Clinical Research

Negative Pressure Therapy Makes Diabetic Foot Dorsum Defects Suitable for Skin Graft Reconstruction

Erkan ORHAN[1,a], Enver ARPACI[2]

[1]*Gaziantep Üniversitesi Tıp Fakültesi, Plastik-Rekonstrüktif ve Estetik Cerrahi Anabilim Dalı, Gaziantep, Türkiye*
[2]*Başkent Üniversitesi Tıp Fakültesi, Plastik-Rekonstrüktif ve Estetik Cerrahi Anabilim Dalı, Konya, Türkiye*

ABSTRACT

Objective: The aim of diabetic foot ulcer reconstruction is to close wounds with a soft tissue of appropriate width and thickness that allows the patient to walk. Tissue reconstruction of appropriate fineness in foot dorsum is ensured with skin grafts. However, since tendon and bony tissues are often exposed in foot dorsum defects, it is normally not possible to perform reconstruction with a skin graft. By negative pressure therapy (NPT) exposed tendons and bone will be covered with granulation tissue. In this study, we describe patient who had diabetic foot dorsum defects with exposed tendons and bone, which were completely covered with the granulation tissue after NPT and this made it possible to perform extremely fine graft reconstructions.

Material and Method: The study included diabetic patients with foot dorsum defects with exposed tendons and bones who were treated with NPT between 2013 and 2016.

Results: In that period 18 diabetic patients with foot dorsum defects with exposed tendons and bones who were treated with NPT. On average, patients' wounds were 25.28 cm^2 and they underwent 5.9 NBT sessions during 28.7 hospital days. The defects of all patients were reconstructed with grafts. In the one-year postoperative follow-ups, there were no problems; all patients were mobile and could wear comfortable shoes.

Conclusion: Graft reconstruction after NBT is a reliable treatment option for foot dorsum defects in diabetic patients.

Keywords: *Negative Pressure Therapy, Diabetic Foot Ulcers, Skin Grafts.*

ÖZET

Negatif Basınçlı Terapinin Diyabetik Hastalardaki Ayak Dorsumu Defektlerini Deri Grefti Rekonstrüksiyonuna Uygun Hale Getirmesi

Amaç: Diyabetik ayak ülserlerinin rekonstrüksiyonunda amaç, hastanın yürümesine olanak sağlayacak şekilde yaraların, uygun kalınlık ve genişlikteki yumuşak doku ile kapatılmasıdır. Uygun incelikte doku ile ayak dorsumu rekonstrüksiyonu greftler ile sağlanabilir. Fakat, çoğu zaman ayak dorsumu defektlerinde kemik ve tendonlar ekspoze olmakta ve deri grefti ile rekonstrüksiyon mümkün olamamaktadır. Negatif basınçlı terapi (NBT) ile ekspoze tendon ve greflerin üzeri granülasyon dokusu ile kaplanabilmektedir. Bu çalışmada, kemik ve tendonların üzerinin NBT yardımı ile tamamen granülasyon dokusu ile kaplandığı ve bu şekilde greft ile uygun şekilde yaraların rekonstrükte edildiği, ayak dorsumu defekti olan diyabetik hastaları sunmaktayız.

Gereç ve Yöntem: Bu çalışmaya, 2013 ile 2016 yılları arasında kemik ve tendonların ekspoze olduğu ayak dorsumu defekti olan ve NBT ile tedavi edilen hastalar dahil edilmiştir.

Bulgular: NBT bu dönemde 18 hastada kullanılmıştır. Hastalar ortalama 25.28 cm^2 yara alanına sahiplerdi ve ortalama 28.7 gün yatarak tedavi gördürerek ortalama 5.9 seans NBT ile tedavi edildiler. Tüm hastaların yaraları greft ile kapatıldı. Bir yıllık takiplerinde herhangi bir problem izlenmedi ve tüm hastaların rahatlık ile ayakkabı giyip yürüyebildiler.

