Total Contact Casting for Neuropathic Ulcers: A Lost Art?

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Abstract:

As the diabetic epidemic continues to increase across the globe, the number of lower extremity complications continues to increase. Lower extremity ulcers remain the number one cause of nontraumatic below knee amputations in persons with diabetes. Many experts believe that total contact casting (TCC) is the gold standard for treatment of neuropathic ulcerations. This belief is supported by evidence based medicine. The authors present the technique for application of TCC and also review the literature on the safety and effectiveness of this treatment modality.

Key words: Diabetes mellitus, diabetic ulcers, total contact cast.

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Introduction

According the Centers for Disease Control and Prevention, the number of people in the United States with diagnosed diabetes has more than doubled over the past 15 years.[1] Of the estimated 23.6 million diabetic Americans, 5.7 million (or one quarter) are unaware they have the disease.[1] It has been estimated that another 57 million people have pre-diabetes, a condition that increases the risk for developing diabetes as well as pre-diabetic neuropathy.[1] The total estimated cost of diabetes for the United States in 2007 was $174 billion in the United States.[1] Foot ulcers will affect up to 25 percent of people with diabetes during their lifetime.[2] People with diabetes have a 30-fold higher lifetime risk of undergoing a lower extremity amputation in comparison to those without diabetes.[3] Foot ulcers precede lower extremity amputations 85 percent of the time [4] and more than 60% of non-traumatic lower-limb amputations occur in people with diabetes.[5]

The foundation of treatment for diabetic foot ulcers (DFU) is based on the simple pneumonic, “VIPs.” The “VIPs” stand for Vascular (ensuring adequate limb perfusion), Infection (controlling infection) and Pressure (mitigation of plantar pressures through proper offloading).[6] Wound healing will not occur if any of these three factors are not addressed appropriately. The one area that is critical to achieving successful ulcer healing, yet often overlooked, is offloading of a neuropathic ulcer.

The gold standard for offloading therapy is total contact casting (TCC). Our purpose is to present the basic technique of applying a total contact cast and to discuss the evidence behind TCC.

Technique

Step 1: Appropriately dress the wound

Dressing should be keep to a minimum to prevent bunching or cast shifting. One may consider using foam to offload the ulceration only; this must be secured using paper tape to prevent migration. The senior author prefers securing the dressing with a single layer of cast padding.

Step 2: Interdigital moisture control and padding

Apply gauze, cotton, lamb's wool, or silver alginate in the interdigital web spaces. (Fig. 1)

Step 3: Cast stocking

Use a seamless stocking to cover the lower extremity from the toes to the tibial tuberosity. (Fig. 2)

Step 4: Padding

Apply self adhering felt padding to bone prominences. These include the lateral and medial malleoli, the anterior shin, the first and fifth metatarsal heads and the medial aspect of the navicular.[7, 8] One must also pad any deformities and may use padding to offload the ulceration. (Fig. 3)

Step 5: Web roll

Apply minimal padding with web roll. This should be about 1 layer thick. Excessive padding will lead to excessive motion when the padding compresses. (Fig. 4)

Figure 1 A light dressing has been scured with a single layer of securing cast roll and 4x4 gauze for interdigital mostiure control.

Figure 2 A seamless stocking is used to cover from the toes to the tibial tuberosity.

Step 6: Offload and protect the forefoot

Apply an adhesive foam pad to the toes in a "sandwich" like manner. (Fig. 4)

Step 7: Casting

Apply fiberglass cast material (generally 3 to 5 rolls) from the toes to just below the tibial tuberosity (to protect the common peroneal nerve).

Figure 3 Self adhering felt padding is used to protect the lateral and medial malleoli, the anterior shin, the first and fifth metatarsal heads and the medial aspect of the navicular.

Figure 4 Adhesive foam is used to protect the digits from iatrogenic ulceration.

