المنظمة الإسلامية للعلوم الطبية
The Islamic Organization for Medical Sciences

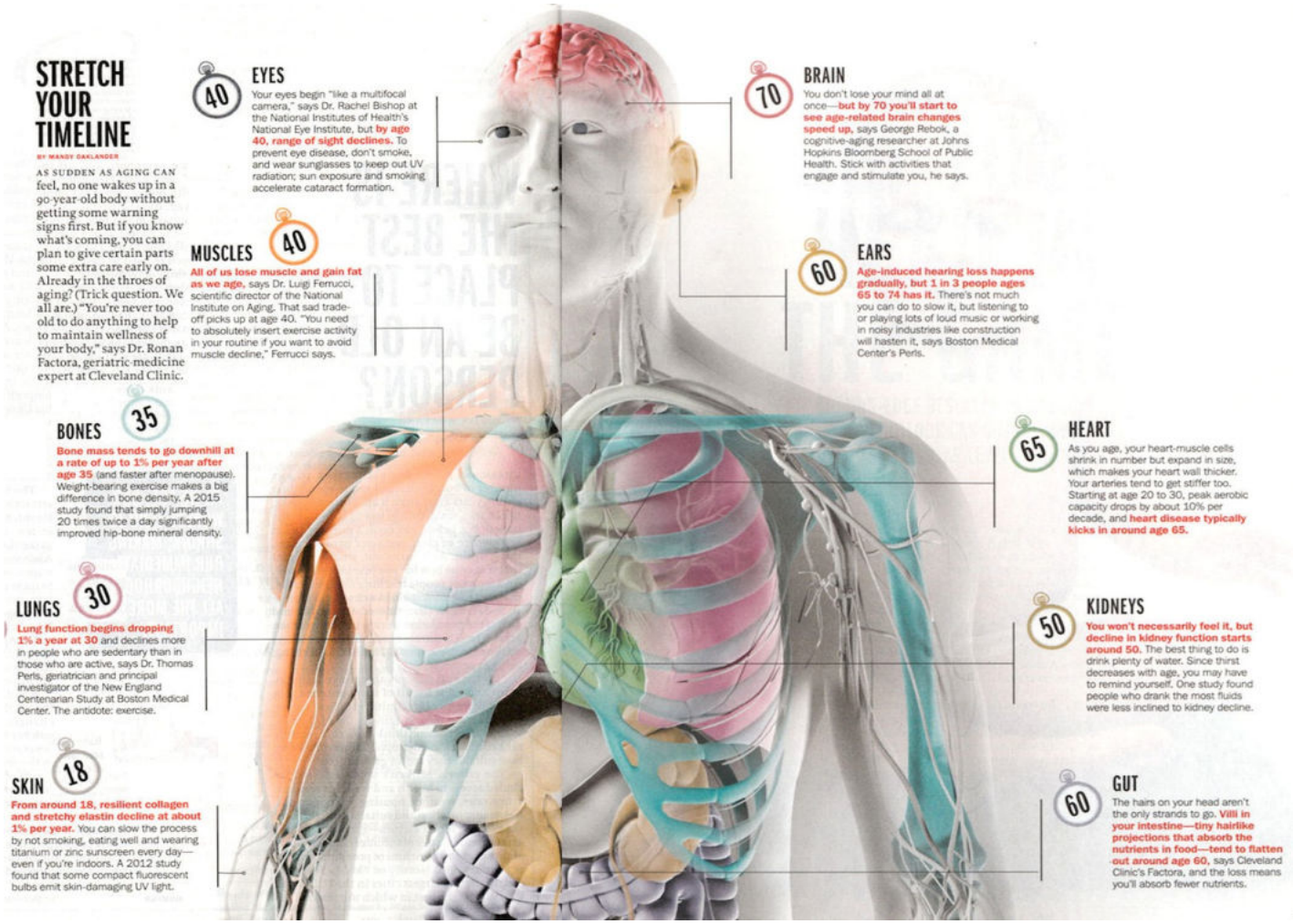
ROKIT HEALTHCARE

Health-care In-novation

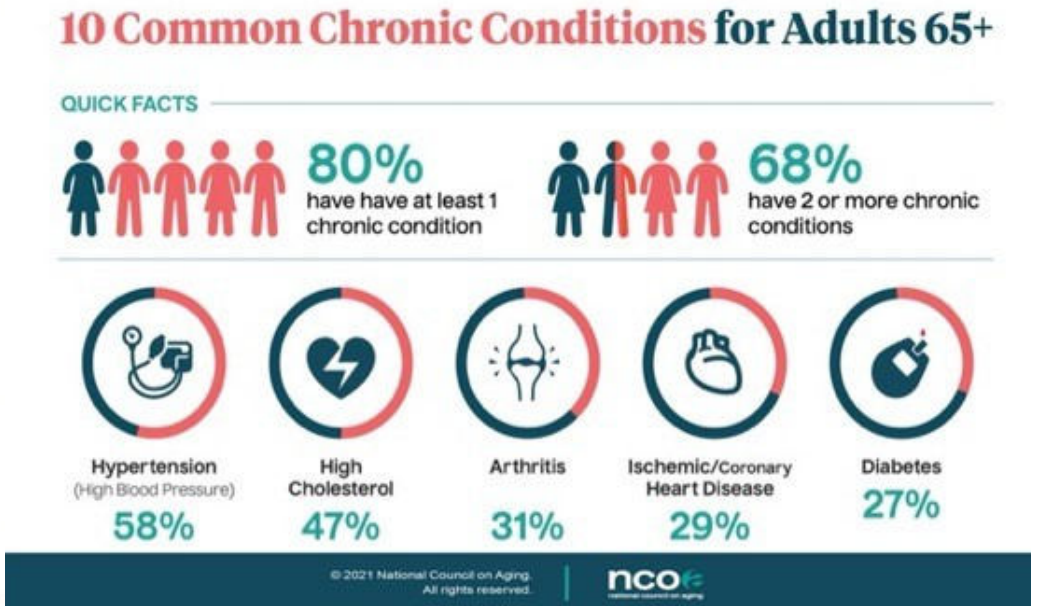
The Convergence of AI & Bio-print in Organ Regeneration