Sonuç: Biz ayak dorsumu defekti olan diyabetik hastalarda NBT ile beraber greft ile rekonstrüksiyonunun iyi bir seçenek olduğu kanaatindeyiz.

Anahtar Sözcükler: *Negatif Basınçlı Terapi, Diyabetik Ayak Ülseri, Deri Greft.*

Bu makale atıfta nasıl kullanılır: Orhan E, Arpacı E. Negatif Basınçlı Terapinin Diyabetik Hastalardaki Ayak Dorsumu Defektlerini Deri Grefti Rekonstrüksiyonuna Uygun Hale Getirmesi. Fırat Tıp Dergisi 2019; 24 (3): 117-121.

How to cite this article: Orhan E, Arpacı E. Negative Pressure Therapy Makes Diabetic Foot Dorsum Defects Suitable for Skin Graft Reconstruction. Firat Med J 2019; 24 (3): 117-121.

Diabetes is a metabolic disease affecting more than 350 million people around the World (1). Diabetic foot ulcers are wounds that appear on the feet of 15-25% of diabetic patients due to vasculopathy and neuropathy (2, 3). Compared to other complications of diabetes, these wounds progress with higher morbidity and lead to longer inpatient treatment because they restrict ambulation. Ulcer treatment is long and costly, and in the absence of appropriate treatment, it can result in minor or major extremity amputations. Foot ulcers are the most common reason for non-traumatic foot amputation (2).

The treatment of diabetic foot ulcers starts with a good glucose control. Next, debridement is done to clean all callus, necrotic, fibrous, and infected tissues to treat infection and provide vascularization in the extremity (2-4). Foot defects that occur after debridement usually require graft reconstruction with local or free flaps (4). The aim is to close wounds with a soft tissue of appropriate width and thickness that lets patients walk (5).

Free flaps are the most appropriate method since they provide appropriately-thick tissue for plantar defects. Foot dorsum skin is considerably thinner than plantar

[a]Yazışma Adresi: Erkan ORHAN, Gaziantep Üniversitesi Tıp Fakültesi, Plastik-Rekonstrüktif ve Estetik Cerrahi Anabilim Dalı, Gaziantep, Türkiye
Tel: 0282 250 7330 e-mail: eorhan@yahoo.com
Geliş Tarihi/Received: 18.07.2018 Kabul Tarihi/Accepted: 23.11.2018

skin, so for free-flap reconstructions, flap thickness is usually thicker than the defect. This prevents patients from wearing appropriate shoes and restricts walking (5). Tissue reconstruction of appropriate fineness in the foot dorsum can be ensured with grafts. However, since tendon and bony tissues are usually exposed in foot dorsum defects, it is not possible to reconstruct them with a skin graft (6).

Negative pressure therapy (NPT) is a non-surgical wound treatment that increases the formation of granulation tissue (6-8). It was developed for closing large, chronic, and infected wounds but recently it has also been used for traumatic wounds. This makes it possible to close the wounds, and if required, wounds can be closed with simpler surgical techniques than would otherwise be required. In this study, we present patients who have undergone successful NPT that resulted in completely covering exposed tendons and bone with granulation tissue. This made it possible to perform extremely fine graft reconstruction, leading to a satisfactory result that let diabetic patients walk even after having large foot dorsum wounds.

MATERIAL AND METHOD

Patients in this study had foot dorsum diabetic ulcers and soft tissue defects that exposed tendons and bone. They underwent NPT between November 2013 and June 2016. This study evaluates their cases retrospectively. Informed consent was obtained from all individual participants. No criteria were used to exclude patients from the study. We recorded patients' ages, genders, the area of defects in foot dorsum, NPT session applied, duration of hospitalization, and lysis amounts in the graft after reconstruction.