The toes should be completely covered. One must ensure that the plantar surface of the foot is reinforced, concentrating especially on the heel. This can be accomplished as one applies the cast, or one can create and interrate a foot plate created with fiberglass cast roll. (Fig. 5)

Figure 5 While patients are able to ambulate with a cast boot immediately after casting, one must confirm that the material has completely dried. There is a high risk of deformation of the cast and iatrogenic complication if one is not careful.

Step 8: Cast boot

Once the cast has dried, a cast boot should be applied. The patient is able to fully bear weight immediately.[9]

Discussion

Drs. Milroy Paul and Joseph Kahn first utilized casting for trophic ulceration secondary to Hansen's disease in Ceylon, India. Khan published his technique and case series on TCC in 1939.[10] Prior to the discovery of insulin, people with diabetes did not live long enough to develop complications of the disease. In 1922, Fredrick Banting and his colleagues discovered the process of extracting insulin; this has lead to the increased life expectancy of patients with diabetes. As a result of increasing longevity in diabetic patients, the frequency and variety of diabetic complications have also increased. Longer duration of the disease is associated with peripheral arterial disease, neuropathy, nephropathy, retinopathy and cardiovascular disease.

Dr. Paul Brand was the first to adopt the TCC, which he learned in India, for the treatment of diabetic foot ulcerations.[11] Brand modified the technique and reduced the amount of padding to allow the cast to conform to the leg. This reduced the shearing forces that occurred as the padding compressed and edema decreased, therefore reducing the risk of developing new ulcerations.[11]

Since that time numerous studies have demonstrated the effectiveness of TCC. Healing rates of plantar ulceration have been reported to range from 73% to 100% [12,13] and currently the TCC is considered the gold standard for offloading the plantar surface of the foot.[14] Lavery, et al., demonstrated a reduction of peak plantar pressure at the ulcer site ranging from 81% to 92% compared to canvas sneakers.[15] The exact mechanism by which TCC unloads the foot is not entirely clear. Two mechanisms have been proposed as to how the TCC offloads the foot: load distribution and load sharing.

The theory of load redistribution was introduced by Brand , who postulated that the decrease in pressure is due to an increase in the weight bearing surface area.[16] Since pressure is defined as force divided by area, increasing the surface area over which the plantar force is applied will in turn reduce the plantar pressure. Shaw, et al., found that TCC transferred load from the forefoot to the rearfoot.[17] Leibner and colleagues, however, found that the forefoot continued to bear the majority of plantar foot pressure (forefoot=36%, midfoot=13%, rearfoot 15%), despite a significant decrease in the overall plantar load.[18] These finding are similar to those of other authors, and the load redistribution theory appears to play a lesser role than previously thought.[19,20] The second theory, known as load sharing, was described by Shaw, et al., in 1997.[17] They postulated that the decrease in plantar pressure is due to the proximal portion of the TCC bearing much of the load. To support this theory they demonstrated the proximal cast wall or shank bore 30% of the load during ambulation.

Leibner, et al., reported similar findings and demonstrated that the shank of the cast bore 36% of the weight bearing load.[18] Once the shank was removed, the plantar load increased to the entire foot (forefoot 36% to 56%, midfoot 13% to 17% and rearfoot 15% to 28%). These findings support the fact that load sharing, or the transfer of force to the tibia, is more important to offloading ulcerations than load distribution.

TCCs are effective for a number of reasons in addition to their ability to mitigate pressure. First, casting helps reduce and/or control edema.[21] This factor becomes obvious to the clinician at the first cast change and is why the initial cast must be changed at day three or four. Mueller, et al., also found that TCC decreases the risk of infection, thereby increasing the efficacy of the treatment.[21] Armstrong and colleagues believed that the most important attribute of the TCC may be its ability to "force compliance."[22] Multiple studies have shown that removable cast walkers (RCW) are as effective as TCC for offloading the plantar neuropathic ulcer, but clinically, the TCC and RCW are not equal.[23-25] The TCC heals a higher proportion of wounds in a shorter amount of time compared to the RCW.[26] This is due to the difficulty of removing the cast, so the patient has little choice other than to adhere to the regimen prescribed by the clinician. Armstrong, et al., reported that patients treated with a removable device wore the device for a total of 28% of their daily activity with the most compliant population not exceeding 60%.[27] Finally, it seems that the TCC significantly decreases the amount of ambulation and activity of the patient. This reduces the number of cycles of repetitive stress on the open ulceration.[26]