Sep. 2023

Life-long Chronic Diseases
Need for New Solution

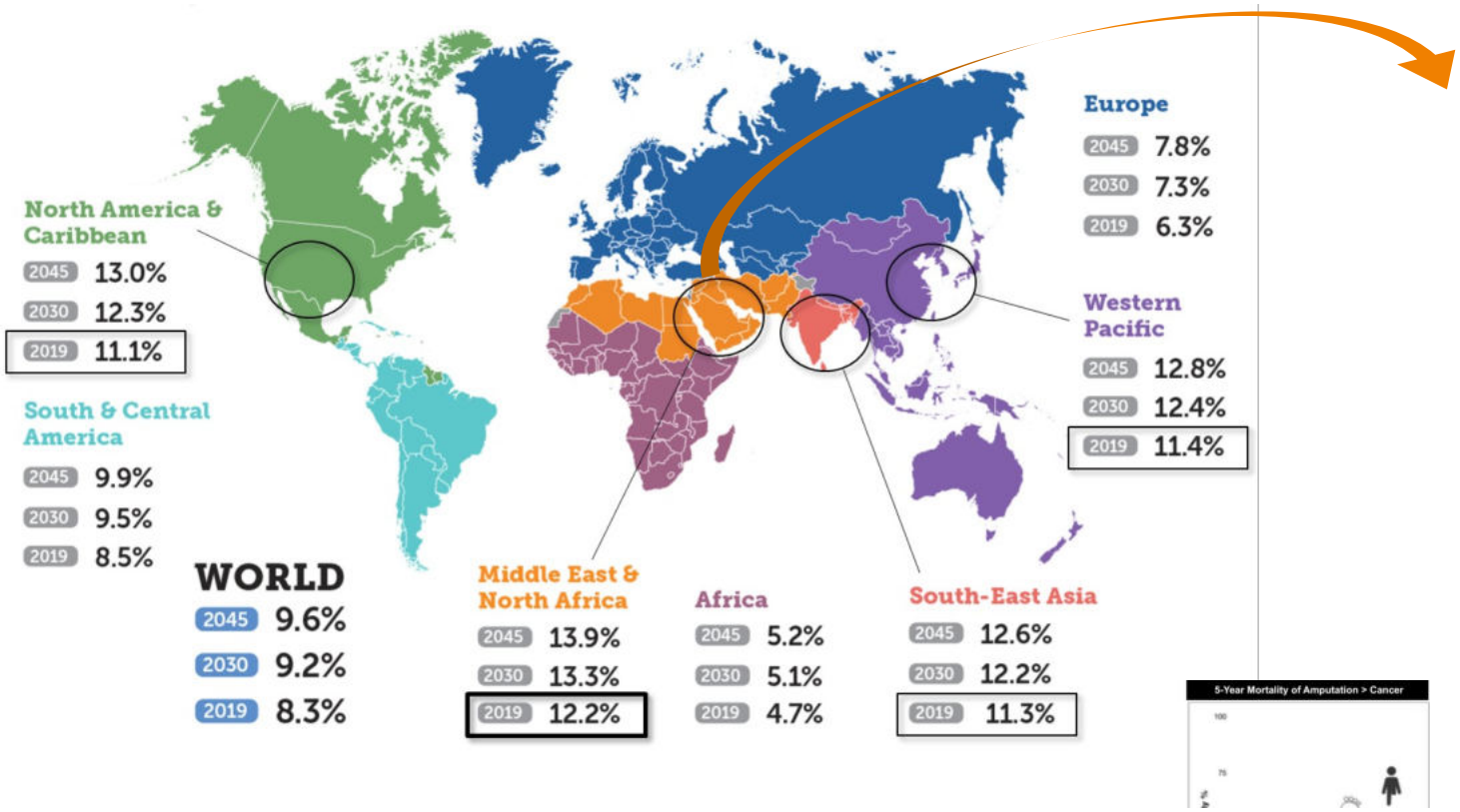


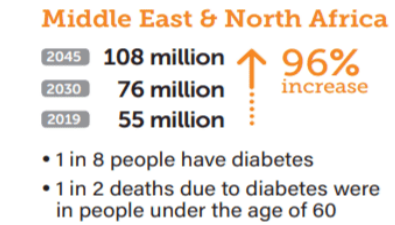
TIME, 2019

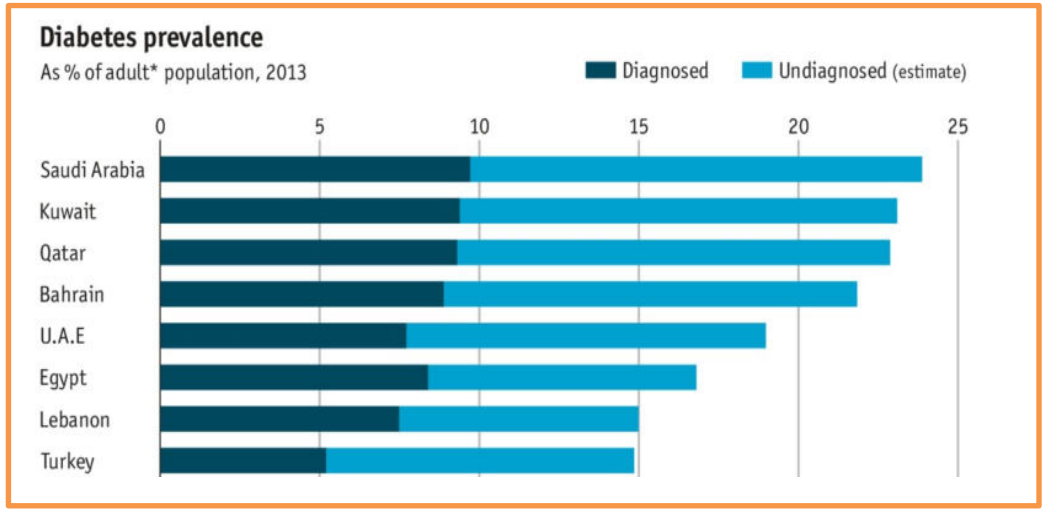


Worldwide Prevalence of Diabetes

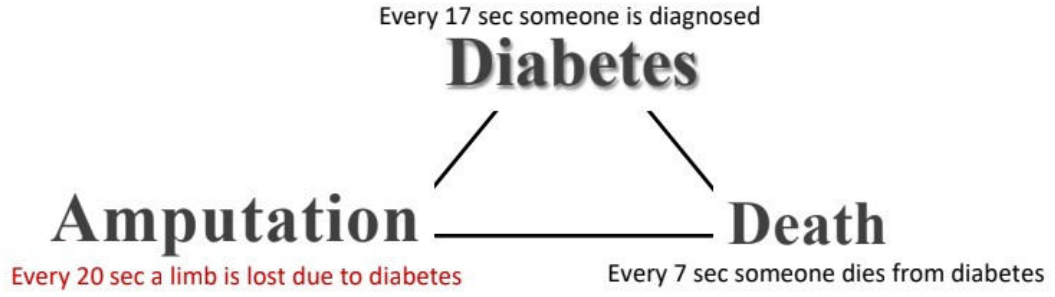
500 Million Diabetes Worldwide, 125 Million DFU Patients







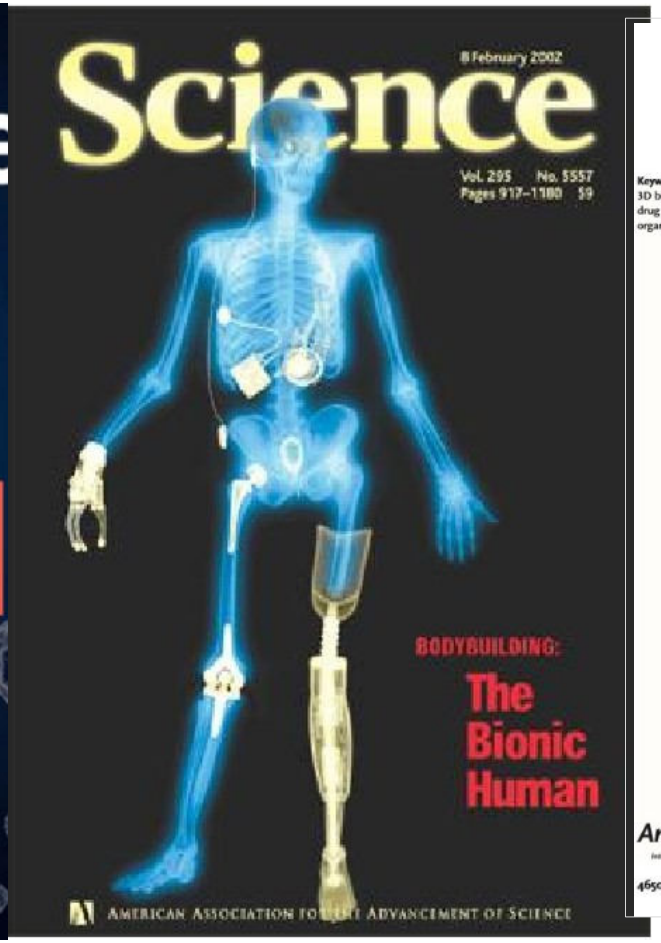
- ✓ 3/4 adults are living with diabetes (352 M), and up to 1/3 of the diabetes will develop a diabetic foot ulcer (117 M).
- ✓ The market is driven by unmet needs in low efficacy of existing treatment methods, (i.e. < 53% biological dressings).

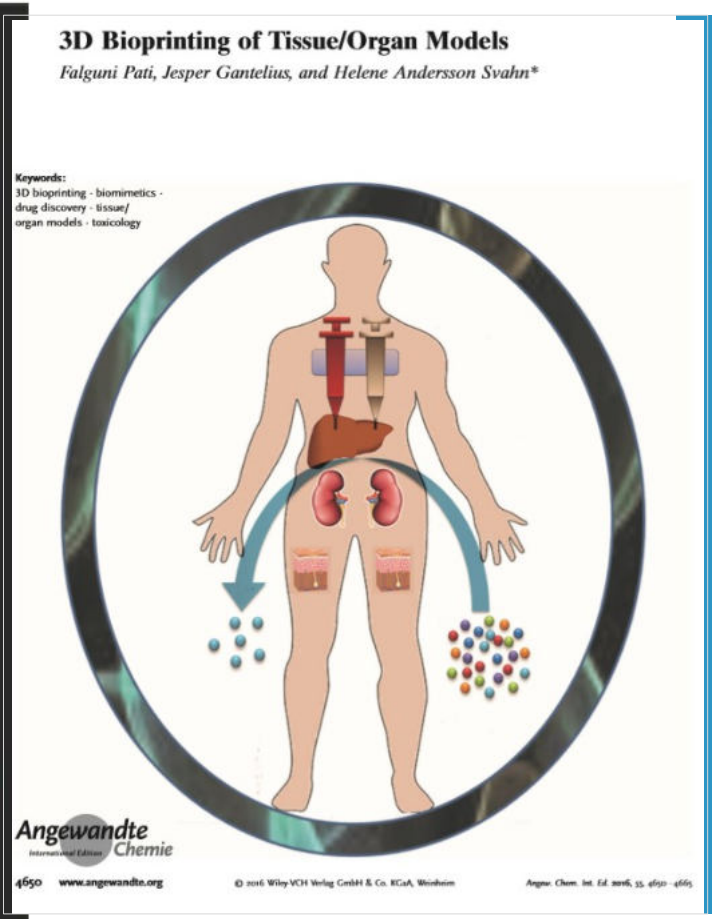


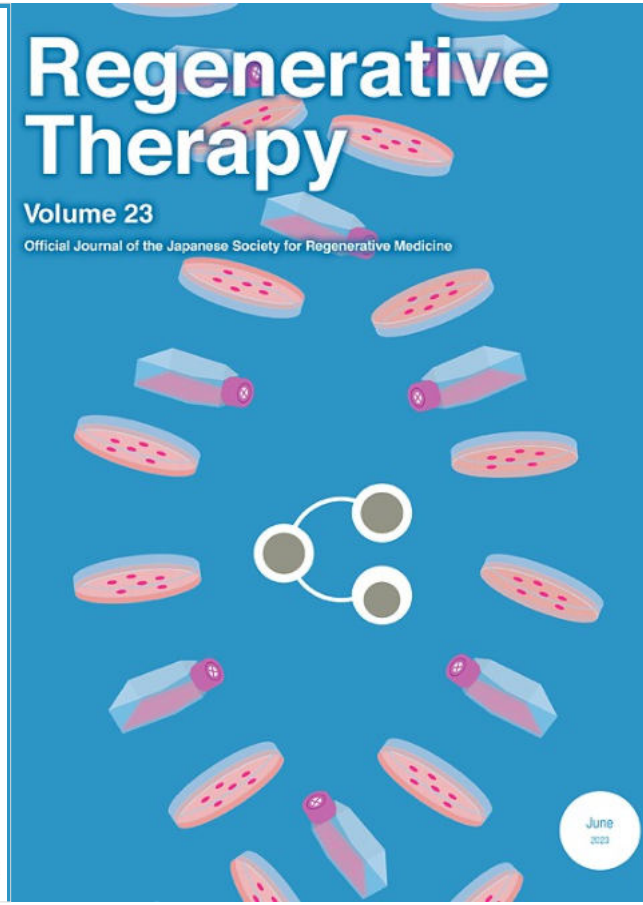
<Source: International diabetes federation, IDF Diabetes atlas, 9th edition 2019>

