BURNS

Case of Thermal Burn in a New Born, The Earliest in the World, 2 years After

Georges Ghanime

Lebanese University Hospital, Plastic Surgery, Lebanon

Burns in infants are rare. The immaturity of their immune system, their fragile thinness skin, difficulties in resuscitation, engraftment paucity limited by donor sites and long- term complications, make the care of newborns burned extremely difficult. The majority of burns occur in the hospital setting. We present the case and a follow up for over two years of a newborn burned 30 minutes after his birth with a body surface of birth with a body surface of35%, when the hot water bottle used in the hospital accidentally ruptured. This is the case of iatrogenic burning in a newborn, the earliest in the world. The newborn returned home after 30 days of coverage: Resuscitation, dressings and skin grafting. So far he is under regular surveillance.

BURNS

Severe Electric Upper Extremity Burn Successfully Treated with Combined Use of a Dermal Regeneration Template and Negative Pressure Wound Therapy

Istvan Juhasz[1], Istvan Frendl[2], Bela Turchanyi[2], Iren Erdei[3], Zoltan Peter[1], Gabor Kiraly[4]

[1]*Department Dermatology, Univ. of Debrecen, Burn Unit, Hungary*
[2]*Dept. of Trauma Univ. of Debrecen, Hand Surgery Team, Hungary*
[3]*Univ. of Debrecen, Clinical Center, Dept. of Anesthesia and Intensive Care, Hungary*
[4]*Dept. of Biotechnology and Microbiology, University of Debrecen, Hungary*

Background: Electric trauma causes severe necrosis not only in the skin but also in deep body compartments. If it involves an extremity, it usually results in loss or mutilation of the affected limb.

Objectives: a 59 year old male suffered full thickness electric burn on both upper extremities due to suicide attempt. First and second digits of the left hand had to be amputated due to 4th degree burn. Necrectomy and fasciotomy was performed on flexor aspect of right wrist and lower arm.

Methods: Negative pressure therapy (NPWT) was initiated followed by the implantation of Integra dermal regeneration template due to the exposed tendons. NPWT was maintained throughout the course of the establishment of the neodermis. Three weeks later autologous split thickness skin graft (STSG) coverage was performed.

Results: Both dermal implant and STSG took completely. Full epithelization occurred in 10 weeks post burn resulting in excellent cosmetic and acceptable functional results.

Conclusion: The simultaneous use of dermal replacement and NPWT is a suitable method for reconstructing full thickness thermic trauma wounds even when tendons are exposed. Salvage of a severely compromised limb is possible by combining biotechnological wound coverage with enhancement of microcirculation for improved take.

CLINICAL TRIALS IN WOUND CARE: DESIGN, CONDUCT AND OUTCOMES

Investigating the most Suitable Imaging Modality to Accurately Record all Wounds for both Clinical Records and Remote Assessments

Kevin Jacob

Medical Photography, Illingworth Research Group Limited, UK

Reviewing any wound in person will always yield a greater understanding of its severity or progress; stereo eyesight, 360^0 perspective and physical contact, provide additional information to that captured within a single 2 dimensional image. Conversely, a quality wound image provides the remote clinician or expert assessor with far more understanding than words alone could achieve.

This investigation identifies which robust, simplistic and cost effective imaging system should be employed when photographing (all) wound types (from 1cm to 1m in length) within the hospital environment. The criteria for such a capture and lighting combination can be grouped into the following areas for investigation:

1. Determine the preferred method for lighting the wide range of wound types and sizes,
2. Which imaging modalities are compatible with the preferred lighting,
3. Which combination of settings balances ease of use and image consistency.

The derived imaging system:

1. Achieved image accuracy and consistency against industry colour charts, which was shown to be acceptable for medical notes and remote assessment by clinicians.
2. At less than £600, was cost effective given its robustness and ease of use, all settings were fixed accept for the zoom lens which required intuitive user intervention to match wound size.
3. Captured images, approx. 6MB in size, are either recorded on the in-camera SD memory card or transferred directly to a secure device via the Nikon WU-1a Wireless Mobile Adapter – whichever method befits the clinic.

DRESSING TECHNOLOGIES

Evaluation of Silver, PHMB and Iodine containing Wound Care Products on *P. aeruginosa* Biofilms in a Colony Drip Flow Wound Model

Katie Bourdillon

Research & Technology, Systagenix, an Acelity Company, UK

Introduction: Data generated by *in-vitro* biofilm models is often conflicting. It is unclear whether any particular antimicrobial agent is superior in its efficacy against biofilms. Here, the ability of a silver hydrofibre with enhanced antimicrobial properties (SHF+)*, collagen/ORC with silver (CORCS)‡, cadexomer iodine pad (CXI)†, and PHMB wound gel (PWG)¥ to reduce *in-vitro* biofilm populations was investigated using a colony drip flow reactor (C-DFR).

Methods: *P. aeruginosa* biofilms were established in a C-DFR, before being exposed to test material (SHF+, CORCS, CXI, PWG or gauze control). After exposure, biofilm total viable counts (TVC) were determined. Scanning Electron Microscopy was also performed.

Results: Of the antimicrobial wound products tested, only CORCS application led to a significant reduction in biofilm TVC compared to pre-exposure populations, with a 1.49 $\log_{10}$ unit reduction observed ($p=0.01$). SHF+, CXI, and PWG had no significant impact on biofilm counts compared to pre-exposure populations ($p>0.05$).

Conclusions: The C-DFR model is extremely challenging, with a constant flow of proteinaceous media across the biofilm, and is designed to reflect conditions in a highly exudative wound environment. Only CORCS significantly reduced *P. aeruginosa* biofilms *in-vitro*. This positive performance of CORCS is especially notable due to the low levels of active agent it contains compared to the other antimicrobial products evaluated. This data suggests that properties of the material aside from antimicrobial content contribute to the efficacy of CORCS against biofilms *in-vitro.*

*SHF+: Aquacel Ag+ Extra (ConvaTec)

‡ CORCS: PROMOGRAN™ PRISMA (Systagenix)

†CXI: Iodoflex (Smith & Nephew)

¥ PWG: Prontosan (Braun)

DRESSING TECHNOLOGIES

Balancing Antimicrobial Activity with Protection of Host Cells; A Strategy for Management of Wounds with Suspected Biofilm

Katie Bourdillon[1], Craig Delury[1]

[1]*Research & Development, Systagenix, an Acelity Company, UK*

Introduction: Current therapies to manage suspected wound biofilm have focused on risk of infection, and consequently contain high levels of antimicrobial agents, which are bactericidal but may be cytotoxic to host dermal cells upon prolonged use. We propose a more effective strategy to reduce bacterial bioburden in biofilms would be to use an antimicrobial therapy, at levels not detrimental to host cells. Here, we test the ability of various antimicrobial products to reduce vegetative and biofilm bacterial populations while not impeding host cell viability.

Methods: Silver hydrofibre with enhanced antimicrobial properties (SHF+)*, collagen/ORC with silver (CORCS)‡, cadexomer iodine pad (CXI)†, and PHMB wound gel (PWG)¥ were evaluated for activity against vegetative *P. aeruginosa*. Additionally, *P. aeruginosa* biofilms were established in a C-DFR, before being exposed to test material. After exposure, biofilm total viable counts (TVC) were determined. An XTT metabolic assay was used to assess viability of dermal fibroblasts grown in the presence of extracts from the materials under investigation.

Results: All antimicrobial test materials were effective in reducing planktonic bacterial growth, but few had any impact on biofilms. Of these, only the CORCS reduced bacterial bioburden in biofilms without inhibiting dermal fibroblast growth. All other test materials were detrimental to cell viability.