Some question exists on the effectiveness of TCC for the treatment of "non-forefoot" ulcerations. As stated previously, the TCC does not transfer the plantar force from the forefoot to rearfoot as much as previously was thought.[18-20]

	# of patients	# of Casts	Healing rate	Complication rate per patient	Complication rate per cast
Baker [31]	13	*	85	15	*
Boulton, et al. [13]	7	*	100	43	*
Guyton[7]	70	398	*	30	5.5
Helm, et al. [12]	22	*	73	14	*
Katz, et al.[34]	20	*	74	65	*
Laing, et al. [30]	46	*	77	11	*
Mueller, et al. [21]	21	*	90	14	*
Myerson, et al. [32]	67	*	90	12	*
Sinacore, et al. [33]	30	*	82	27	*
Wukich and Motko[8]	13	82	83	*	17
* =not reported					

Table 1 Literature reivew on the reported total contact casting complication rate.

Armstrong and Stacpoole-Shea found that TCC is significantly more effective at offloading heel pressure than any other offloading devices.[28] Walker and Helm demonstrated that the TCC is effective in both forefoot and non-forefoot ulcerations, though forefoot ulcerations healed significantly faster than ulcers on other parts of the foot.[29] Therefore, TCC should be considered for offloading all plantar ulcerations.

A major area of concern is the risk of iatrogenic complications with TCC therapy. Complication rates have ranged from 11% to 30% of high risk patients, though the vast majority of these complications are minor. (Table 1) Most of the reported major complications are due to previously undiagnosed osteomyelitis and patient noncompliance.[30-33] The most common minor complications are dermal abrasions.[7,8,13,30-34] Wukich and Motko found that 93% (13/14) of their complications were minor pressure ulcers and did not require a change in the treatment protocol.

The locations of these iatrogenic wounds were as follows: hindfoot – four, medial aspect of the navicular – four, tibial crest – three, and second toe – two. The authors found that the medial aspect of the navicular is a high risk area for pressure related complications in patients with Charcot arthropathy who had rocker bottom deformity. This is consistent with the findings of Guyton and colleagues.[7] To address the increase risk over the navicular, Wukich and Motko altered their TCC technique. While this did not prevent ulceration, all of the areas that were protected with adhesive-backed felt only developed stage I ulcerations. Areas protected by a single layer of cast padding led to stage II ulcerations. Iatrogenic abrasions generally heal quickly because they are not generally on the plantar aspect of the foot.[8, 21] Other complications include maceration,[34] fungal infection,[21] claustrophobic-like response to the cast,[32] the cast being too tight,[8] and difficulty ambulating.[30] The most important factor for decreasing the risk of iatrogenic compilations is frequent cast changing.[7,8]