Armstrong et al. *Journal of Foot and Ankle Research* (2020) 13:16

Medical Science Development
Disruptive Convergence Technology

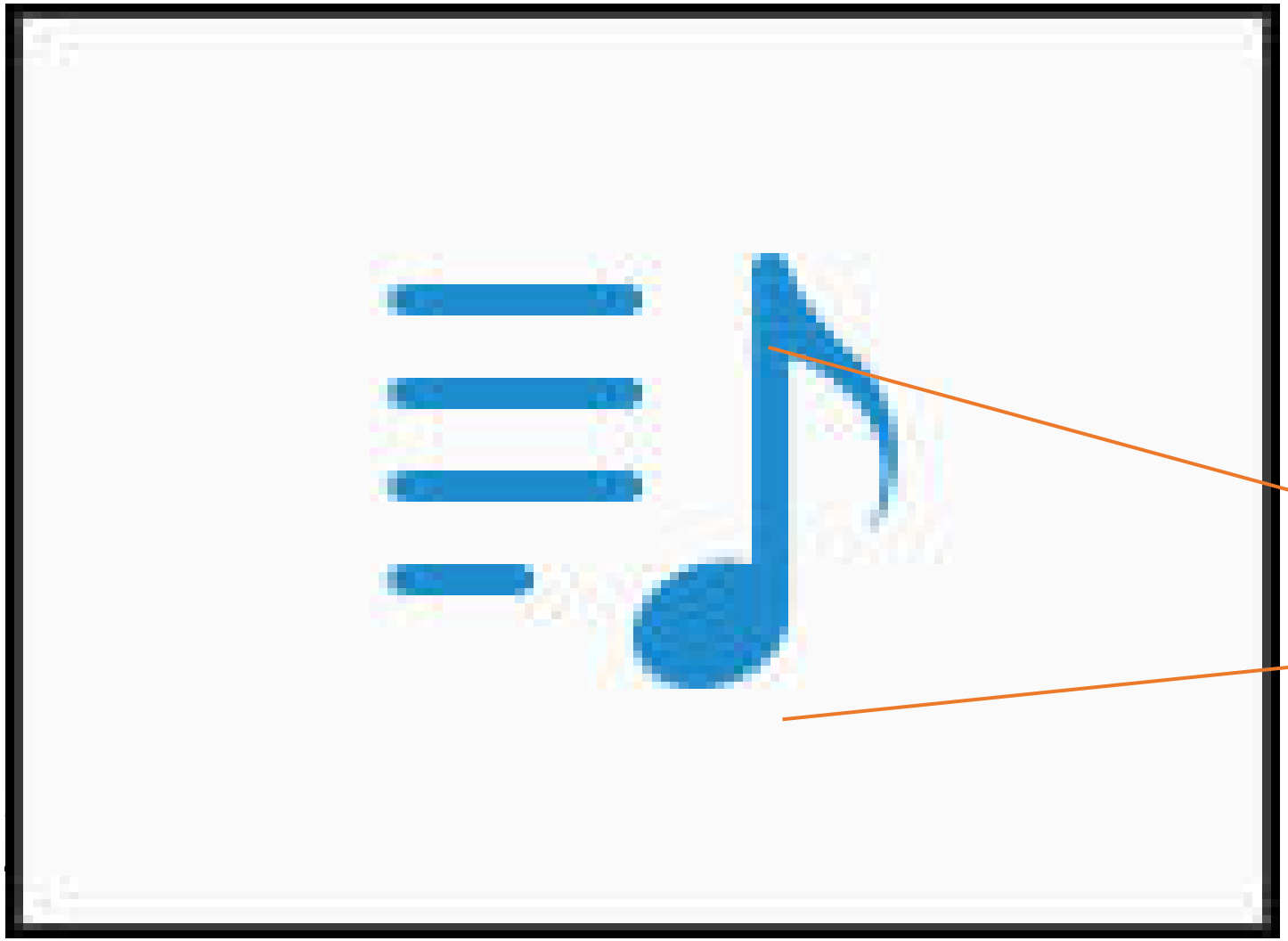


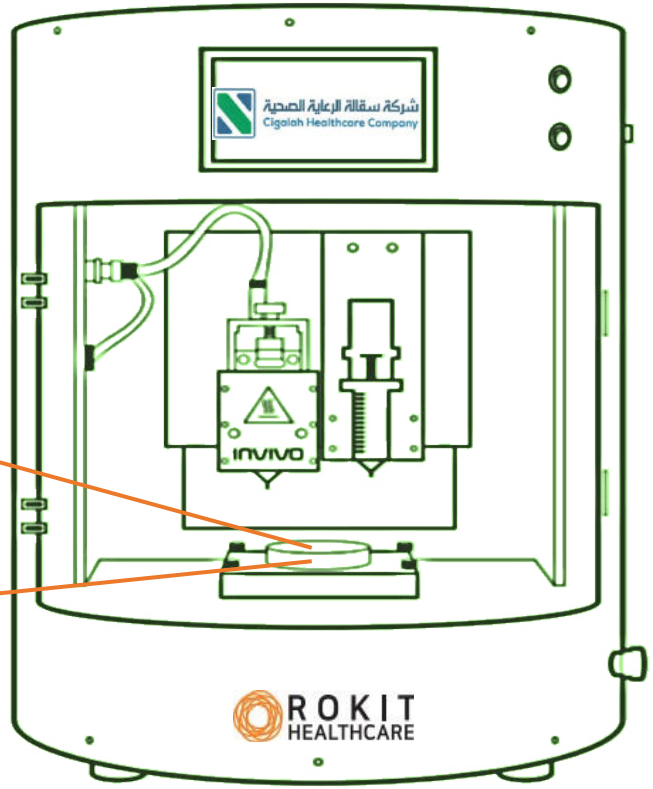




4th Industrial Revolution

3D Bioprinting in Organ Regeneration



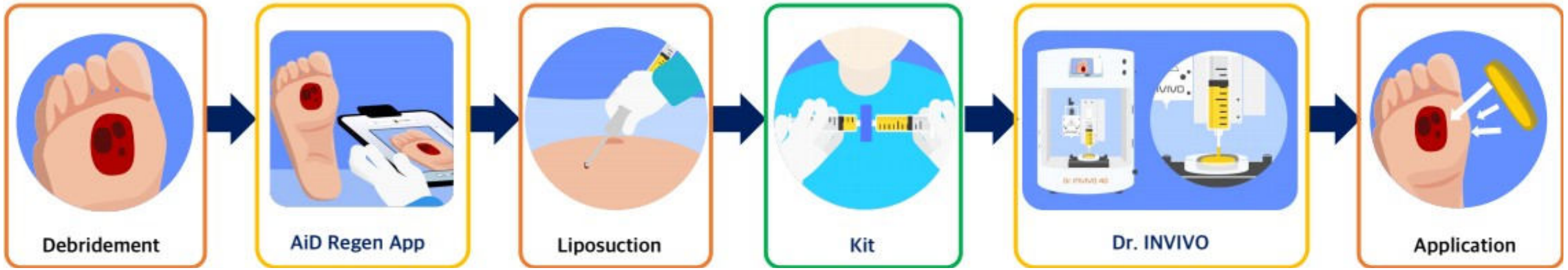


Paradigm Shift in Healthcare Service

Hyper-Personalized Autologous Therapy

Dr.INVIVO AI Regen Kit

Autologous ECM Patch for DFU Treatment



Wound Bed Preparation (e.g., Debridement)

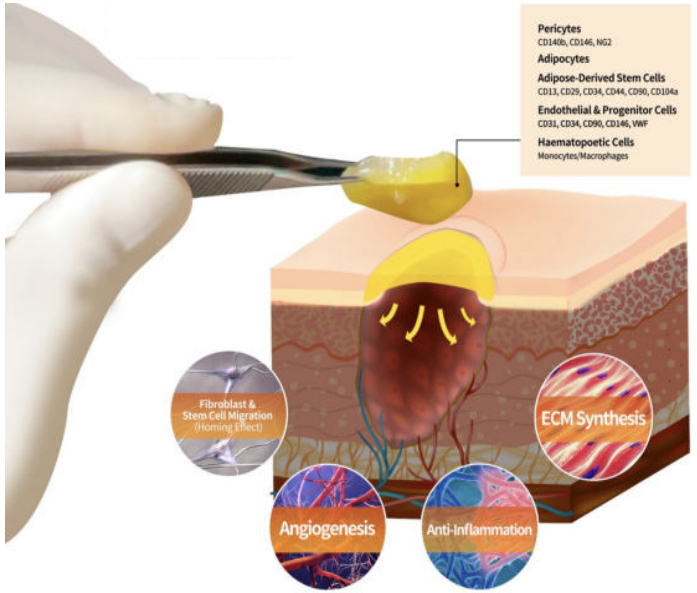
Wound Scanning Using AiD Regen

Autologous Tissue Harvesting (e.g., Fat)

Bioink Preparation

3D Bioprinting autologous ECM patch

Dressing



EU CE-MARK, US FDA, MENA Registration

Medical Device Approvals

Component	Class	Status
Dr. INVIVO 4D2D	CE Class 1	Complete
	FDA Class 1	Complete
	UAE (System)	Complete
	KSA Class A	Complete
	EGY Class 1	Progress
	BAH nonMD	Complete
AiD Regen	CE Class 1	Complete
	FDA Class 1	Complete
	KSA Class A	Complete
	BAH nonMD	Complete
Dr. INVIVO AI Regen KIT	CE Class 2a	Complete
	FDA Class 2	Complete
	UAE (System)	Complete
	KSA Class B	Complete
	EGY Class 2a	Progress
	BAH Class 2a	Progress

omparisons of Conventional Therapies
uality of Service & Regeneration Efficiency

Therapy	Regenerative Ther-apy	Skin Substitute	Skin Autograft	Negative Pressure Wound Therapy	Amputation
Manufac-turer	ROKIT Healthcare				
Product	Hyper-Personalized Skin Regeneration 	Epifix 		INFO V.A.C. 	
Description	3D wound-specific regenerative patch made of the patient's own adipose tissue fabricated with a 3D bioprinter				
Autologous	O	X	O	X	at all costs to be avoided (5-year mortality is higher than that of cancer)
Customiza-tion	O	X	X	X	
Combina-tion	Sole/Single	Combination/Mul-tiple	Combination/Mul-tiple	Combination/Mul-tiple	
Regenera-tive	O	X			
Recurrence	Low to zero				High

Global Pioneers & New Era

Clinical Approaches for Chronic Wound (DFU) Healing

Clinical studies with over 150 patients suffered from chronic ulcers in 6 countries showed skin regeneration within 4 weeks and had complete wound healing within 3 months.