Conclusions: We hypothesised that an effective means of dealing with biofilms and optimising healing could be to reduce bacterial bioburden without harming host cells. Our study demonstrated that a combination of collagen/ORC/silver* was the only material of those tested that met these design principles.

*SHF+: Aquacel Ag+ Extra (ConvaTec)

‡ CORCS: PROMOGRAN™ PRISMA (Systagenix)

†CXI: Iodoflex (Smith & Nephew)

¥ PWG: Prontosan (Braun)

DRESSING TECHNOLOGIES

In-Vitro Evaluation of a New Gelling Fibre Dressing

Craig Delury, Rachel Bolton

R&D, Systagenix: an Acelity Company, UK

Background/Objective: Gelling fibre dressings are designed to meet the many challenges posed by moderate to heavily exuding wounds, absorbing excess exudate whilst maintaining a moist wound healing environment. These dressings take the form of an absorbent pad, which gels on contact with wound fluid providing absorbency, strength and confident usage in a variety of wound types. To provide additional wet tensile strength and ease of removal these products may also contain non-gelling reinforced fibers (NRF). To assess the in vitro physical properties of a gelling fiber dressing (Dressing A) relative to an alternative gelling fibre dressing with a unique design, incorporating NRFs (Dressing B). The ability of these dressings to absorb fluid and their structural integrity was evaluated.

Methods: Absorbent capacity was ascertained using the standard test method BP1993 Addendum 1995, Absorbency Test Methods for Alginate Dressings. Dressing integrity was tested in vitro by comparing the wet tensile strength of the two dressings along with reduction in area on hydration.

Results / Discussion: Dressing B displayed significantly higher absorbency in-vitro compared with Dressing A ($p=<0.01$). Markedly less shrinkage was observed on hydration for dressing B relative to dressing A ($p=<0.01$) as well as increased wet tensile strength.

Conclusion: The gelling fiber dressing which incorporates NFRs was found to be more absorbent than the alternative dressing without these fibers. Moreover, the data suggests the incorporation of the NRFs throughout the structure in Dressing B provide an advantage in terms of dressing structural integrity, compared with Dressing A.

DRESSING TECHNOLOGIES

An Evaluation to Record Initial Clinical Experiences with a Non-adhesive Antimicrobial Foam* Dressing

N M Ivins, N J Jones, S M Haelstein, N A Walker, K G Harding CBE

WWIC, Welsh Wound Innovation Centre, UK

Background/Objective: The aim was to record clinical experiences using a non-adhesive antimicrobial foam* dressing and the performance of the dressing in the management of infected, moderate to heavily exuding wounds.

Method: Ten patients with wounds of differing aeitiologies were followed for 4 weeks. Any chronic and acute wounds that were infected or at risk of infection, were included. The dressing under evaluation formed part of the standard of care required for all patients.

Control of bacterial bioburden was assessed using the MolecuLight i: X™ camera as well as an assessment of the clinical signs of wound bioburden.

Weekly assessments and photographs using the MolecuLight i: X™ camera.

At final visit, feedback from both the patient and clinician was recorded in addition to these interim assessments.

1. Control of Bacterial Bioburden
2. Dressing Adherence
3. Exudate management

Results / Discussion: Initial results suggest that the antimicrobial foam* dressing was effective at controlling the bacterial bioburden in all of the wounds assessed. The dressing was easy to apply and remove and well tolerated by the patients. The antimicrobial foam dressing was worn under compression without any complications such as indentation and slippage. Clinicians found the dressing very easy to apply and remove. (Do we need to add in that it managed exudate?)

Conclusion: The dressing is designed to absorb exudate, help maintain a moist wound healing environment and minimise risk of maceration in moderate to heavily exuding wounds. Results to date suggest that the dressing has been very effective at achieving the main objectives of the study.

*TIELLE™ PHMB Non-Adhesive is a product of Systagenix an Acelity company.

DRESSING TECHNOLOGIES

A Case Series Evaluating a New Gelling Fibre Dressing* as a Primary Dressing for Moderate to Highly Exuding Wounds of Differing Aetiology in the Lower Limb

N M Ivins, N J Jones, V Young, N Jones, S Hagelstein, K G Harding CBE

WWIC, Welsh Wound Innovation Centre, UK

***Background/Objective**:* Ten patients with differing wound aetiologies were recruited over a 4-week period.

Methods: Patients recruited into the case series evaluation had either moderate to highly exuding wounds of mixed, venous or diabetic foot aetiology without clinical features of infection. All cases were reviewed over a four week period where standard care was provided. Objective measures including wound tracing and photographs were performed once a week.

The objective measures included were:

- Wound measurement (cm^2)
- Exudate levels and absorbency of dressing
- Appearance of surrounding skin
- Conformability of dressing to contour to the wound bed on application
- Integrity of dressing on removal from the wound

Results: This is part of an ongoing case series. Results to date suggest that the dressing has been very effective at managing wound exudate and contours to the wound bed. The removal of the dressing was reported as being pain free for the patient. The patients have reported that the dressing was comfortable in place, demonstrated high absorbency and there were no contra-indications associated with peri-wound maceration of the surrounding skin. Clinicians reported that the dressing was highly conformable and retained its integrity on removal from the wound bed.

Conclusion: The preliminary findings from this case series evaluation suggests that the new gelling fibre* is a highly absorbent gelling fibre dressing that locks in exudate to protect the peri-wound skin from maceration whilst maintaining a moist wound healing environment.

BIOSORB™ Gelling Fibre Dressing a product of Systagenix an Acelity Company.

DRESSING TECHNOLOGIES

Flufenamic Acid-Collagen-Dextran Spongious Burn Dressings: Optimization and Characterization

Mihaela Violeta Ghica[1], Durmuș Alpaslan Kaya[2], Mădălina Georgiana Albu Kaya[3], Cristina Dinu-Pîrvu[1], Lăcrămioara Popa[1]

[1]*Physical and Colloidal Chemistry Department, Faculty of Pharmacy, Carol Davila University of Medicine and Pharmacy, Romania*
[2]*Department of Field Crops, Faculty of Agriculture, Mustafa Kemal University, Turkey*
[3]*Collagen Department, Division of Leather and Footwear Research Institute, The National Research & Development Institute for Textiles and Leather, Romania*

A first step in improving the burns healing is the treatment of affected inflamed area. For this reason, obtaining and using an adequate drug release support represent a reliable solution for an efficient regeneration of burned skin.

The goal of this study consists in the design, evaluation and optimization of some topical collagen-dextran sponges with flufenamic acid, un- and-cross-linked with glutaraldehyde, designed as potential dressings in burn healing.

Type I fibrillar collagen gel was extracted from calf hide. The spongious matrices were obtained by lyophilization of hydrogels designed according to a 3-factor, 3-level experimental design. The composites were characterized by spectral (FT-IR), morphological (water absorption) and biological analysis (enzymatic biodegradation). The *in vitro* flufenamic acid release was conducted with a transdermal sandwich device adapted to a dissolution equipment.

The FT-IR analysis indicates that the sponges preserve the triple helicoidal structure integrity of native collagen. The kinetic data were fitted with the Power law model and the drug release mechanism was established. The analysis of swelling capacity and enzymatic degradation is correlated with the results of drug release from spongious forms. The optimization process based on response surface methodology and Taguchi approach lead to the formulation factors optimal combinations which ensure an adequate flufenamic acid release to the application site.

The results generated by the complex characterization of the designed spongious matrices indicate that these formulations could be promising systems for burn dressing applications.