Necrotic tissues were removed from wounds surgical debridement in the operating room environment. All patients were under anesthesia. Debridement was repeated every two days if it was insufficient the first time. All dead tissue was removed from the wounds and NPT was initiated with a vacuum assistant closure system (Kinetic Concepts, Inc, San Antonio, Texas, USA). Polyurethane sponges were cut to size and placed over the wounds, so they were completely covered the wounds but did not cover surrounding skin. Next, the sponge was covered with an adhesive to create an air-tight seal. A small hole was made in the sponge and a hose was attached between the sponge and a collecting vessel.

NPT was repeated with clean sponges three times a week on Mondays, Wednesdays, and Fridays when patients were in bed. A negative pressure of 125 mm/Hg was applied to all patients. NPT was applied continuously during the first three days then intermittently: 5 minutes actives and 2 minutes passive (6).

NPT was repeated until exposed bones and tendons were completely covered with granulation tissue. Next, defects were reconstructed with 2.0-cm thick Split thickness skin graft (STDG) from the thigh. The patients were followed-up at least for one year in the post-operative period.

RESULTS

Between November 2013 and June 2016, 18 diabetic patients (5 female and 13 male) with foot dorsum defects and exposed tendons underwent NPT. The average age of the patients was 55.17 (47-71) years. The average area of defects was 25.28 (±6.62) cm^2. The average number of NPT sessions was 5.9 (4-10). The average length of hospitalization was 28.7 (16-45) days. All dressings were changed at the bedside and there was no pain. The defects of all patients were reconstructed with grafts. The grafts adhered at an average rate of 91.1% (75-100%), and a patient with 25% lysis was subjected to grafting twice. In other patients, the missing graft area recovered from secondary healing. There were no problems in the one-year postoperative follow-ups. All patients are mobile and could wear comfortable shoes (Table 1).

Case 1

A 65-year-old male patient was admitted with necrosis on the dorsa of the left foot and toes. Debridement of all necrotic tissues and amputation of the finger revealed a 7×4 cm defect with exposed tendons on left foot dorsum. After 6 NPT sessions, the surface of the defect was completely covered by granulation tissue. The defect was reconstructed with skin grafts and there were no complications after one year (Figure 1a-d).

Figure 1a. *View of 65 years old male patient's foot with necrosis on the dorsum of the foot and fingers.*

Figure 1b. *View of the 7 x 4 cm defect with exposed tendon on the base of the wound after debridement and amputation of the finger.*

Figure 1c. *With 6 sessions of NPT treatment, the surface of the defect were completly covered by granulation tissue and the defect was reconstructed with skin grafts.*

Figure 1d. *View of the defect in the 3 months postoperative. There were no complication.*

Case 2

A 53-year-old male patient was admitted with necrosis on the left foot dorsum. Debridement of all necrotic tissues revealed a 6×4 cm defect with exposed tendons. After 5 NPT sessions, the defect surface was completely covered by granulation tissue. It was reconstructed with skin grafts and there were no complications after one year (Figure 2a-d).

Figure 2a. *View of 53 years old male patient's foot with 6x4 cm defect on the dorsum of the foot with exposed tendon after debridement.*

Figure 2b. *With 5 sessions of NPT treatment, the surface of the defect were completly covered by granulation tissue and the defect was reconstructed with skin grafts.*

Figure 2c. *The defect was reconstructed with skin grafts.*

Figure 2d. *View of the defect in the 3 months postoperative. There were no complication.*

DISCUSSION

The aim of reconstructing defects in diabetic foot ulcers is to close the wound with well-vascularized tissue of sufficient thickness and contour to allow the patient to walk with friction-resistant shoes (9). As with all defects, the reconstruction options for diabetic foot ulcers are grafts, local flaps, and free flaps. The simplest option is grafts, however, when reconstruction in the plantar area does not fill contours, the graft tears quickly and does not withstand friction (10). Hence flaps are preferred for plantar defects. For large defects, free flaps are most appropriate (11).