Clinical Publication

Namgoong et al. 2022 *Journal of Clinical Medicine*

Han, Seung-Kyu MD, PhD
- Head of Plastic Surgery at Korea University Medical Center
- Chairman of Korean Society for Diabetic Foot

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Journal of *Clinical Medicine*

MDPI

Article

A Pilot Study Comparing a Micronized Adipose Tissue Niche versus Standard Wound Care for Treatment of Neuropathic Diabetic Foot Ulcers

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Abstract: Numerous studies have demonstrated the various properties of micronized adipose tissue (MAT), including angiogenic, anti-inflammatory, and regenerative activities, which can be helpful in wound healing. This exploratory clinical trial aimed to report the efficacy and safety of MAT niche for treating diabetic foot ulcers. Twenty subjects were randomly divided into MAT niche treatment (n = 10) and control groups (n = 10). All patients were followed up weekly for 16 weeks. We evaluated the efficacy of the MAT niche treatment by assessing the (1) reduction in wound area after 4 weeks and (2) percentage of patients who achieved complete wound closure after 16 weeks. All possible adverse events were recorded. The wound area was reduced by 4.3 ± 1.0 cm² in the treatment group and by 2.0 ± 1.1 cm² in the control group (p = 0.043). Complete wound healing was achieved after 16 weeks in eight out of 10 patients (80%) in the treatment group and three out of six (50%) in the control group (p = 0.299). No serious adverse events related to MAT niche treatment were observed. Although the present study's findings do not support the use of this therapy to treat foot ulcers of patients with diabetes owing to the small number of patients included and the absence of statistical significance, the results of this pilot preliminary study are promising in that MAT niche autografts may offer the possibility of a simple and effective treatment for diabetic ulcers. Further follow-up studies with a larger number of patients are required to validate our findings.

Keywords: diabetic foot; micronized adipose tissue

Citation: Namgoong, S.; Yoon, I.-J.; Han, S.-K.; Son, J.-W.; Kim, J. A Pilot Study Comparing a Micronized Adipose Tissue Niche versus Standard Wound Care for Treatment of Neuropathic Diabetic Foot Ulcers. *J. Clin. Med.* **2022**, *11*, 5887. https://doi.org/10.3390/jcm11195887

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1. Introduction

Since the first report on autologous adipose tissue graft was published in the early 20th century [1], it has long been commonly used in cosmetic and reconstructive surgery [2]. Initially, adipose tissue grafts were used for their volume-increasing effect, such as in breast reconstruction secondary to oncologic resection or facial volumizing secondary to age-related volume loss. However, adipose-derived stem cells (ASCs) were discovered by Zuk et al. in 2002 [3], promoting a plethora of research on the regenerative properties of adipose tissue. Thus, the scope of clinical application of adipose tissue graft is now being expanded beyond volumizing procedures to skin rejuvenation procedures [4–6] and treatment of wounds [7–9], among others.

Recently, micronized adipose tissue (MAT) obtained by mechanical dissolving, as opposed to collagenase usage, has been newly developed and has demonstrated positive effects of angiogenesis, antioxidant properties, and protein synthesis in vitro [10] and in vivo [11]. MAT has been demonstrated to have favorable therapeutic effects in treating scars and improving wrinkles clinically [12]. Considering the regenerative potential of MAT, which is composed of (1) cellular components, such as ASCs, fibroblasts, endothe-

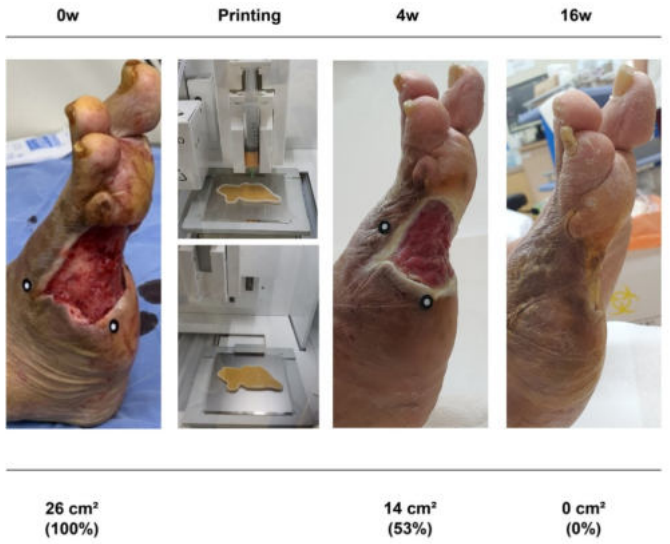

Figure 5. A 70 year old man with diabetes mellitus had a nonhealing ulcer on his right foot for 8 weeks. A micronized adipose tissue niche was applied to the wound.

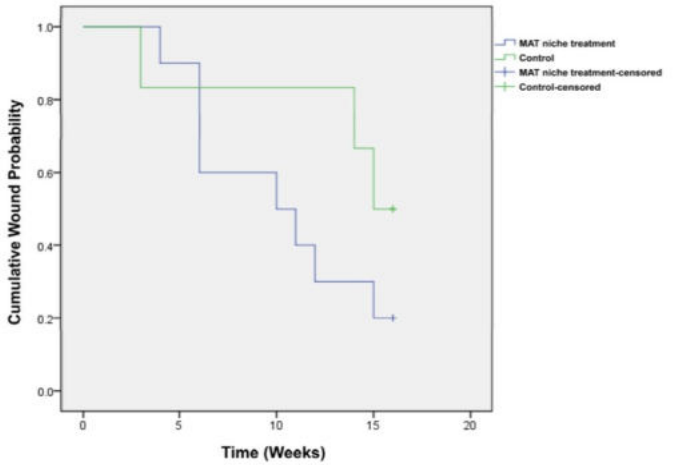

Figure 7. Kaplan–Meier diagram showing results of the time to wound closure. The Kaplan–Meier median times to complete closure were 10.2 ± 1.4 and 13.3 ± 1.9 weeks in the treatment and control groups, respectively.

Figure 6. Three representative examples of micronized adipose tissue niche grafts of diabetic foot ulcers. Baseline: before treatment. Final: after treatment at the first closure at 6, 10, and 11 weeks in Patients **A**, **B**, and **C**, respectively).

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Fig 6-B. *Sik Namgoong et al (2022) , Journal of Clinical Medicine*

Pre-OP

Post-OP

Week 0 : after debridement

Week 0 : after applying the ECM patch

Week 4

Week 12

Clinical Publication

Armstrong et al. 2022 *Plastic and Reconstructive Surgery*

Lww | October 13, 2022 5:58 PM | 17:58 | 4 Color Fig(s): F1-5 | Art: GOX-D-22-00103

OPEN

PRS GLOBAL OPEN ORIGINAL ARTICLE Research

Autologous Minimally Manipulated Homologous Adipose Tissue (AMHAT) for Treatment of Nonhealing Diabetic Foot Ulcers

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Zachary Rasor, DPM‡
Charles M. Zelen, DPM§
Jeehee Kim, PhD¶
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Background: Diabetic foot complications are increasingly burdensome for patients, clinicians, and society. Development of innovative therapies to support good quality basic care is a priority among those with an interest in this area. One of these involves scanning and printing tissues to match and conform to a defect (so-called "3D printing").
Methods: A single-arm pilot study of ten consecutive patients with a history of a chronic diabetic foot ulcer (DFU), treated with autologous minimally manipulated homologous adipose tissue (AMHAT), dispensed by a specialized 3D bioprinter, Dr. INVIVO, was performed. Patients with nonhealing DFUs present for >4 weeks and refractory to standard-of-care therapies were included. Wounds were treated with a single application of AMHAT, and then followed weekly for up to 12 weeks, or until the wounds healed. The primary outcome measure was complete epithelialization of the wound up to 12 weeks after the treatment. Secondary outcome measures included wound size and/or volume reduction, assessment of ulcer grade, and time to closure.
Results: Five wounds were healed by 5 weeks and one at 8 weeks. The mean percent area reduction at 12 weeks was 78.3% (SD: 33.23). Complete closure was achieved in 60% of wounds. The mean time to closure in these wounds was 49.1 days (95% CI, 29.9–68.3). No adverse events were reported.
Conclusions: Single treatment of bioprinted AMHAT appears to be a safe and potentially effective treatment modality for patients with chronic DFUs. Further studies are warranted to explore the full potential of 3D bioprinting for tissue repair in this high-risk population. *(Plast Reconstr Surg Glob Open 2022;10:e4588; doi: 10.1097/GOX.0000000000004588; Published online xxx xxx 2022.)*

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Related Digital Media are available in the full-text version of the article on www.PRSGlobalOpen.com.

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PERI

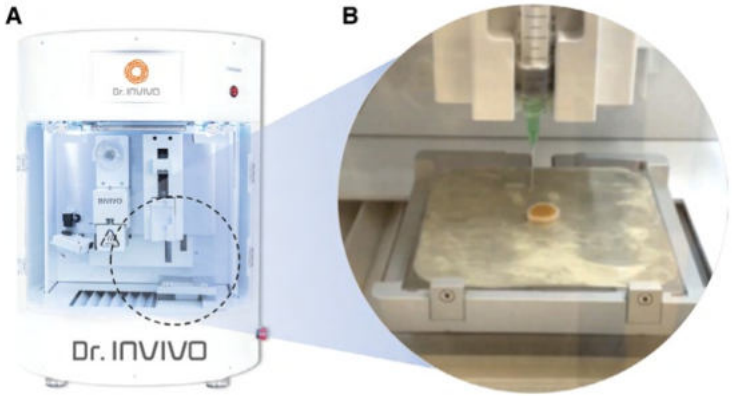

Fig. 1. 3D bioprinting system for AMHAT.

Fig. 2. 3D bioprinted AMHAT treatment process. A, Wound imaging file. B, Single treatment of AMHAT.

Fig. 4. Case example showing a 66-year-old woman with chronic DFU on lateral ankle. A, The ulcer is shown pretreatment. B, Following treatment with AMHAT. C, One week following treatment with the adipose graft. D, The ulcer healed 2 weeks after initial treatment with the adipose graft.

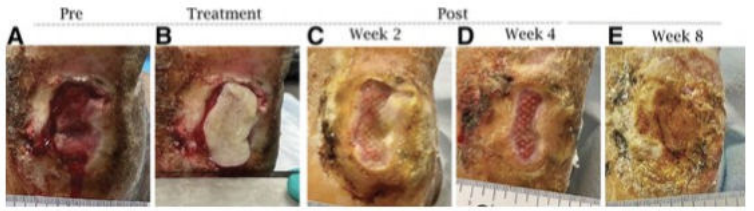

Fig. 5. Case example shows a 58-year-old man with chronic heel DFU. A, Initial ulcer area 6.8 cm^2. B, Following treatment with AMHAT. C, Two weeks following treatment with the adipose graft. D, Four weeks posttreatment. E, The ulcer healed 8 weeks after initial treatment with the adipose graft.