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DRESSING TECHNOLOGIES

The Mode of Action of a Novel Anti-biofilm Hydrofiber Wound Dressing

Kate Meredith[2], David Parsons[1], Darryl Short[3], Victoria Rowlands[2], Daniel Metcalf[1], Philip Bowler[1]

[1]*Science & Technology, ConvaTec GDC, UK*
[2]*Microbiology Services, Research & Development, ConvaTec GDC, UK*
[3]*Analytical Services, Research & Development, ConvaTec GDC, UK*

When used clinically, Aquacel Ag+ Extra has been shown to contribute to wound healing [1,2]. It has been proposed that this is due to its ability to decrease wound biofilm via its synergistic anti-biofilm formulation [3]. *In vitro* studies were undertaken to further understand how and why this dressing works. Biofilms were grown using single species, antibiotic-resistant strains of *Pseudomonas aeruginosa* and *Staphylococcus aureus*, and also polymicrobial biofilms of clinical wound isolates, to demonstrate the ability of various silver test dressings to reduce biofilm over various treatment times. Confocal laser scanning microscopy and staining techniques (live/dead staining, polysaccharide staining and peptide nucleic acid fluorescent *in situ* hybridisation) were performed to examine the ability of the test dressings to kill and reduce biofilm during testing. Elemental analysis (using inductively-coupled plasma mass spectrometry) was also used to elucidate antimicrobial and anti-biofilm action. Using these microscopy techniques, compared to other standard silver dressings, Aquacel Ag+ Extra was significantly more effective at killing bacteria present in biofilm, reducing biofilm mass and thickness, and reducing polysaccharides that surround the biofilm cells ($p<0.05$). Elemental analysis of biofilm following dressing treatment also showed that Aquacel Ag+ Extra sequestered significantly more divalent cations from the biofilm ($p<0.05$), and donated significantly ($p<0.05$) more silver ions to the biofilm, than the other dressings.

To summarise, *in vitro* testing demonstrated that Aquacel Ag+ Extra is able to disrupt biofilm, absorb and reduce biomass, donate antimicrobial silver into biofilm, and kill biofilm-associated microorganisms [4]. This study increases our knowledge of the mode of action of Aquacel Ag+ Extra dressing, which may help explain its effectiveness when using in clinical settings.

DRESSING TECHNOLOGIES

Glycosaminoglycan-based hydrogels to control pro-inflammatory chemokines and rescue wound healing deficiency

Lucas Schirmer[1,4], Nadine Lohmann[2,4], Passant Atallah[4], Carsten Werner[1,3,4], Jan C. Simon[2,4], Sandra Franz[2,4], Uwe Freudenberg[1,4]

[1]*Max Bergmann Center of Biomaterials Dresden (MBC), Leibniz Institute of Polymer Research Dresden (IPF), Germany*
[2]*Department of Dermatology, Venerology und Allergology, Leipzig University, Germany*
[3]*Center for Regenerative Therapies Dresden (CRTD), Technische Universität Dresden, Germany*
[4]*Matrix engineering Leipzig and Dresden, Collaborative Research Center (SFB-TR67), Germany*

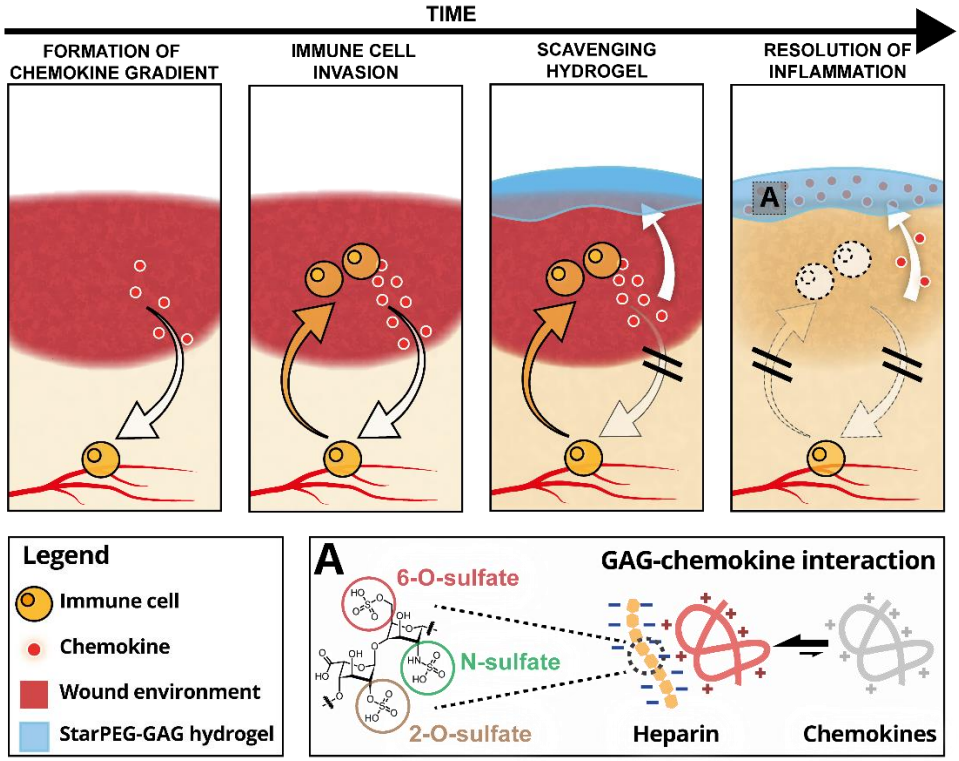
Background: Excessive production of inflammatory chemokines can cause chronic inflammation and thus impair wound healing. Accordingly, capturing such chemokine signals may stop chronic inflammatory processes and thus become a powerful treatment option for chronic wounds.

Objective: In here, a modular hydrogel based on star-shaped poly (ethylene glycol) (starPEG) and derivatives of the glycosaminoglycan (GAG) heparin was customized for maximal chemokine sequestration.

Methods: The resulting scavenging characteristics of the materials were compared in binding assays using recombinant chemokines MCP-1 and IL-8, inflammatory conditioned media and wound exudates of human patients suffering from chronic venous leg ulcers, respectively. Transmigration assays and a murine model of full thickness excisional wounds were performed to investigate the consequences of hydrogel-based chemokine sequestration. A model of delayed cutaneous wound healing (db/db mice) was applied to evaluate the overall pro-regenerative effect of the starPEG-GAG wound dressings.

Results: The material has been shown to effectively scavenge the inflammatory chemokines MCP-1, IL-8, MIP-1a and MIP-1b from conditioned medium and wound fluids from patients with chronic venous leg ulcers and to reduce the migratory activity of human monocytes and polymorphonuclear neutrophils. In an *in vivo* model of delayed wound healing (db/db mice) starPEG-GAG hydrogels outperformed the "standard of care" product Promogran™ with respect to reduction of inflammation, as well as improvement of granulation tissue formation, vascularization and wound closure.

Conclusion: Wound dressings formed from GAG-based gels were demonstrated to act as an efficient 'molecular sink', sequestering high amounts of chemokines, preferentially IL-8 and MCP-1 from the inflamed wound, thereby preventing further recruitment of immune cells to ultimately resolve the inflammatory process.



DRESSING TECHNOLOGIES

Intelligent Dressing for Wound Infection Detection using Ex-vivo Porcine Burn Wound Biofilm Model

Naing Tun Thet[1], Toby Jenkins[2], Amber Young[3]

[1]*Department of Chemistry, University of Bath, Senior Research Associate, UK*
[2]*Department of Chemistry, University of Bath, Professor, UK*
[3]*School of Social and Community Medicine, University of Bristol, Senior Research Fellow, UK*

Background: Bacterial infection in burns is a major cause of worldwide morbidity and mortality. Young children with burn wound is especially in high risk due to immature immune systems. Early detection of burn wound infection is therefore critical and helps clinicians with options for better treatment, avoiding unnecessary use of antibiotics. Developed wound dressing provides early infection warning by colour change before bacteria reach the critical colonisation threshold (CCT) in infected wounds.