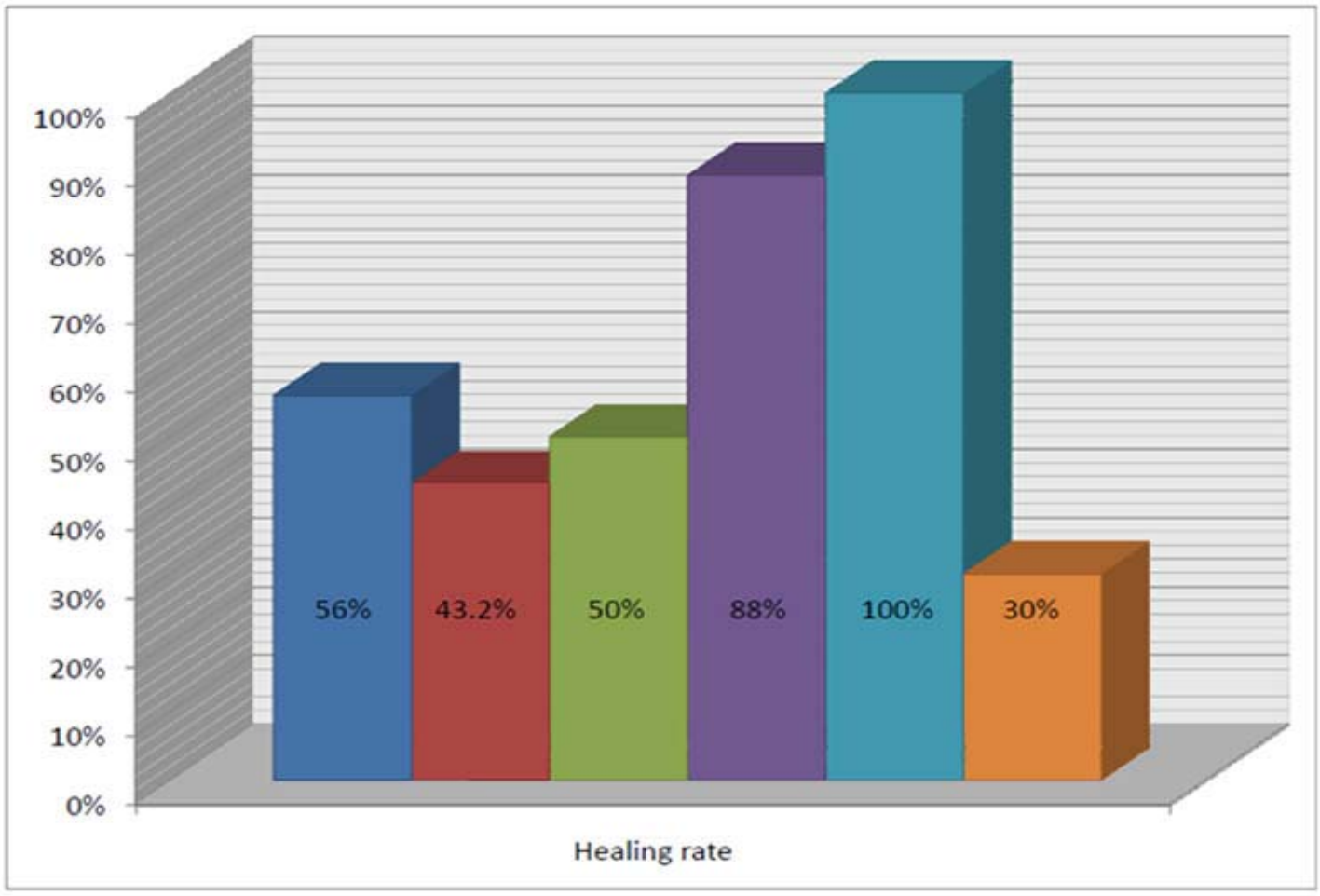

Figure 7

Guyton, et al., analyzed the iatrogenic complications associated with TCC.[7] They reported a complication rate of 5.5% per cast.[7] The authors then evaluated the various risk factors which may predict TCC complications. The highest risk for complication was Charcot neuroarthropathy, which was associated with 1.5 fold risk of increased complication.[7] The presence of diabetes (odds ratio [OR]=1.34) as opposed to other causes of neuropathy was also associated with an increased risk of iatrogenic complications.