80% Regeneration

Fig. 3. Representative cases of healed patients. A, Patient with chronic DFU (Wagner grade 1/University of Texas grade 1A) overlying the dorsal hallux. B, Wound healed at 4 weeks following application of the adipose graft. C, Chronic heel DFU (Wagner grade 2/University of Texas grade 2A). D, Wound healed at 5 weeks following application of the adipose graft.

Clinical Publication

Akin et al. 2022 *Wounds*

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ORIGINAL RESEARCH

Graft of 3D Bioprinted Autologous Minimally Manipulated Homologous Adipose Tissue for the Treatment of Diabetic Foot Ulcer

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Acknowledgments: All authors contributed equally to this work.

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Disclosure: This study was financially supported by ROKIT Healthcare Inc. Dr. Jeehee Kim is managing director/scientist at ROKIT America. She is also the main educator of Turkey's team for the whole process. She and her team stayed in Turkey during the study. She did not receive any grant for this study from ROKIT Healthcare.

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Recommended Citation: Yastı AÇ, Akgun AE, Surel AA, Kim J, Akın M. Graft of 3D bioprinted autologous minimally manipulated homologous adipose tissue for the treatment of diabetic foot ulcer. *Wounds*. 2023;35(1):E22-E28. doi:10.25270/wnds/21136

ABSTRACT

Introduction. Adipose-derived stem cells are multipotent precursor cells with the ability to differentiate into cell lineages associated with the regeneration of tissues. **Objective.** The authors investigated the efficacy of AMHAT with 3D bioprinting technology in DFU. **Materials and Methods.** Twenty patients were enrolled in a clinical prospective interventional pilot study. The primary endpoint was a reduction in the size of DFU, and the secondary endpoints were the epithelialization rate and amount of granulation of wound bed at weekly assessments. A bioprinter was used to produce AMHAT in the customized shape of DFU. The data were obtained using photography and computerized digital surface calculation. **Results.** The mean wound size at the time of hospitalization was 7.529 cm^2. All but one of the wounds were completely epithelialized at the ninth week. The mean wound areas decreased at weekly assessments for the first 7 weeks of treatment compared to the pre-application. When the mean decrease in the wound size was compared between consecutive weeks, there were decreases at each of the first 7 weeks. The mean time to the complete closure was 32.20±23.862 days. **Conclusion.** These data indicate that AMHAT is beneficial in terms of ease of application, significant decrease in the wound surface area, no scarring compared to grafting, and full healing times.

Keywords: adipose tissue, bioprinter, diabetic foot ulcer, extracellular matrix

Due to its complications, consequences, and growing disease burden across the globe, diabetes is one of the diseases most targeted by health authorities.[1] The International Diabetes Federation has estimated that approximately 537 million adults are currently living with diabetes, and by 2045, the number of patients with diabetes will have increased to 783 million.[2] Diabetes affects approximately 61 million people in Europe annually, with Turkey having the highest age-adjusted prevalence (14.5%) in adults, followed by Spain (10.3%) and Albania (10.2%).[2] Although better management and early detection have reduced morbidity and mortality in patients with diabetes,[3] the complications associated with the condition continue to pose serious problems. Around 15% of patients with diabetes are still at risk of developing a foot ulcer in their lifetime, and the emergence of DFU significantly increases the risk of further ulcerations, lower extremity amputation, and mortality.[4] Compared to patients without diabetes, those with DFU have an approximately 15- to 20-fold increased risk of lower extremity amputations.[4] Of all amputation cases involving patients with diabetes, 85% are preceded by foot ulceration with infection or gangrene.[5-7] Various therapies, including biological skin substitutes and physical treatment options, have been developed over the past 20 years. Therefore, to manage this serious health problem, an important first step is to

Table 1: Gender, wound sites and existence of pre-hospital surgeries of the patients

Parameter		N	(%)
Gender			
	Female	7	(35%)
	Male	13	(65%)
Wound site			
	Forefoot	3	(15%)
	Hind foot	3	(15%)
	Fingers	3	(15%)
	Plantar	9	(45%)
	Amputation area	2	(10%)
Pre-hospital surgery			
	Yes	7	(35%)
	No	13	(65%)

Table 2: The mean age, duration of wound and wound size of the patients.

Parameter	Age (years)	Duration (days)	Wound size (cm^2)
Mean	60.70	48.75	7.5290
Median	63.00	35.00	5.6500
Standard Deviation	10.766	39.864	7.30224
Minimum	41	15	.50
Maximum	79	180	24.20

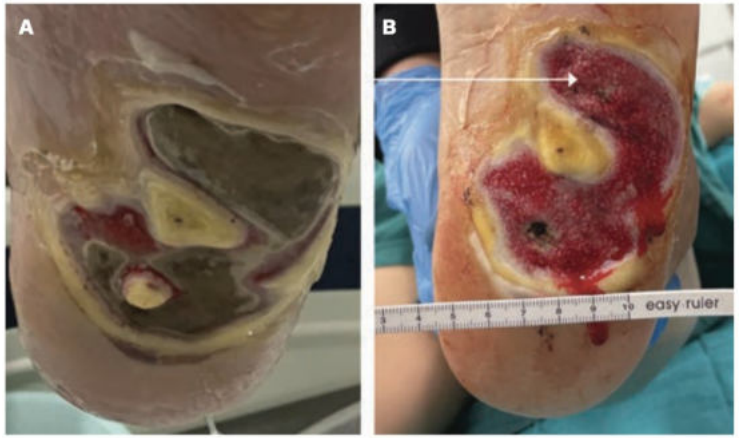

Figure 3. A diabetic foot ulcer at (A) first presentation to clinic on December 18, 2020, and (B) after serial debridement but prior to AMHAT application, December 29, 2020. The arrow denotes the area treated with STSG.
Abbreviations: AMHAT, autologous minimally manipulated homologous adipose tissue; STSG, split-thickness skin graft.

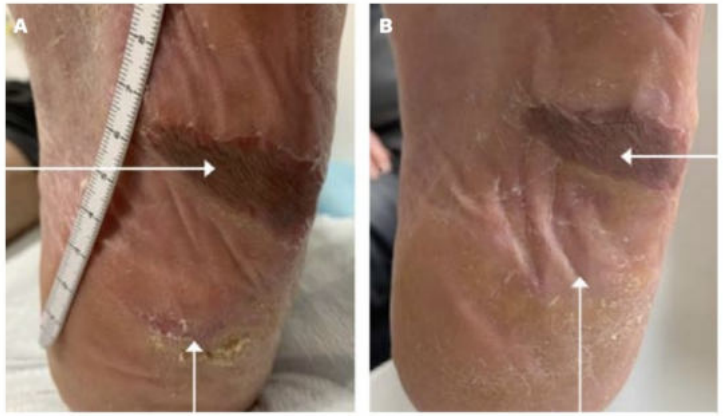

Figure 4. Wound healing after AMHAT application in the patient shown in Figure 3. (A) May 2021; the bottom arrow denotes the DFU region treated with AMHAT, while the top arrow denotes the area treated with STSG. (B) October 2021; the bottom arrow denotes the DFU region treated with AMHAT, while the top arrow denotes the area treated with STSG.
Abbreviations: AMHAT, autologous minimally manipulated homologous adipose tissue; DFU, diabetic foot ulcer; STSG, split-thickness skin graft.

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Fig 3 & 4. **Akin et al. 2022 *Wounds***

Pre-OP

Post-OP

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Before submission; keep confidential

Burn Patient i (M/30, 2nd degree Burn on Rt. hand)

Clinical Publication IV

Yazid et al. 2023 *Gels*

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- Head of foot and ankle, Universiti Kebangsaan Malaysia Hostpial

Universiti Kebangsaan Malaysia
The National University of Malaysia

gels

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Article

New Paradigm in Diabetic Foot Ulcer Grafting Techniques Using 3D-Bioprinted Autologous Minimally Manipulated Homologous Adipose Tissue (3D-AMHAT) with Fibrin Gel Acting as a Biodegradable Scaffold

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Abstract: Adipose tissue is an abundant source of extracellular substances that support the tissue repair process. This pilot study was carried out to determine the efficacy of 3D-bioprinted autologous adipose tissue grafts on diabetic foot ulcers (DFUs), with fibrin gel used to stabilise the graft. This was a single-arm pilot study in a tertiary hospital that provides diabetic wound care services. A total of 10 patients with a DFU were enrolled, and the primary endpoint was complete healing within 12 weeks. The secondary endpoints were wound size reduction, time to healing, and adverse events. Seven out of ten patients showed complete healing of their DFU within 12 weeks (at 2, 4, 5, 10, and 12 weeks, respectively). The wound size reduction rate was significantly and progressively reduced over time. According to our data, autologous adipose tissue grafting using a 3D bioprinter, with the addition of fibrin gel that acts as a scaffold, promotes wound healing with high-quality skin reconstruction. Throughout this study period, no adverse events were observed.

Keywords: 3D bioprinter; autologous adipose tissue graft; diabetic foot ulcer; fibrin glue; biodegradable scaffold; tissue regeneration

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1. Introduction

Diabetes mellitus is a major non-communicable illness that affects millions of people worldwide [1]. Long-term uncontrolled high blood sugar levels frequently result in neuropathy and peripheral vascular disease, which can lead to a plethora of problems, including diabetic foot ulcers (DFUs) [2]. Three out of every twenty diabetic patients are affected by DFUs, facing greater risk of disability via amputation or even death [3]. This undoubtedly exposes the DFU patients and their families to significant financial burden that may arise from the disease.

Blood sugar monitoring, wound debridement, moist dressings, antibiotic therapy for wound infection, and weight-bearing ulcer offloading are all part of conventional DFU care [4]. However, these methods fail to resolve the ulcers completely, and patients are often left with recurring DFUs, which greatly affect their quality of life [2]. The emergence of skin substitute technology has changed the paradigm of DFU treatment [5]. Accordingly, a variety of biological skin substitutes, derived from either natural or synthetic biomaterials, have been developed over the last 20 years to improve the prognosis of DFUs [5].

Mojallal et al. paved the way for the use of autologous fat grafting in wound healing through their observation of enhancement in collagen fibre neosynthesis, vascularisation, and the thickness of the dermis and subcutaneous tissue with this easily accessible tissue source [6]. Since then, evidence supporting the efficacy of autologous fat grafting in wound healing has continued to grow over time [7,8].