Objective: The objective is to validate the ability of smart wound dressing in detecting wound infection using ex-vivo porcine burn wound biofilm model.

Methods: Burns with blisters on porcine skin were infected with the extract of infection-suspected bandages removed from (burn) wounds. After incubation in humidity chamber at 37°C for 5 days, biofilms were tested with wound dressings in triplicate following further incubation at 37°C for 48 hours. With controls, colour response of dressings was then examined and verified with respect to clinical outcomes of infection judged by clinicians from participating hospitals.

Results: Dressing response was mostly definite with positive (colour change) or negative (no colour change). With the study size of 32, dressing sensitivity and specificity of 65% and 73% were achieved respectively.

Conclusion: Developed wound dressing using clinical extracts of infection-suspected wounds on porcine wound biofilm model was validated. Results of pilot phase pre-clinical study demonstrate the capability of intelligent dressing to detect the infection in burn wounds.

LEG AND FOOT ULCERATION

A Novel Treatment Modality in Diabetic Foot Ulcers: Cold Atmospheric Pressure Plasma

Rimke Lagrand[1], Paulien Smits[2], Guus Pemen[3], Louise Sabelis[1], Ana Sobota[3], Bas Zeper[2], Bouke Boekema[4], **Esther Middelkoop**[4,5], Edgar Peters[6]

[1]*Dept of Rehabilitation Medicine, VU University Medical Center, Netherlands*
[2]*Plasma Medicine, Plasmacure, Netherlands*
[3]*Dept of Applied Physics and Dept of Electrical Engineering, Eindhoven University of Technology, Netherlands*
[4]*Preclinical Research, Association of Dutch Burn Centres, Netherlands*
[5]*Dept of Plastic, Reconstructive and Hand Surgery, VU University Medical Center, Netherlands*
[6]*Dept of Internal Medicine, VU University Medical Center, Netherlands*

Cold atmospheric plasma (CAP) devices generate an ionized gas with highly reactive species and electric fields at ambient air pressure and temperature. Plasma treatments disinfect efficiently, painlessly, instantly and can stimulate aspects of human wound healing. We studied efficacy and safety of a novel, simple to use CAP device.

Bactericidal effect was tested on *Staphylococcus aureus* in collagen matrices and on human skin in vitro. Safety was monitored preclinically in skin biopsies, after multiple daily treatments, and clinically in human subjects with diabetic foot ulcers. Subjects were treated with daily CAP for 10 days in 2 weeks. Primary endpoint was occurrence of serious adverse events (SAE) as a result of treatment. Standard protocols for wound treatment were deployed.

High reduction of *S. aureus* in vitro was reached in 1-2 minutes of plasma treatment. Plasma treatment was less efficient on dermal samples. Plasma did not affect viability or DNA integrity of skin biopsies when used for 1-2 min. Repeated daily treatments of up to 4 times slightly lowered viability of skin biopsies.

Interim clinical data were available for 7 patients. No SAE occurred as a result of plasma treatment, while 71% of subjects experienced transient tingling during one or more applications. No wound expanded during treatment. One wound healed and no amputations or infections occurred within 30 days after treatment.

The novel CAP device kills bacteria on skin, without affecting viability of dermal cells in laboratory tests. During the clinical study no SAE occurred, while AEs were low graded and transient.

LEG AND FOOT ULCERATION

An Investigation to Accurately Measure the Healing and Receding Edges in Venous Leg Ulcer

Kevin Jacob

Medical Photography Department, Illingworth Research Group Limited, UK

The boundary of Chronic Venus Leg Ulcers are constantly changing so accurately recording the ebb-and-flow of healing and expanding edges to determine treatment impact proves challenging. Physical tracing and 3D imaging records changes in ulcer area but without consistent leg/ulcer registration, the accuracy of individual boundary changes lack confidence; the ulcer area will appear unchanged if one side has expanded and the other healed to a similar degree.

Three methodologies were investigated:

1. Standard photography with strict leg/camera positioning,
2. 3D capture system with automatic ulcer sequence alignment,
3. Standard photography utilising (on leg) ulcer registration markings.

The primary goal was to accurately measure the healing and receding ulcer edges over time – so enabling direct comparison of localised treatments. Secondary considerations of; system cost, ease of capture, ease of analysis and accuracy of data were noted, as such combinations could out way the primary result for certain indications.

Accurate measurements of the healing and receding ulcer edges could be achieved via both 2D and 3D image capture, providing patient registration marks remained throughout. Neither 2D photography or 3D imaging was practical (in this instance) without the inclusion of registration markings. Ulcer image positioning was achieved via four perpendicular semi-permanent ink markings beyond the ulcer boundary, which acted to identify the treatment areas – investigating the number and application of registration marks was beyond remit.

NOVEL APPROACHES FOR ACCELERATING WOUND HEALING

The Effect of Aminaphtone in an *in vitro* Model of Wound-Healing

Rossella Di Stefano[1], Francesca Felice[1], Egidio Imbalzano[2], Paola Losi[3], Giorgio Soldani[3]

[1]*Department of Surgical, Medical and Molecular Pathology and of the Critic Area, university of Pisa, Italy*
[2]*Department of Clinical and Experimental Medicine, University of Messina, Italy*
[3]*Laboratory of Biomaterials, Institute of Clinical Physiology - National Research Council, Italy*

Background: Failure to re-epithelialize is the major clinical problem in ulcers. Fibroblasts must migrate to and proliferate in the wound responding appropriately to cytokines and other factors that modulate and direct the production of extracellular matrix. Clinical studies suggest that Aminaphtone (AMNA), a naphtohydrochinone used in the treatment of capillary disorders, may enhances healing of recurrent ulcers.

Objective*:* Evaluate the effect of AMNA on wound healing process in fibroblasts.

Methods: Fibroblasts were isolated from normal thigh skin and grown until confluence in complete medium. For wound healing assay, cells were treated as follows: a) cells were pre-treated with AMNA (6 and 10 µg/ml) for 24h. AMNA was then removed and cells were scratched by a pipette tip to simulate a wound; b) cells were scratched to obtain the wound and AMNA (6 and 10 µg/ml) was added for 24h. At 0 and 24h after wounding, digital images of cells were captured by a phase-contrast microscope equipped with a digital CCD camera. To quantify the closure of the scratch the difference between wound width at time 0 and time 24h was determined.

Results: In 24-h exposure to 10 µg/ml AMNA, fibroblasts moved toward the opening to close the scratch wound by about 90% and significantly accelerated the wound healing process compared to control. Moreover, pre-treatment results more effective than treatment after scratch (70% wound healing).

Conclusion: AMNA resulted to be very effective in improving wound healing process in a time and dose-dependent manner, suggesting a new application also in wound healing.