Graft reconstruction is an appropriate option for foot dorsum because they have a thinner and flatter struc-

ture, they do not make contact with the ground, and do not bear weight. However, skin graft reconstruction requires a well-vascularized bed and cannot be applied to exposed bone, cartilage, tendons, or surgical implants. This is not possible in foot dorsa because there is no subcutaneous muscle tissue and little adipose tissue, so tendons and bone are usually exposed (6). Free flaps are preferred in large foot dorsum defects in the plantar area, but free flaps are thick and can prevent patients from wearing appropriate shoes and restrict walking. To address this, free flaps must be de-bulked in almost half of patients after free flap reconstruction (5, 11). Alternatively, exposed tendons and bone can be covered with granulation tissue, which makes it possible to perform fine graft reconstruction (10).

NPT was principally developed to make large, chronic, and infected wounds suitable for reconstruction (12). It was first used by Fleischmann in 1993 and after Morywas and Argenta suggested using polyurethane foam it became more popular (12, 13). Following surgical debridement, NPT increases the formation of granulation tissue and thus, a large wound can be reconstructed with less aggressive surgical procedures and small wounds can be closed without surgery (12, 14).

NPT removes excess exudate and edema from the wound site (12) and can remove over 500 cc of fluid in the first 24 hours. NPT reduces edema and exudate surrounding the wound, blood vessels dilate, and blood flow increases. Increased blood flow causes granulation tissue to form more rapidly (8). Joseph et al. (15) showed that with NPT, granulation tissue forms much faster than wet dressings, in a randomized prospective study.

There are many studies on NPT's effectiveness for treating wounds from high energy trauma with exposed bone and plates. For example, Mullner et al. (16) reported that granulation tissue completely covered this type of wound in lower extremities. The prospective study reported an average of 16 days of NPT treatment for 12 patients. DeFranzo et al. (8) also reported on these lower-extremity defects in 75 patients; 12 patients' wounds closed primarily, skin grafts were used in 58 patients, and local flaps were used to reconstruct wounds in 5 patients. None required free flap surgery and there were no complications in six-month to six-year follow-ups. Lang et al. (17) reported on 96 patients with this type of wound. After an average six-weeks of NPT, granulation tissue completely covered wounds and 92 patients' wounds could be closed with grafts or local flaps. In our clinic, sufficient granulation tissue developed in these wounds in 63 patients after an average of 27 days of NPT; graft reconstruction was performed in 58 patients. These studies consistently show that post-traumatic defects with exposed bone, tendon, and plaques in the ankle and foot can be covered with sufficient granulation tissue in 2-6 week (6-19 sessions) of NPT treatment (7, 8).

In this study, exposed bones and tendons were completely covered with granulation tissue after an average of 5.9 NPT sessions. This made it possible to do graft reconstructions of appropriate fineness on foot dorsum. There was no graft separation in the one-year follow-ups and the patients had no problems wearing comfortable shoes.

Although it is a very effective treatment, NPT has some potential complications. There may be pain while changing sponges and during NPT. The pain is intermittent and is mostly due to the negative pressure, so it can mostly be eliminated by reducing the pressure (18). In our study, none of the patients complained about pain. Theoretically, NPT can cause arterial injury and major bleeding, so it is contraindicated to apply spongstudy, none of the 75 patients had bleeding. However, in White et al. (19) study, there was a case with artery injury 22 days after NPT. Excessive granulation tissue may also cause bleeding, especially in children and young adults (20). In our study, none of the patients had bleeding.

In conclusion the aim of diabetic foot treatment is to ensure that patients walk. It is indisputable that the most appropriate reconstruction option is free flaps for large plantar defects. However, NPT makes successful graft reconstructions possible for foot dorsum defects and lets patients walk comfortably without long-term complications.

Acknowlegment:
The author received no financial support for the research, author- ship, and/or publication of this article.