Figure 1. Complete wound healing outcomes among the patients with diabetic foot ulcers: (**A**–**D**) Complete healing of 4 patients within 12 weeks. Black squares at baseline indicate the ulcer before the treatment. Complete wound healing images at week 12 are magnified.

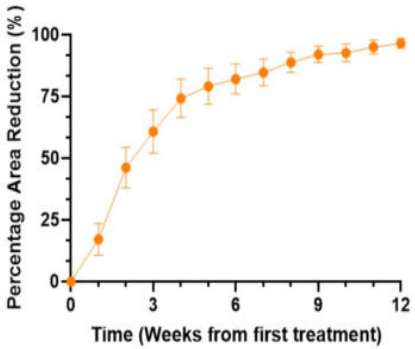

Figure 2. Average percentage wound area during the course of the study ($n = 10$). Repeated measures one-way ANOVA revealed a significant trend of increasing reduction ($p < 0.05$).

Clinical Publication

Kesavan et al. 2021 ***International Journal of Lower Extrimity Wounds***

Rajesh Kesavan, MD
- Wound Specialist at Diabetic Foot Clinic
- Chairman with Scientific committee of Diabetic Foot Society of India
- Director of NRA Advanced Wound Care Ltd.

Original Article

Management of Diabetic Foot Ulcer with MA–ECM (Minimally Manipulated Autologous Extracellular Matrix) Using 3D Bioprinting Technology – An Innovative Approach

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1–8

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Rajesh Kesavan[1,2], Changam Sheela Sasikumar[3,4], V.B. Narayanamurthy[5], Arvind Rajagopalan[6], and Jeehee Kim[7]

Abstract

Chronic foot ulcers are the leading cause of prolonged hospitalization and loss of social participation in people with diabetes. Conventional management of diabetic foot ulcers (DFU) is associated with slow healing, high cost, and recurrent visits to the hospital. Currently, the application of autologous lipotransfer is more popular, as the regenerative and reparative effects of fat are well established. Herein we report the efficacy of minimally manipulated extracellular matrix (MA-ECM) prepared from autologous homologous adipose tissue by using 3D bioprinting in DFU (test group) in comparison to the standard wound care (control group). A total of 40 subjects were screened and randomly divided into test and control groups. In the test group, the customized MA-ECM was printed as a scaffold from the patient autologous fat using a 3D bioprinter device and applied to the wound directly. The control group received standard wound care and weekly follow-up was done for all the patients. We evaluated the efficacy of this novel technology by assessing the reduction in wound size and attainment of epithelialization. The patients in the test group (n = 17) showed complete wound closure with re-epithelialization approximately within a period of 4 weeks. On the other hand, most of the patients in the control group (n = 16) who received standard wound dressings care showed a delay in wound healing in comparison to the test group. This technique can be employed as a personalized therapeutic method to accelerate diabetic wound healing and may provide a promising potential alternative approach to protect against lower foot amputation a most common complication in diabetes.

Keywords

diabetic foot ulcer, autologous fat, lower extremity wound, minimally manipulated autologous extracellular matrix, amputation, 3D bioprinting

Figure 2. Wouund healing in the test group. Epithelialization and wound healing were completed at 4 weeks after the new treatment in this test group (0 week; at baseline, 4 week; 4 weeks from the treatment). The location of DFU: first toe (A); Plantar fore foot (B); Plantar mid foot (C), Dorsal mid foot (D); Heel (E).

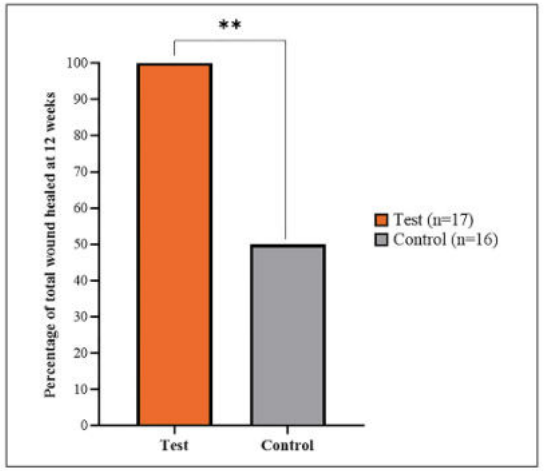
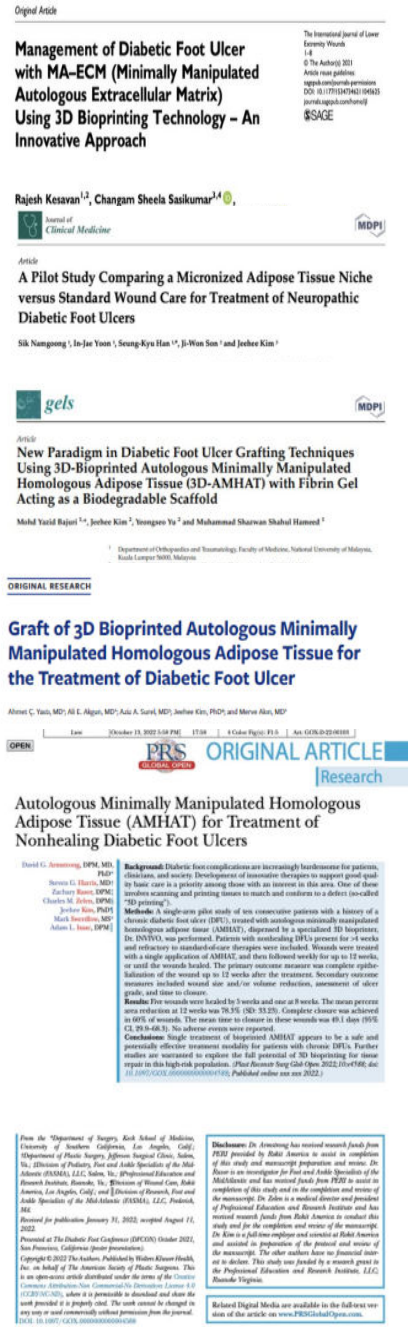


Figure 4. Percentage of subjects presented complete epithelialization at 12 weeks. The bar represents the number of subjects who completed the wound healing process within a period of 12 weeks in percentage. With the help of our innovative treatment in test group, irrespective of wound size and location, we observed all the subjects in the test group were completely healed. In control group, only 50% of the subjects showed healed wound at 12 weeks period. There was statistically significant difference in the test subjects when compared to the contol. ($P < 0.0001$, **).



Original Article

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Rajesh Kesavan[1,2], Changam Sheela Sasikumar[3,4],

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Article

A Pilot Study Comparing a Micronized Adipose Tissue Niche versus Standard Wound Care for Treatment of Neuropathic Diabetic Foot Ulcers

Sik Namgoong [1], In-Jae Yoon [1], Seung-Kyu Han [1,*], Ji-Won Son [2] and Jeehee Kim [2]

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New Paradigm in Diabetic Foot Ulcer Grafting Techniques Using 3D-Bioprinted Autologous Minimally Manipulated Homologous Adipose Tissue (3D-AMHAT) with Fibrin Gel Acting as a Biodegradable Scaffold

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ORIGINAL RESEARCH

Graft of 3D Bioprinted Autologous Minimally Manipulated Homologous Adipose Tissue for the Treatment of Diabetic Foot Ulcer

Ahmet Ç. Yazıcı, MD*; Ali E. Akgun, MD*; Aziz A. Sural, MD*; Jeehee Kim, PhD†; and Merve Akın, MD*

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ORIGINAL ARTICLE
Research

Autologous Minimally Manipulated Homologous Adipose Tissue (AMHAT) for Treatment of Nonhealing Diabetic Foot Ulcers

David G. Armstrong, DPM, MD, PhD*
Steven G. Harris, MD†
Zachary Rosen, DPM‡
Charles M. Zelen, DPM§
Jeehee Kim, PhD¶
Mark Swerdlow, MS‖
Adam L. Isaac, DPM‡

Background: Diabetic foot complications are increasingly burdensome for patients, clinicians, and society. Development of innovative therapies to support good quality basic care is a priority among those with an interest in this area. One of these involves scanning and printing tissues to match and conform to a defect (so-called "3D printing").
Methods: A single-arm pilot study of ten consecutive patients with a history of a chronic diabetic foot ulcer (DFU), treated with autologous minimally manipulated homologous adipose tissue (AMHAT), dispensed by a specialized 3D bioprinter, Dr. INVIVO, was performed. Patients with nonhealing DFUs present for >4 weeks and refractory to standard-of-care therapies were included. Wounds were treated with a single application of AMHAT, and then followed weekly for up to 12 weeks, or until the wounds healed. The primary outcome measure was complete epithelialization of the wound up to 12 weeks after the treatment. Secondary outcome measures included wound size and/or volume reduction, assessment of ulcer grade, and time to closure.
Results: Five wounds were healed by 3 weeks and one at 8 weeks. The mean percent area reduction at 12 weeks was 78.3% (SD: 33.2%). Complete closure was achieved in 60% of wounds. The mean time to closure in these wounds was 49.1 days (95% CI, 29.0–68.3). No adverse events were reported.
Conclusions: Single treatment of bioprinted AMHAT appears to be a safe and potentially effective treatment modality for patients with chronic DFUs. Further studies are warranted to explore the full potential of 3D bioprinting for tissue repair in this high-risk population. (*Plast Reconstr Surg Glob Open 2022;10:e4588; doi: 10.1097/GOX.0000000000004588. Published online xxx xxx 2022.*)