The use of a cast after deformity-correcting surgery, the overall presence of neuropathy , age and time between cast changes were not found to increase the risk of complications.[7] The strict cast changing protocol and adherence to proper techniques likely reduced the risk of TCC complications.[7] While biomechanical and thermometric evaluation have shown that the contralateral limb does not seem to have an increased risk of ulceration this is always an area of potential concern due to a change in the patient's customary gait pattern.[15,35,36]

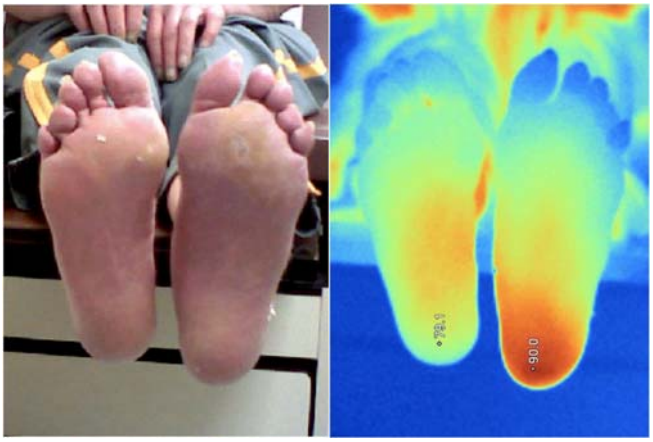

Figure 6 A and B A: Clinical photo of a patient treated with an Achilles tendon lengthening for a neuropathic forefoot ulceration. B: While the ulceration successfully healed, a thermometric photo shows an increase in temperature below the calcaneus indicating impending breakdown of the skin secondary to a over-lengthening of the triceps surae. (Photo courtesy of Nicholas Bevilacqua, DPM and Lee Rogers, DPM)

A separate risk of iatrogenic calcaneal ulceration exists if an Achilles tendon lengthening (TAL) has been performed in combination with TCC. Mueller, et al., found that TAL decreases the risk of ulcer recurrence by 75% at seven months and 52% at two years.[37] The decrease in recurrence is due to the decrease in plantar flexor power caused by a transient weakness of the triceps surae.[38] While a TAL offers a decrease in recurrence rate, over lengthening of the heel cord may result in a calcaneal gait and increased pressure on the plantar aspect of the heel.[37](Fig. 6 A and B) Nishimoto and colleagues estimated that the risk of overloading the heel is 2 to 10% in a diabetic population undergoing a TAL.[39] Care must be taken to avoid over-lengthening in any patient with a neuropathic heel.[37] Alternatively, one can consider performing a gastrocnemius recessions which has been postulated to reduce the risk of over lengthening the Achilles tendon while still offloading the forefoot.[40]

While the medical evidence supports the use of TCC in the treatment of plantar ulcers, this treatment modality is grossly underutilized and underappreciated.[14] The multi-billion dollar industry that has spawned the advanced wound care industry has not produced any treatment regimen that compares to the total contact cast. (Fig. 7) As the medical field continues to evolve towards evidence based medicine and possibly pay for performance, clinicians must reevaluate their present treatment protocols. The high efficacy of the total contact cast with the low risk of major complications will continue to be the gold standard for the treatment of neuropathic pedal ulcerations.

References

1. CDC. *Diabetes 2008: disabling disease to double by 2050.* 2008; Available from: http://www.cdc.gov/nccdphp/publications/aag/pdf/diabetes.pdf.
2. Singh, N., D.G. Armstrong, and B.A. Lipsky, *Preventing foot ulcers in patients with diabetes.* Jama, 2005. **293**(2): p. 217-28.
3. Lavery, L.A., et al., *Risk factors for foot infections in individuals with diabetes.* Diabetes Care, 2006. **29**(6): p. 1288-93.
4. Pecoraro, R.E., G.E. Reiber, and E.M. Burgess, *Pathways to diabetic limb amputation: basis for prevention.* Diabetes Care, 1990. **13**: p. 513-521.
5. CDC. *National diabetes fact sheet: general information and national estimates on diabetes in the United States, 2007.* 2008 [cited 2008; Available from: http://www.cdc.gov/diabetes/pubs/factsheet07.htm#contents.
6. Inlow, S., H. Orsted, and R.G. Sibbald, *Best practices for the prevention, diagnosis, and treatment of diabetic foot ulcers.* Ostomy Wound Manage, 2000. **46**(11): p. 55-68; quiz 70-1.