NOVEL APPROACHES FOR ACCELERATING WOUND HEALING

A comparative study of the wound healing activity and safety assessment of aqueous extract of *Sargassum ilicifolium*

AD Premarathna[1], M.N.R Somasiri[1], M.L.W.P De Silva[1], K.A Wijesekera[1], R.R.M.K.K Wijesundara[1], S.K Wijesekera[2], T.H Ranahewa[1], A.P Jayasooriya[3], R.P.V.J Rajapakse[1]

[1]*Department of Veterinary Pathobiology, Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Sri Lanka*
[2]*Department of Zoology, Faculty of Natural Sciences, Open University Polgolla, Sri Lanka*
[3]*Department of Veterinary Basic Science, Faculty of Veterinary Medicine and Animal Science, University of Peradeniya, Sri Lanka*

Previous studies have proven that Seaweeds contain bioactive molecules with therapeutic values. However, seaweed properties in cutaneous wound healing have not explained yet. Therefore, a study was conducted to explore the potential wound healing properties of a seaweed (*Sargassum ilicifolium*) extracts. Seaweed samples were collected from the south coastal algae beds in Sri Lanka. Fifteen, 8-week-old, female, New Zealand rabbits were divided into five groups: excision skin wounds (10.40 ±0.60 mm) were induced in groups I, II, and III. Rabbits in groups I and IV were given *S. ilicifolium* extracts (orally, 90 mg/kg/day, two weeks), whereas groups II and V were given equal amounts of distilled water. Rabbits in group IV were given *S. ilicifolium* extracts (orally, 90 mg/kg/day, two weeks) before the induction of skin wounds. Wound healing properties were measured in groups I, II, and III. After 14 days, wound tissue samples were collated, formalin-fixed, wax-embedded, stained with haematoxylin and eosin and examined for healing process. In comparison to group II (26%), highest wound healing was observed in group I (58%), on day 3. On day 9, wound contractions were 94%, 58%, and 95% for groups I, II, and III, respectively. Histopathology, SGPT and SGOT levels showed no toxicity effects in seaweed treated groups. In conclusion, this study showed the wound healing properties of the *S. ilicifolium* and further *in-vitro* and *in-vivo* studies are being carried out to identify the active components with wound healing mechanism.

PATIENT MANAGEMENT

Using Novel Point of Care Assessment to Assist Wound Management: A Case Study

Frances Henshaw, Deborah Turner

School of Science and Health, University of Western Sydney, Australia

Background: Foot ulcers are notoriously difficult to heal and place significant burden on patients and health care services. Traditionally foot ulcers are managed by multidisciplinary teams. Wound management decisions are based largely on visual observations along with expert knowledge of treating practitioners. More sophisticated methods of assessment such as MRI are often prohibitively expensive, may have long waiting lists and restricted referral rights.

Objective: This case study demonstrates the utility of point of care (POC) wound assessment using ultrasound and gait studies to inform management planning.

Methods: Barefoot pressures were undertaken using the Emed® and Pliance® systems (Novel GMBH,Germany) from a patient with a chronic plantar ulcer that had not responded to sustained multidisciplinary care and offloading with a knee crutch and CAM walker combination (fig. 1). Ultrasound imaging of the wound was undertaken using the Esaote MyLab TMAlpha machine with a 6-18MHz transducer.

Fig. 1: Knee crutch/CAM walker combination

Results:

- At the ulcerated site peak pressures of ~ 430kPa were recorded on double leg support weight bearing
- These reduced to ~105kPa on the ulcerated limb when the patient mobilised using a CAM walker together with the knee crutch
- When the crutch was worn without the CAM walker pressures reduced to 15kPa

Ultrasound imaging –The medial sesamoid appeared irregular in shape with a marked hyperechoic structure immediately adjacent but superficial to the sesamoid.

Conclusion: The novel combination of POC wound assessment facilitated targeted care: the CAM boot was removed as it appeared to transmit force through the knee crutch to the ulcerated area; surgical excision of the medial sesamoid was arranged after further imaging supported the ultrasound finding of avascular necrosis.

PRESSURE ULCERS

Sacral Skin Blood Flow Response to a Novel Low Profile Alternating Pressure Overlay

Vinoth Ranganathan[2], David Brienza[1], Patricia Karg[1], Michael Churilla[1]

[1]*Department of Rehabilitation Science and Technology, University of Pittsburgh, USA*
[2]*Clinical Research, Dabir Surfaces Inc, USA*

Lengthy surgeries often expose bony prominences to loading conditions associated with high risk of pressure injuries (PIs). Roughly 25% of PIs that develop in acute care settings are acquired intra-operatively during surgeries that last more than three hours. Prolonged ischemia may be one of the factors increasing risk. Alternating pressure (AP) has been shown to increase skin blood flow (SBF). This study compared the response of sacral SBF on a foam operating room (OR) pad with and without an AP overlay. An experimental, crossover research design was conducted. Healthy participants (n=19) with mean age 46.9±21.2 years (Range 19-76) and body mass index (BMI) 26.1±5.4 kg/m^2 (Range 18.5-37.5) laid supine for sixty minutes in each condition while sacral SBF data was collected using a laser Doppler optic probe. Mean SBF measurements were tested for significant differences between conditions. The loaded SBF data was normalized to the mean baseline SBF. The ratio of the mean normalized SBF of the last 10 minutes to the mean SBF of the first 10 minutes represented the SBF response to each test condition. The difference in this measure between test conditions quantified the relative effectiveness. Post-hoc regression analyses examined the relationships between the overlay effectiveness and demographic factors. Mean SBF was greater with the overlay (AP mean SBF=1.4±1.1; OR mean SBF=1.0±0.4;p=0.16). Regression analysis revealed having a BMI under 30 predicted that use of the overlay with the OR pad would result in improved SBF response compared to use of the OR pad without the overlay (p=0.018).

PRESSURE ULCERS

Preventing Peri-Operative Pressure Ulcers – Interface Pressure Evaluation of a Sacral Dressing and a Low Profile Alternating Pressure Surgical Overlay

Vinoth Ranganathan[2], Xiaoming Zhang[1], Vernon Lin[1]

[1]*Department of Physical Medicine and Rehabilitation, Cleveland Clinic, USA*
[2]*Clinical Research, Dabir Surfaces Inc, USA*

Background: A significant portion of pressure ulcers (PUs) in acute-care settings originate from surgeries that last more than 3 hours. Limited options are available during surgeries to manage risk factors such as pressure, friction and shear. Sacral dressings are used for pressure redistribution and shear reduction during surgeries. A low profile alternating pressure (AP) overlay has been developed for providing periodic pressure relief during surgeries.

Objective: To evaluate the interface pressure redistribution provided by an AP overlay and a sacral dressing.

Methods: Twelve healthy young and elderly adults (age range: 23-80yrs, BMI range: 19.5-27.4) participated. A foam-based dressing was applied on the participants' sacrum. The interface pressures for three types of operating room (OR) pads (2" thick highly resilient foam OR pad, 1.5" thick highly resilient foam OR pad with a 0.5" layer of viscoelastic foam, and 1.5" thick highly resilient foam OR pad with a 0.5" layer of gel) were measured with and without the AP overlay.

Results: Use of sacral dressing did not significantly reduce the average and peak interface pressure at the sacrum for all three types of OR pads. The alternating pressure overlay (in combination with sacral dressing), when placed over the three types of OR pads, provided almost complete off-loading at the sacrum (average and peak interface pressures were below 20mmHg) during the deflation cycles.

Conclusion: The low profile alternating pressure overlay along with sacral dressing may be a more effective way for preventing peri-operative pressure ulcers from long duration surgeries.

PRESSURE ULCERS

Use of a Shear Reduction Surface in Pre-hospital Transport

Ann Tescher[1], Kathleen Berns[2], Lucas Myers[3], Evan Call[4], Patrick Koehler[7], Kip Salzwedel[7], Heather McCormack[5], Marianne Russon[4], Josh Burton[4], Christine Lohse[6], Jay Mandrekar[6], Scott Zietlow[8]

[1]*Department of Nursing, Mayo Clinic, USA*
[2]*Medical Transport, Mayo Clinic, USA*
[3]*Gold Cross Ambulance, Mayo Clinic, USA*
[4]*Biomechanical Testing, EC Services, USA*
[5]*Physical Medicine and Rehabilitation, Mayo Clinic, USA*
[6]*Healthcare Policy and Research-Biomedical Statistics and Informatics, Mayo Clinic, USA*
[7]*Respiratory Care, Mayo Clinic, USA*
[8]*Trauma, Critical Care, and General Surgery, Mayo Clinic, USA*

Background: Shear is a known risk factor in Pressure Injury development.