Conflicting Interests:
The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

REFERENCES

1. Schrauwen P, van Marken Lichtenbelt WD. Combatting type 2 diabetes by turning up the heat. Diabetologia 2016; 59: 226979.
2. Tchero H, Herlin C, Bekara F, Kangambega P, Sergiu F, Teot L. Failure rates of artificial dermiş products in treatment of diabetic foot ulcer: A systematic review and network meta-analysis. Wound Repair Regen 2017; 25: 691-6.
3. Wang R, Feng Y, Di B. Comparisons of negative pressure wound therapy and ultrasonic debridement for diabetic footulcers: a network meta-analysis. Int J Clin Exp Med 2015; 8: 12548-56.
4. Cavanagh PR, Bus SA. Off-loading the diabetic foot for ulcer prevention and healing. Plast Reconstr Surg 2011; 127: 248S-56S.
5. Neville RF, Kayssi A, Buescher T, Stempel MS. The diabetic foot. Curr Probl Surg 2016; 53: 408-37.
6. Herscovici D Jr, Sanders RW, Scaduto JM, Infante A, DiPasquale T. Vacuum-assisted wound closure (VAC therapy) for the management of patients with high-energy soft tissue injuries. J Orthop Trauma 2003; 17: 683-8.
7. Bovill E, Banwell PE, Teot L et al. Topical negative pressure wound therapy: a review of its role and guidelines for its use in the management of acute wounds. Int Wound J 2008; 5: 511-29.
8. DeFranzo AJ, Argenta LC, Marks MW et al. The use of vacuum-assisted closure therapy for the treatment of lower-extremity wounds with exposed bone. Plast Reconstr Surg 2001; 108: 1184-91.
9. Lin TS, Quing R. Long-term results of a one-stage secondary debulking procedure after flap reconstruction of the foot. Plast Reconstr Surg 2016; 138: 923-30.
10. Gross CE, Garcia R, Adams SB, DeOrio JK, Easley ME, Nunley JA 2nd. Soft tissue reconstruction after total ankle arthroplasty. Foot Ankle Int 2016; 37: 522-7.
11. Hong JP. Reconstruction of the diabetic foot using anterolateral thigh perforator flap. Plast Reconstr Surg 2006; 117: 1599-608.
12. Argenta LC, Morykwas MJ. Vacuum-assisted closure: a new method for wound control and treatment. Clinical experience. Ann Plast Surg 1997; 38: 563-76.
13. Novak A, Khan WS, Palmer J. The evidence-based principles of negative pressure wound therapy in trauma & orthopedics. Open Orthop J 2014; 27: 168-77.
14. Mooney JF III, Argenta LC, Marks MW, Morykwas MJ, DeFranzo AJ. Treatment of soft tissue defects in pediatric patients using the V.A.C. system. Clin Orthop Relat Res 2000; 376: 26-31.
15. Joseph E, Hamori CA, Bergman S, Roaf E, Swann NF, Anastasi GW. A prospective randomized trial of vacuum-assisted closure versus standard therapy of chronic nonhealing wounds. Wounds: A Compendium of Clinical Research and Practice 2000; 12: 60-7.
16. Mullner T, Mrkonjic L, Kwasny O, Vecsei V. The use of negative pressure to promote the healing of tissue defects: a clinical trial using the vacuum sealing technique. Br J Plast Surg 1997; 50: 194-9.
17. Lang E, Bauer G, Becker U, Bischoff M. The vacuum sealing technique in the treatment of foot and ankle trauma with severe soft-tissue damage. Aktuelle Traumatol 1997; 27: 223-7.
18. Krasner DL. Managing wound pain in patients with vacuum-assisted closure devices. Ostomy Wound Manage 2002; 48: 38-43.
19. White RA, Miki RA, Kazmier P, Anglen JO. Vacuum-assisted closure complicated by erosion and hemorrhage of the anterior tibial artery. J Orthop Trauma 2005; 19: 56-9.
20. Fuchs U, Zittermann A, Stuettgen B, Groening A, Minami K, Koerfer R. Clinical outcome of patients with deep sternal wound infection managed by vacuum-assisted closure compared to conventional therapy with open packing: a retrospective analysis. Ann Thorac Surg 2005; 79: 526-31.

Erkan ORHAN 0000-0001-6532-5840
Enver ARPACI 0000-0001-6713-8387