7. Guyton, G.P., *An analysis of iatrogenic complications from the total contact cast.* Foot Ankle Int, 2005. **26**(11): p. 903-7.
8. Wukich, D.K. and J. Motko, *Safety of total contact casting in high-risk patients with neuropathic foot ulcers.* Foot Ankle Int, 2004. **25**(8): p. 556-60.
9. Saltzman, C.L., et al., *Effect of initial weight-bearing in a total contact cast on healing of diabetic foot ulcers.* J Bone Joint Surg Am, 2004. **86-A**(12): p. 2714-9.
10. Khan, J.S., *Treatment of Leprous Trophic Ulcers.* Lepr India, 1939. **11**: p. 19-25.
11. Coleman, W.C., P.W. Brand, and J.A. Birke, *The total contact cast. A therapy for plantar ulceration on insensitive feet.* J Am Podiatry Assoc, 1984. **74**(11): p. 548-52.
12. Helm, P.A., S.C. Walker, and G. Pullium, *Total contact casting in diabetic patients with neuropathic foot ulcerations.* Arch Phys Med Rehabil, 1984. **65**(11): p. 691-3.
13. Boulton, A.J., et al., *Use of plaster casts in the management of diabetic neuropathic foot ulcers.* Diabetes Care, 1986. **9**(2): p. 149-52.
14. Wu, S.C., et al., *Use of pressure offloading devices in diabetic foot ulcers: do we practice what we preach?* Diabetes Care, 2008. **31**(11): p. 2118-9.
15. Lavery, L.A., et al., *Total contact casts: pressure reduction at ulcer sites and the effect on the contralateral foot.* Arch Phys Med Rehabil, 1997. **78**(11): p. 1268-71.
16. Brand, P.W., *The insensitive foot (including leprosy)*, in *Disorders of the Foot and Ankle*, Jahss M, Editor. 1991, Saunders: Philadelphia. p. 2170-2175.
17. Shaw, J.E., et al., *The mechanism of plantar unloading in total contact casts: implications for design and clinical use.* Foot Ankle Int, 1997. **18**(12): p. 809-17.
18. Leibner, E.D., et al., *Unloading mechanism in the total contact cast.* Foot Ankle Int, 2006. **27**(4): p. 281-5.
19. Hartsell, H.D., et al., *The effects of total contact casting materials on plantar pressures.* Foot Ankle Int, 2004. **25**(2): p. 73-8.
20. Wertsch, J.J., et al., *Plantar pressures with total contact casting.* J Rehabil Res Dev, 1995. **32**(3): p. 205-9.
21. Mueller, M.J., et al., *Total contact casting in treatment of diabetic plantar ulcers. Controlled clinical trial [see comments].* Diabetes Care, 1989. **12**(6): p. 384-8.
22. Armstrong, D.G., et al., *Off-Loading the Diabetic Foot Wound: a Randomized Clinical Trial.* Diabetes Care, 2001. **24**(6): p. 1019-1022.
23. Lavery, L.A., et al., *Reducing dynamic foot pressures in high-risk diabetic subjects with foot ulcerations. A comparison of treatments.* Diabetes Care, 1996. **19**(8): p. 818-21.
24. Pollo, F.E., et al., *Plantar pressures in fiberglass total contact casts vs. a new diabetic walking boot.* Foot Ankle Int, 2003. **24**(1): p. 45-9.
25. Baumhauer, J.F., et al., *A comparison study of plantar foot pressure in a standardized shoe, total contact cast, and prefabricated pneumatic walking brace.* Foot Ankle Int, 1997. **18**(1): p. 26-33.
26. Armstrong, D.G., et al., *Off-loading the diabetic foot wound: a randomized clinical trial.* Diabetes Care, 2001. **24**(6): p. 1019-22.
27. Armstrong, D.G., et al., *Activity patterns of patients with diabetic foot ulceration: patients with active ulceration may not adhere to a standard pressure off-loading regimen.* Diabetes Care, 2003. **26**(9): p. 2595-7.
28. Armstrong, D.G. and S. Stacpoole-Shea, *Total contact casts and removable cast walkers. Mitigation of plantar heel pressure.* J Am Podiatr Med Assoc, 1999. **89**(1): p. 50-3.
29. Walker, S.C., P.A. Helm, and G. Pullium, *Total contact casting and chronic diabetic neuropathic foot ulcerations: healing rates by wound location.* Arch Phys Med Rehabil, 1987. **68**(4): p. 217-21.