Objective: Examine effectiveness of an anti-shear mattress overlay (ASMO) in reducing shear/pressure and increasing comfort on an ambulance stretcher.

Methods: Randomized, cross-over design. Thirty adult volunteers in 3 BMI categories served as their own controls. PREDIA shear/pressure sensors applied to sacrum, ischial tuberosity (IT), and heel. Stretcher was placed in sequential 0°, 15°, and 30° elevations, with and without ASMO. The ambulance travelled over a closed course achieving 30 mph, with 5 complete stops at each HOB elevation for a total of 900 trials. Subjects rated discomfort on a 0-10 scale after each series of 5 runs.

Results: Peak shear difference between surfaces was -0.89, indicating that after adjusting for elevation, sensor location, BMI, starting pause peak shear levels were 0.89 Newtons (N) lower for ASMO compared with standard surface ($p=0.057$). Compared with 0°, elevations of 15° and 30° increased these levels by 2.41N ($p<0.001$) and 3.44N ($p<0.001$), respectively. Compared with sacrum, IT and heel increased pre-run shear levels by 2.54N ($p<0.001$) and 1.01N ($p=0.079$), respectively. Peak pressure difference between surfaces was -1.69, indicating pre-run peak pressure levels were 1.69mmHg lower for ASMO compared with standard surface ($p=0.070$). Discomfort was lower on ASMO than standard surface at 0° and 30° ($p=0.004$, $p=0.014$). Both surfaces had increased discomfort moving from 0° to 30° ($p=0.005$ and 0.039 respectively).

Conclusion: ASMO reduced levels of shear, pressure and discomfort. During transport, attention should be given to heels and HOB elevation.

PRESSURE ULCERS

Descriptive Analysis of Deep Tissue Pressure Injury: Predisposing Factors, Presentation, Evolution

Ann Tescher[1], Susan Thompson[1], Heather McCormack[3], Brenda Bearden[2], Christine Lohse[4], Mark Christopherson[3], Beth Sievers[1], Catherine Mielke[1]

[1]*Department of Nursing, Mayo Clinic, USA*
[2]*Department of Nursing - Surgical Services, Mayo Clinic, USA*
[3]*Physical Medicine and Rehabilitation, Mayo Clinic, USA*
[4]*Healthcare Policy and Research-Biomedical Statistics and Informatics, Mayo Clinic, USA*

Background: A Deep Tissue Pressure Injury (DTPI) is challenging to identify and treat. Limited evidence is available related to etiologies, effective treatments, and outcome prediction.

Objective: Describe common intrinsic and extrinsic factors and outcomes of hospital-acquired DTPIs

Methods: Retrospective descriptive cohort design. Data abstracted from the Electronic Health Record from a two year period. Descriptive data, relevant co-morbidities, assessments, treatments, therapies, and patient/wound outcomes were collected from the EHR.

Results: A total of 179 DTPIs occurred in 141 patients. Of the patients, 63 died within 1 year of DTPI occurrence, including 25 who died during hospitalization. Of the DTPIs, 41 were device-related. The most common sites were the coccyx, heel, and buttock. Outcomes were resolved, 28 DTPI; partial thickness/stable, 131 DTPI; and full thickness/unstageable, 20 DTPI. The median (range) hospital length of stay (LOS) was 23 (4-258) days; 76 patients had a portion of their hospital stay in the ICU (median 12 days, range 1-173); 40 patients had surgery before DTPI; 119 had a diagnostic procedure before DTPI. The following variables were significant between outcome groups: mechanical ventilation (P=.01), history of cerebrovascular accident (P=.03), LOS (P<.001), time-to-event (P=.001), vasopressor after DTPI (P=.003), device-related (P=.002), and noncontact low-frequency ultrasound (P<.001).

Conclusion: Cerebral and peripheral vascular diseases, head-of-bed elevation, and medical devices were associated with DTPI development. However, progression to full-thickness injury was not inevitable. Maintaining a high index of suspicion in patients with risk factors, including early and frequent assessment and timely intervention, may help prevent DTPI deterioration and poor patient outcomes.

RISK FACTORS AND RISK ASSESSMENT

Assessing the Impact of the Removal of Umbilicus Wound Healing in Patients above 60 Years of Age Treated for Gastrointestinal Cancers

Jacek Zielinski[1], Radoslaw Jaworski[3], Ninela Irga-Jaworska[4], Michal Pikula[2], Janusz Jaskiewicz[5]

[1]*Department of Surgical Oncology, Medical University of Gdansk, Poland*
[2]*Department of Clinical Immunology and Transplantology, Medical University of Gdansk, Poland*
[3]*Department of Pediatric Cardiac Surgery, Copernicus Hospital, Poland*
[4]*Department of Pediatrics, Hematology, Oncology and Endocrinology, Medical University of Gdansk, Poland*
[5]*Department of Surgical Oncology, Medical University of Gdansk, Poland*

Background

After the surgery, an important element of the surgery is to obtain proper healing of the wound. For this purpose it is necessary to get as knowledge of the factors affecting wound healing. Equally important condition for wound healing in patients with cancer is correct surgical technique.

Objective

The aim of the study is to compare the course of healing of surgical site in patients after excision of the umbilicus with patients without cut navel treated for gastrointestinal cancers.

Methods: *The material consists of 122 patients treated in the Department of Surgical Oncology of Medical University in Gdansk from March 2014 until January 2017. Patients with gastrointestinal cancer were qualified to this research. In a retrospective study of patients enrolled in the course of wound healing was assessed in groups (A, n = 66) after excision of the umbilicus to group (B, n = 66) treated conventionally, i.e. without cutting breaks. Other surgical procedures such as sewing wounds in both groups was performed equally.*

The trial evaluated the state of local wounds in the postoperative period 1, 2, 3 era and at discharge based on the International Classification of surgical site infection (SSI, surgical side infections).

Results: Mean age, weight, height and BMI came to 49,8 (years), 67 (kg), 164 (cm) and 24,6 (kg/m2). The average time of follow-up of patients amounted to 5 months (the range of observation: 1**–12** months).

Infectious complications of surgical site occurred in the entire group in 5% of patients. In group A, complications were 1.5%, while in Group B in 6%.

Conclusion: The introduction of navel cutting elderly patients reduces post-operative complications and did not deteriorate the quality of life.

RISK FACTORS AND RISK ASSESSMENT

Prediction of the Degree of Microvascular Closure in the Sacral Region under Compression and Shear with a Strain-State Measure

Hiroshi Yamada, Keisuke Sakata

Dept. of Biological Functions Engineering, Grad. Sch. of Life Science and Systems Engineering, Kyushu Institute of Technology, Japan

Background: Pressure ulcers develop in soft tissue at bony prominences such as the sacrum under sustained pressure and shear on the body surface. From a mechanical perspective, computational analyses have been conducted to evaluate the risk of microvascular closure. However, understanding the mechanisms underlying such ulcers requires correlation of the mechanical states in soft tissue with the boundary conditions on the body surface.

Objective: The objective of this study was to evaluate the degree of microvascular closure in soft tissue under body surface deformations using a measure of the strain state of soft tissue.

