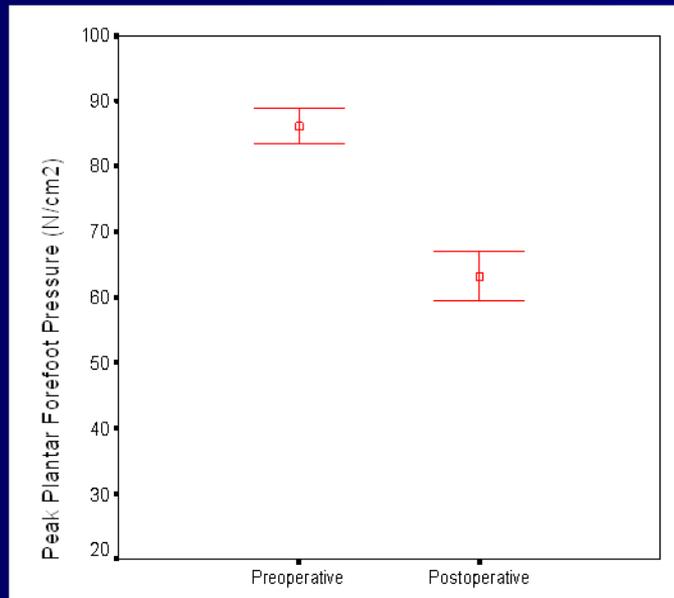
Armstrong et al JBJS 81A(4) April 1999

- 10 Subjects with DM
 - All UT DM Foot Risk Category 3
 - All with pre-operative AJ DF <10 degrees
 - TAL Performed
 - Peak plantar forefoot pressure assessments pre and 8-weeks postoperatively



Achilles Tendon Lengthening

Armstrong et al JBJS 81A(4) April 1999



- Reduction in postoperative peak plantar pressure
 - (86.1 ± 9.4 vs. 63.3 ± 13.2 N/cm², p < 0.001).
- Increase in ankle joint range of motion eight weeks, postoperatively
 - (0.4 ± 3.1 vs. 8.7 ± 2.3, p < 0.001).

Effect of Achilles Tendon Lengthening on Neuropathic Plantar Ulcers

Mueller et al, *JBJS*, Vol 85A (8) August 2003

Compare outcomes for diabetic patients with ulcerations treated with TCC +/- Achilles tendon lengthening

33 TCC

31 TCC + TAL

Time to healing

Ulcer recurrence rates

Range of AJ dorsiflexion

Peak torque (strength) of PF muscles

Forefoot peak plantar pressures

Primary hypothesis:

TAL group would have lower ulcer recurrence rates



Effect of Achilles Tendon Lengthening on Neuropathic Plantar Ulcers

Mueller et al, *JBJS*, Vol 85A (8) August 2003

	TCC	TCC+TAL
Time to healing	41 days (29/30)	58 days (30/30)
Recurrence 7 mo	59%	15% (<i>75%RR</i>)
Recurrence 24 mo	81%	38% (<i>58%RR</i>)

- TAL increased AJ dorsiflexion
 - *Remained at 7 months*
- TAL decreased plantar flexor strength
 - *Returned to baseline by 7 months*
- TAL reduced peak plantar pressures in the forefoot
 - *Returned to baseline at 7 months*

Neuropathic Plantar Forefoot Ulcers Treated with Tendon Lengthenings

Laborde, *Foot & Ankle Intl*, Vol 29 (4) April 2008

Describes the healing and recurrence rates of plantar metatarsal head ulcers with tendon lengthening

Gastroc-soleus lengthening via Vulpius technique

+ Peroneus longus for ulcers sub 1st met head

+ Tibialis posterior for ulcer sub 5th

- 20 ulcers in 17 patients
 - 14 DM all neuropathic
 - 1 lumbar radiculopathy
 - 2 alcoholic neuropathy
- Average age 60 (30-91)
- Average AJ active DF was -7 degrees pre-op
- Average duration ulcer 17 months (1 month – 7 years)

Neuropathic Plantar Forefoot Ulcers Treated with Tendon Lengthenings

Laborde, *Foot & Ankle Intl*, Vol 29 (4) April 2008

19 ulcers:

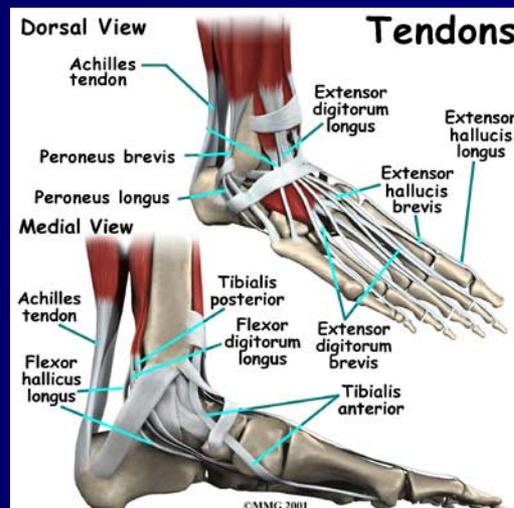
13 sub 1st (GS + PL)

1 sub 2nd (GS)

1 sub 3rd (GS)

1 sub 4th (GS)

1 sub 5th (GS + PT)



Results

- 19/20 wounds healed in less than 2 months
- 3/19 ulcers recurred* during f/u average 45 months (22-81)
- No infections, 2 transfer lesions to great toe, 1 PE, 1 open dislocation of 5th toe (amputated)

Longer follow-up

Describes location of ulcers

Adds additional lengthening procedures

Heterogenous population

Conclusions

Operative Management of Diabetic Foot Ulcers

- In order to *treat* wounds, we must understand the factors associated with the *development* of those wounds
- Healing success is related to the tenants of good wound care
- EBM exists to support surgical management of appropriately selected patients
- Education and the multidisciplinary approach are key