30. Laing, P.W., D.I. Cogley, and L. Klenerman, *Neuropathic foot ulceration treated by total contact casts.* J Bone Joint Surg Br, 1992. **74**(1): p. 133-6.
31. Baker, R.E., *Total contact casting.* J Am Podiatr Med Assoc, 1995. **85**(3): p. 172-6.
32. Myerson, M., et al., *The total-contact cast for management of neuropathic plantar ulceration of the foot.* J Bone Joint Surg Am, 1992. **74**(2): p. 261-9.
33. Sinacore, D.R., et al., *Diabetic plantar ulcers treated by total contact casting. A clinical report.* Phys Ther, 1987. **67**(10): p. 1543-9.
34. Katz, I.A., et al., *A randomized trial of two irremovable off-loading devices in the management of plantar neuropathic diabetic foot ulcers.* Diabetes Care, 2005. **28**(3): p. 555-9.
35. Hartsell, H.D., R.A. Brand, and C.L. Saltzman, *Total contact casting: its effect on contralateral plantar foot pressure.* Foot Ankle Int, 2002. **23**(4): p. 330-4.
36. Armstrong, D.G., P.J. Liswood, and W.F. Todd, *Contralateral limb during total contact casting. A dynamic pressure and thermometric analysis.* J Am Podiatr Med Assoc, 1995. **85**(12): p. 733-7.
37. Mueller, M.J., et al., *Effect of Achilles tendon lengthening on neuropathic plantar ulcers. A randomized clinical trial.* J Bone Joint Surg Am, 2003. **85-A**(8): p. 1436-45.
38. Maluf, K.S., et al., *Tendon Achilles lengthening for the treatment of neuropathic ulcers causes a temporary reduction in forefoot pressure associated with changes in plantar flexor power rather than ankle motion during gait.* J Biomech, 2004. **37**(6): p. 897-906.
39. Nishimoto, G.S., C.E. Attinger, and P.S. Cooper, *Lengthening the Achilles tendon for the treatment of diabetic plantar forefoot ulceration.* Surg Clin North Am, 2003. **83**(3): p. 707-26.
40. Greenhagen, R.M., et al., *Gastrocnemius Recession as an Alternative for Relief of Forefoot Pressure in Patients with Peripheral Neuropathy: A Case Report.* J Foot Ankle Surg, 2009. **In press**.
41. Veves, A., et al., *Graftskin, a human skin equivalent, is effective in the management of noninfected neuropathic diabetic foot ulcers: a prospective randomized multicenter clinical trial.* Diabetes Care, 2001. **24**(2): p. 290-5.
42. Blume, P.A., et al., *Comparison of negative pressure wound therapy using vacuum-assisted closure with advanced moist wound therapy in the treatment of diabetic foot ulcers: a multicenter randomized controlled trial.* Diabetes Care, 2008. **31**(4): p. 631-6.
43. Smiell, J.M., et al., *Efficacy and safety of becaplermin (recombinant human platelet-derived growth factor-BB) in patients with nonhealing, lower extremity diabetic ulcers: a combined analysis of four randomized studies.* Wound Repair Regen, 1999. **7**(5): p. 335-46.
44. Marston, W.A., et al., *The efficacy and safety of Dermagraft in improving the healing of chronic diabetic foot ulcers: results of a prospective randomized trial.* Diabetes Care, 2003. **26**(6): p. 1701-5.