Methods: We formulated kinematic relationships in a region with uniform deformation subjected to compression and shear. To estimate the degree of microvascular closure, the minimum principal strain in soft tissue was calculated. We also estimated the minimum and maximum principal strains in soft tissue through two-dimensional finite element analysis of the sacrum.

Results: The maximal compressive strain in soft tissue, which occurs in a certain direction, can be estimated using the minimum principal strain as the total effect of body surface deformation. The results from finite element analysis show that one can trace the time course of the strain state in soft tissue under loading with shear and compression on the body surface.

Conclusion: Compression and shear can be expressed using minimum and maximum principal strains. The strain-state measure in soft tissue may be suitable as an index of the risk of microvascular closure.

TECHNOLOGIES FOR PREVENTION, EARLY DETECTION AND MONITORING OF WOUNDS

Smart Bandage Technologies: Developing New Functional Materials for Monitoring Wound Healing

James Davis[1], Anna McLister[1], Jordan Atchison[1], Karl McCreadie[2]

[1]*School of Engineering, Ulster University, UK*
[2]*School of Computing and Intelligent Systems, Ulster University, UK*

The design of a diagnostic platform through which a sensing system can be integrated directly within conventional wound dressings is described. The central aim is to enable the remote/periodic monitoring of biochemical markers within the wound such that the clinician is provided with a much clearer picture of the wound status. The ability to monitor the dynamics of the key players in situ could therefore provide insights into the various healing stages and also offer the possibility of spotting the early onset of infection. The “smart” wound dressing advocated here is based on a conductive polymer mesh that operates using a voltammetric methodology that can interrogate the wound providing multi-parametric quantitative information on a variety of key biomarkers. The sensing mesh layer is manufactured using conventional polymer processing techniques and can be produced at low cost. The complete sensing package consists of two parts: the disposable sensing mesh and the electronic controller system. The latter is an unobtrusive, miniaturised patch, worn by the patient and responsible for monitoring the wound. The electronic device reports back to the patient through a mobile phone app - providing the healthcare practitioners with a record of the diagnostic telemetry of the wound dynamics but, importantly, will alert the patient when the signs of infection appear. Preliminary data outlining the response of the prototype device under a variety of simulated conditions is presented and its application within a clinical and home health care environment is critically appraised.

TECHNOLOGIES FOR PREVENTION, EARLY DETECTION AND MONITORING OF WOUNDS

Effective Pressure Application and Air Leakage Detection of Current Negative Pressure Wound Therapy Systems in a Lab Model

Tim Schmidt[2], Schachtrupp Alexander[1], Bernhard Knauf[1], Kerstin Seemann[3]

[1]*Medical Scientific Affairs Cooperate, B.Braun Melsungen, Germany*
[2]*Surgery, Kassel School of Medicine, Germany*
[3]*General and Visceral Surgery, Klinikum Kassel, Germany*

Background: Both inaccurate pressure application and air leakage during NPWT have been shown to be unfavourable for wound healing, secondary to dehydration and necrosis. It is, however, unknown how current NPWT systems reliably apply and monitor these two parameters.

Objective: To analyse four leading NPWT systems in their ability to apply accurate pressure and detect air leakage.

Methods: Systems from B. Braun (BBS), Smith & Nephew (SNS), KCI (KCIS) and Hartmann (HS) were tested using an artificial wound model connected to a pressure measuring device and a row of 15 filters to gradually simulate air leakage. For each system three different vacuum pumps were set to pressures of -70, -120 and -160 mmHg. Agreement between displayed and effective negative pressure at wound ground was expresses as mean differences and with limits of agreement (LOA, 1.96 SD). Air leakage sensitivity was assessed by applying air leakage in set increments until an alert occurred.

Results: Mean differences between set and effective pressures were -0.87 (BBS), 0.61 (SNS), -6.28 (KCIS), -0.79 (HS) mmHg and statistically significant ($p<0.0001$) across all systems, with LOA of -9.37 and 7.79. At -70 and -120 mmHg, only BBS detected air leakage (4 of 15 filters open); at -160 mmHg, also SNS (11) and KCIS (15). HS was insensitive to air leakage (15).

Conclusion: Agreement between set and effective pressure can be considered clinically sufficient. Air leakage sensitivity, however, differs significantly between different systems involving the risk of an air leak staying unnoticed with subsequent negative effects on wound healing.

TECHNOLOGIES FOR PREVENTION, EARLY DETECTION AND MONITORING OF WOUNDS

MentalPlus® can be an Accessible Tool to Assess Cognitive Dysfunction. A clinical Trials Randomized Exploratory Study for Reliability Evaluation.

Livia Valentin

Anesthesiology, University of Sao Paulo School of Medicine, Brazil

Postoperative cognitive dysfunction (POCD) is a multifactorial adverse event most frequently in elderly patients. POCD diagnosis usually demands a long neuropsychological battery. As a tentative to overcome that issue, Mental Plus® video game was developed as a tool to assess cognitive function and future rehabilitation. METHODS: 163 volunteers were randomized to play MentalPlus® versions A and B with a week interval between both moments. Mini-Mental State Examination was applied to assess the volunteers mental state, and we excluded those with scores below 18 or 23 related to a determined educational level. MentalPlus® applicability and reproducibility were evaluated by kappa index and McNemar test. RESULTS: The results disclosed the following characteristics: mean age of 36±16 years; 46 % male; School level mean of 5±2 years, the mean income of 4.6± 3 Brazilian minimum wage and the Mini-Mental score of 28±3, for an expectation of more than 25±3. The MentalPlus® A and B versions results revealed the subsequent kappa coefficients for reliability tests. For general cognitive function, kappa coefficient was 0.7122 ($p<0.005$); selective attention and alternating attention presented 0.4004 and 0.3998 ($p<0.005$); long-term memory and inhibitory control had comparable coefficients: 0.4103 and 0.4406 ($p<0.005$); executive function disclosed a kappa coefficient of 0.4406, through construct inhibitory control. There was a marked dispersion for visual perception, concerning to motion and resolution of objects: 0.2029 and 0.2453 ($p<0.005$). The expected cognitive function scores in MentalPlus® were expressed as a mean and standard deviation and confidence interval of 95%, $\alpha=0.05$. CONCLUSION: MentalPlus® digital game presented reliable evidence for cognition evaluation. It might be a future accessible tool for POCD evaluation and probable future rehabilitation. Trial registration: www.clinicaltrials.gov Identifier: NCT02551952.

TISSUE ENGINEERING, REPAIR AND REGENERATION

Electromagnetic Therapy for the Treatment of Diabetic Ulcers: Preclinical Evaluation

Michael Creane[1], Colman Dillon[2], Timothy O'Brien[1]

[1]*CURAM, Centre for Research in Medical Devices, National University of Ireland Galway, Galway, Ireland*
[2]*Medical Energetics, Raheen Industrial Estate, Athenry, Galway, Ireland*

Background: Diabetic foot ulceration (DFU) represents a major unmet medical need and is having an extensive impact on our healthcare system. Despite the current standard of care, the incidence of DFU amputations is continuing to rise. Therefore, new treatments are urgently needed to reduce amputation rates and also hospital expenditure for care of this condition. An alternative approach to treating DFU is the application of electromagnetic fields (EMF) to the wound bed. Medical Energetics have developed a novel EMF device called the MK II coil which emits a low frequency EMF.

Objective: This study was designed as a proof of concept using the MK II EMF coil as a potential therapy for DFU.

Methods: The alloxan-induced hyperglycaemic rabbit ear ulcer model was used to determine the healing response following EMF treatment. Ear wound ulcers were created and animals were exposed to EMF for one hour per day for 1 week. Ear wound closure was measured at 1 week along with additional toxicological measurements such as blood hematology and blood biochemistry.