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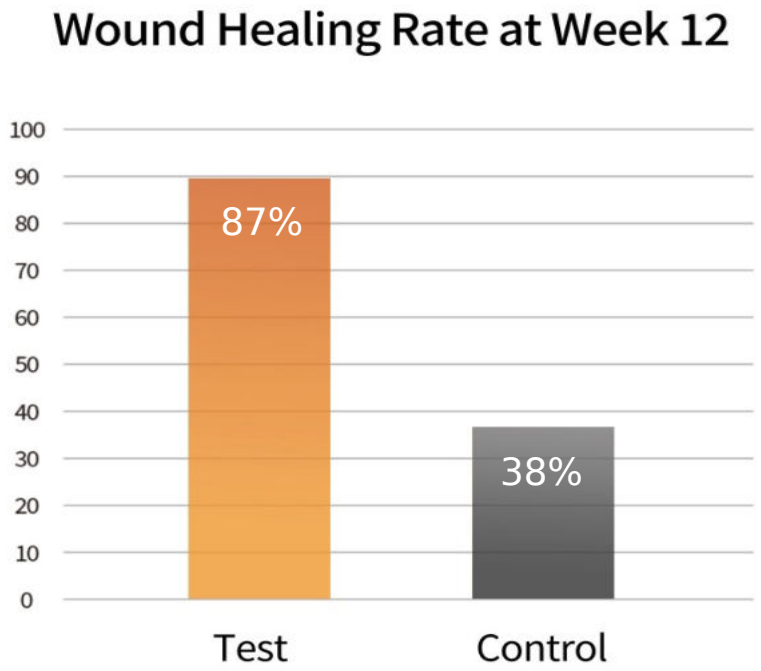
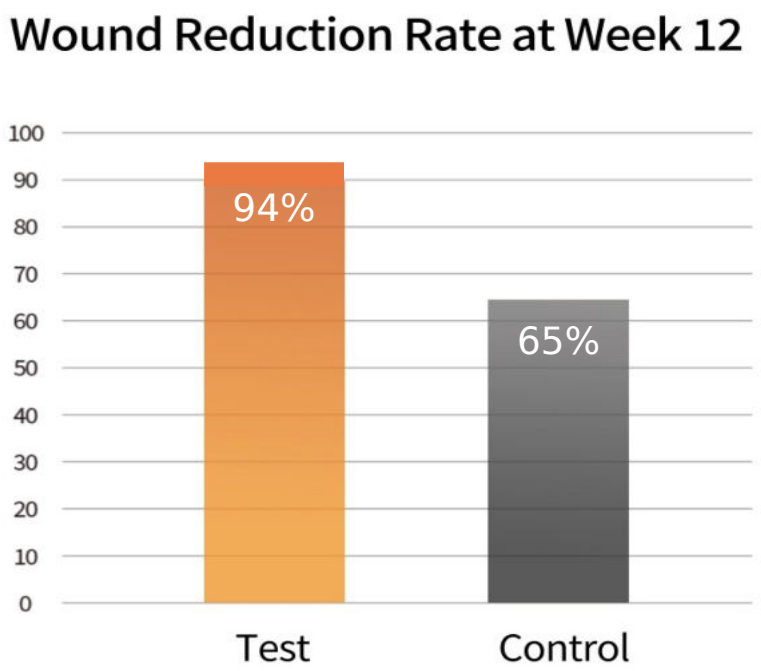




- Completed studies: Total 5 counties, 130 patients (DFU 100, BURN 20, Skin Cancer 10

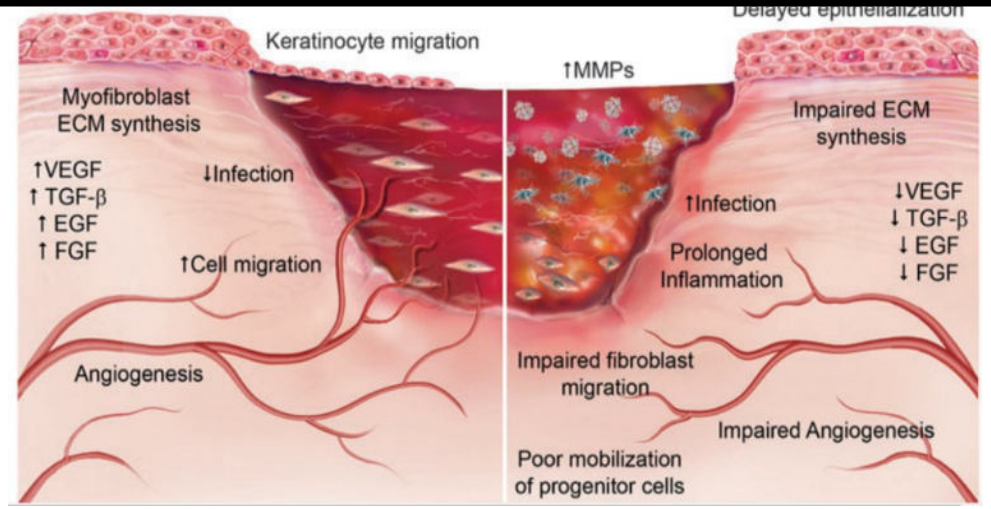
  INDIA (40), KOREA (DFU 20, Skin Cancer 10), TURKEY (DFU 20, BURN 20), USA (10), MALAYSIA

- 120 patients enrolled, 9 patients dropped & <u>111 patients analyzed (Test 87, Control 24</u>

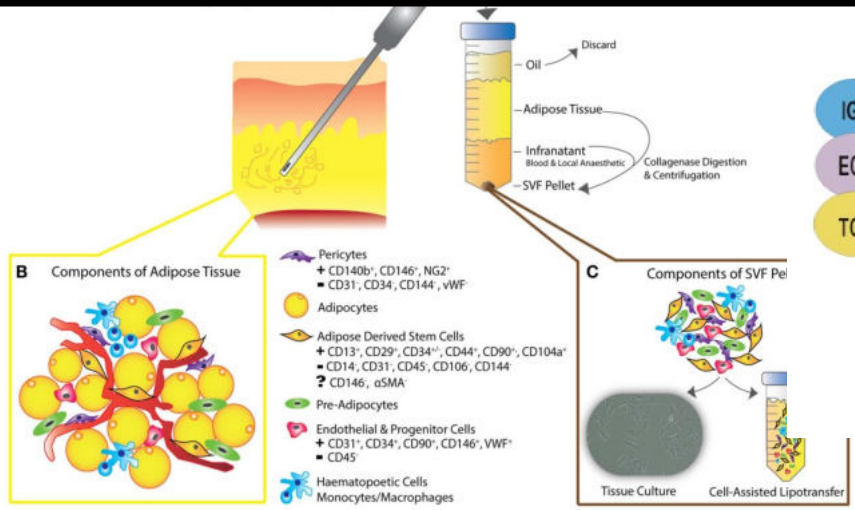
  *Skin Cancer patients are not included

Advantages of Autologous ECM Patch

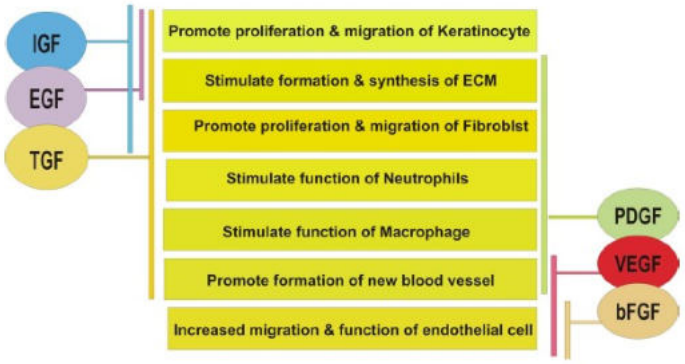
Cell Proliferation & Tissue Remodeling



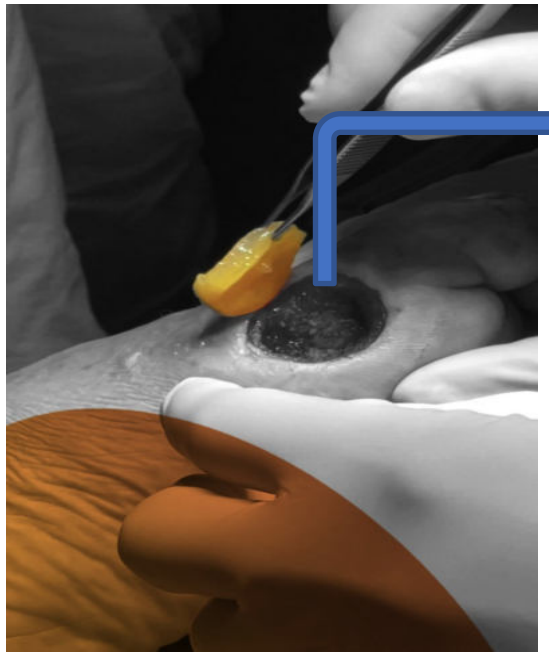
Neill J. Turner et al., Wound Healing Society (2014)

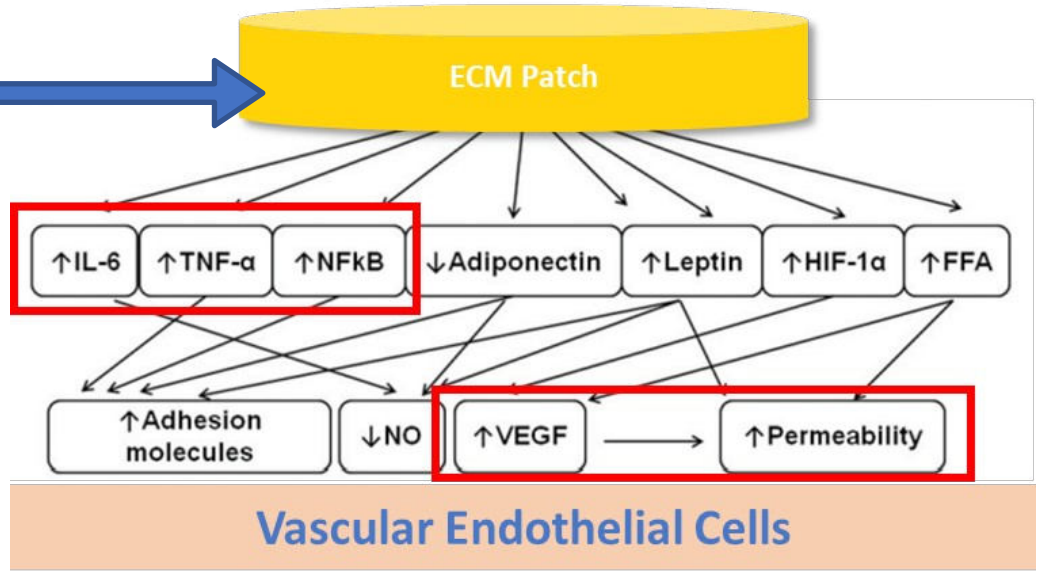


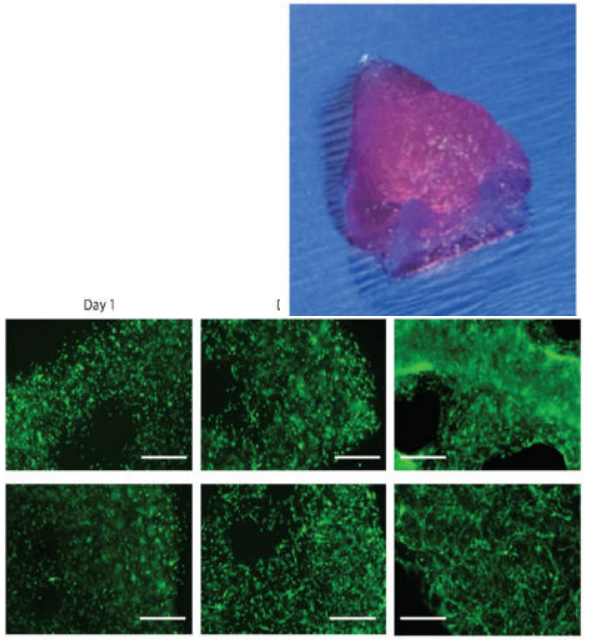
Lipi Shukla et al. Front in Surgery (2015)



Shukla et al. Front in Surgery (2015) Volume2 Article1

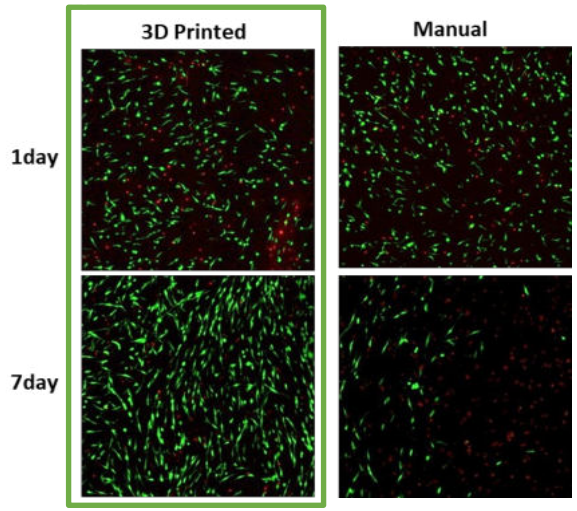




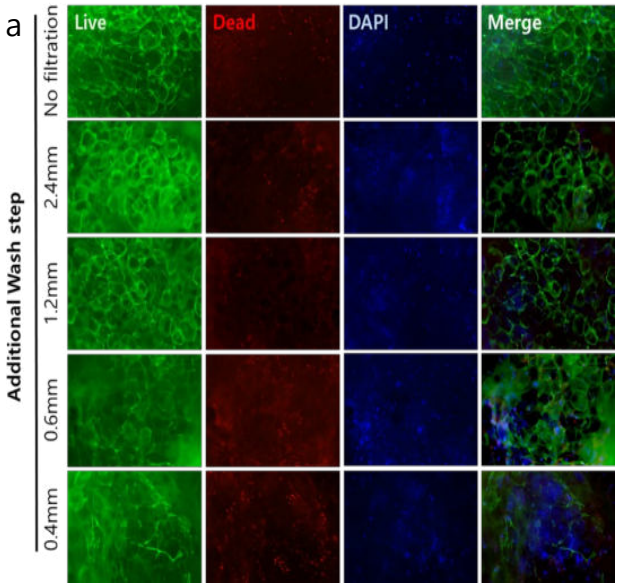


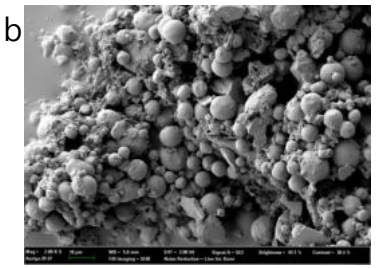
Skin Remodeling & Neovascularization

3D printing system makes possible to design and fabricate cells, tissue & materials for tissue engineering



(Cell proliferation test)





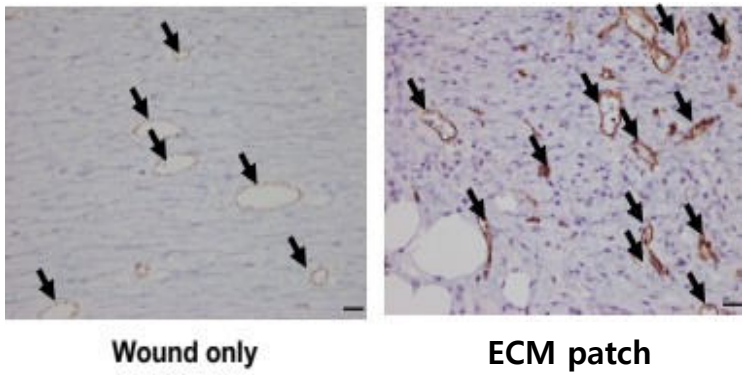
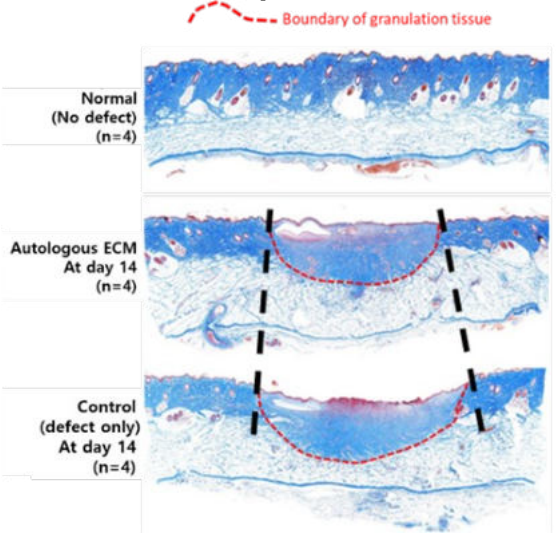


Fig 1. Cell Morphology test

a. Live-dead staining; b. SEM Image (mag x2,000)



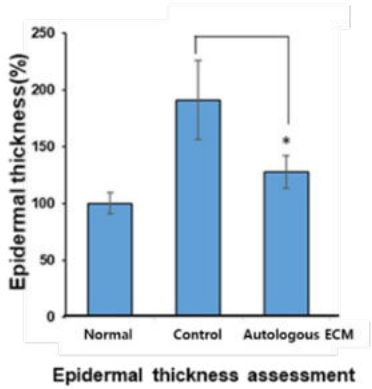


Fig 2. Collage regeneration, epidermal thickness comparison (Masson's-Trichrome staining)

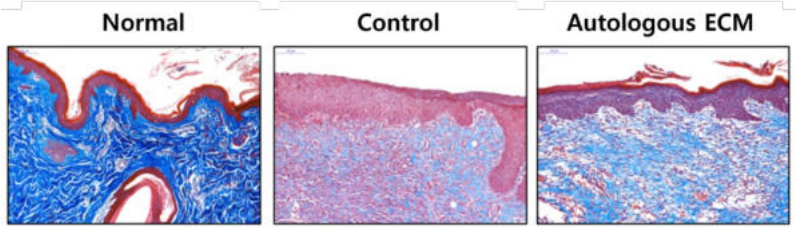


Fig 3. Dermal layer collagen regeneration

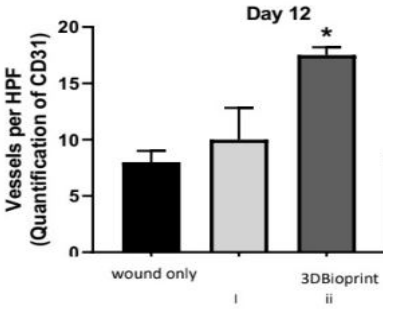
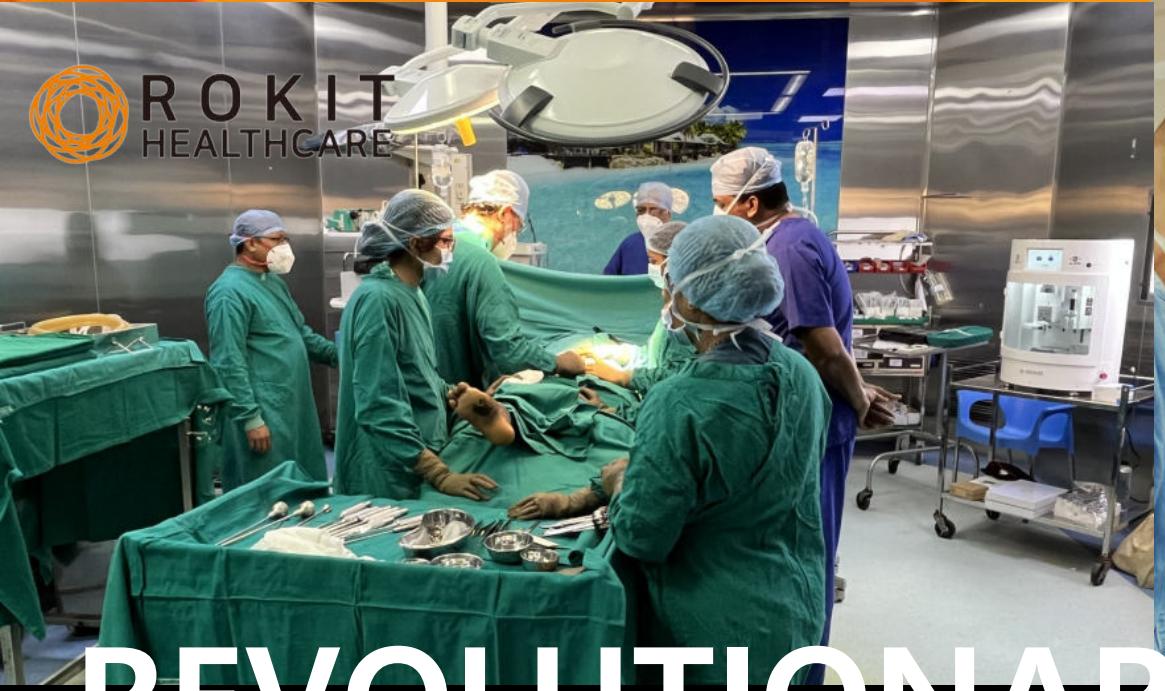


Fig 4. Neovascularization comparison (CD31, x40)



REVOLUTIONARY GAME CHANGER