Results: A significant improvement in wound healing as assessed by percentage wound closure was observed in the EMF treated animals in comparison to the control animals. No significant differences were observed in body weights, blood haematology or blood biochemistry between control and EMF treated animals.

Conclusion: These data suggest that EMF therapy was not only efficacious for ulcer healing but also well tolerated in these animals. Based on the observations in this study we believe that the EMF therapy represents a novel therapeutic strategy for increasing wound closure and has provided justification for testing the MK II coil in humans with non-healing DFU.

TISSUE ENGINEERING, REPAIR AND REGENERATION

Limbal Cell Monolayer Regeneration: Video microscopy and Digital Image Analysis in a Corneal Surface Regeneration Model

Gábor Király[1], Melinda Turáni[1], Orsolya Ungvári[1], Gábor Szemán-Nagy[1], Ádám Kemény-Beke[2], István Juhász[3]

[1]*Department of Biotechnology and Microbiology, University of Debrecen, Hungary*
[2]*Department of Ophthalmology, University of Debrecen, Hungary*
[3]*Department of Dermatology and Venerology, University of Debrecen, Hungary*

Background: Main functions of the cornea: serve as barrier against fluid loss and micro-organisms, furthermore it's refractional properties are indispensable for acute vision. Limbal epithelial stem cells have a key role in a regeneration of the corneal epithelium. This cell migration scratch model allows an *in vitro* research method, which can be carried out in a cell culture laboratory.

Objective: Create an *in vitro* model system to investigate the regeneration of the harness surface of the cornea and modeling the cellular processes of the regeneration.

Methods: The regeneration of the scratched cell monolayer was followed up with a long-term video microscopy during the experiments. The evaluation of the image sequences made by video microscopy, were carried out with a digital image analyser. During this we analyzed the motility of the monolayer versus time in the scratched region. The regeneration of the monolayer was investigated in the absence and in the presence of collagen matrix, furthermore collagen, hyaluronic acid and gelatin scaffold, so the experiments were carried out in an arrangement similar to the physiological environment.

Conclusions: We created an *in vitro* model, with which we can analyze the time sequences of the regeneration of the injured corneal surface. The dynamics of the monolayer regeneration was analyzed and was compared on collagen coated and not coated glass surfaces and scaffold in case of cultured cells.

TISSUE ENGINEERING, REPAIR AND REGENERATION

Cerium Chloride Application Promotes Wound Healing and Cell Proliferation in Human Foreskin Fibroblasts

Liza L. Ramenzoni[1], Franz E. Weber[2], Thomas Attin[1], Patrick R. Schmidlin[1]

[1]*Clinic of Preventive Dentistry, Periodontology and Cariology, University of Zurich - Center of Dental Medicine, Switzerland*
[2]*Oral Biotechnology and Bioengineering, Division of Cranio-Maxilo-Facial and Oral Surgery, University Hospital Zurich - University of Zurich, Switzerland*

Background: Cell proliferation and migration are fundamental elements of tissue repair. Cerium was shown as a potential trigger of cell proliferation and could also play a role in wound healing-related tissue remodeling.

Objective: This study investigated the effect of cerium chloride ($CeCl_3$) on cell migration and gene expression of human foreskin fibroblasts (HFF).

Material and Methods: HFF were exposed to 3 different $CeCl_3$ solutions (1, 5 and 10%) in 3 different time-points (1, 5 and 10min). After 72h of exposure to $CeCl_3$, cell proliferation was assessed by MTT-test. A scratch-wounded monolayer model determined the cell migration assays and the width of the wound was measured during 24h. Gene expression patterns for cell proliferation (*Cyclin B1, D1* and *E1*) was analyzed by quantitative RT-PCR ($p<0.05$, t-test).

Results: The proliferation of HFF was significantly enhanced at 1 and 5min of 1%, 5% and 10% of $CeCl_3$exposure compared to cells cultured in the absence of $CeCl_3$ ($p<0.05$ at 24h). No influence of $CeCl_3$ was found after 10min. The scratch wound healing assay showed an increase in cell migration up to 60% at 1 and 5min after 24h at concentrations of 5% and 10%. The RT-PCR showed up-regulation of *Cyclin B1*, *D1* and *E1* at respective concentrations, confirming the increase in cell proliferation.

Conclusion: This study demonstrates a positive effect of $CeCl_3$ on proliferation and migration of fibroblasts depending on the concentration and cell culture time. $CeCl_3$ could be applied as cell-stimulating agent leading to therapeutic tissue fibrosis or more resistant tissue around teeth if warranted during different periodontal therapies.

WOUND CARE AND NURSING PRACTICE

Why Apps when you could Wheel?

Wan Zuraini Mahrawi, Mazlina Mohamed

Telok Datok Health Clinic, Ministry of Health Malaysia, Malaysia

Background: The statistics of chronic wounds are on the rise and if left unaddressed this can lead to devastating sequale such as amputations. In developing countries, the lack of wound training among health care providers (HCPs) have triggered primary care HCPs to take a leading role in managing wounds. This has led to the development of digital software applications to assist with wound management for the new or untrained primary HCPs. However, not all HCPs have access to these especially those who are in very rural areas and personnel who do not have access to computers or smartphones.

Objective: To create an easily handled reference to assist with wound management targeted specifically for primary HCPs who have not received formal wound care training and all HCP in general.

Method: After reviewing the relevant information and references, a draft "Wound Wheel" was made. It is based on the concept of the Triangle of Wound Assessment (TOWA). Using AutoCAD software this draft has been converted into softcopy and being printed out for use.

Result: The first plate of the wheel has been divided into 3 segments which are the wound bed, wound edge and periwound. The second plate of wheel has dressing materials options according to their group. As the wheel turns, it will show the recommended dressing material in a coding of 1 – 5.

Conclusion: The Wound Wheel is an innovative, low-tech and easy to use guide for treating and managing wounds for the new HCP or for those who have not received any formal wound care training.

WOUND CARE AND REHABILITATION

Outcome of Three Hundred & Ten Traumatic Amputations at A Level 1 Trauma Center

Amulya Rattan, Kamlesh Bairwa, Subodh Kumar, Amit Gupta, Biplab Mishra, Sushma Sagar

Division of Trauma Surgery & Critical Care, JPN Apex Trauma Center, All India Institute of Medical Sciences, India

***Background**:* JPN Apex Trauma Center is a Level 1 trauma center in New Delhi, India with an annual footfall of 60,000 patients. We studied the outcomes of patients undergoing post traumatic amputations at our center.

Methods: Ethical approval taken from Institutional committee. Retrospective review of trauma database for all patients presenting with extremity trauma, requiring amputation during a two year period from Jan 1, 2015 to Dec 31, 2016 was done. Demography, epidemiology, kinematics, presentation, first aid received, reason and level for amputation, change in the quality of life and mortality were studied. Times to surgery, discharge, stump optimization, skin grafting or flap coverage, use of NPWT, prosthesis application and return to pre-injury work were noted.

Results: Two hundred seventy seven patients underwent post traumatic amputation during the above said period. Thirty three patients had bilateral amputations. Male: Female 5.7:1 (234/ 43). Majority of patients were adults. Two hundred and forty four patients underwent unilateral amputations as follows: Upper Limb- above elbow 42, below elbow. Lower limb- above knee 90, below knee 96. Disarticulation was required in 17 lower limbs and 12 upper limbs. Reasons for amputations in limbs apparently salvageable in retrospection were studied.

Conclusion: The findings are discussed and reviewed with contemporary literature. Lack of trauma systems in a developing nation compounded by limited access to definitive surgical care emerged as the most frequent reason for preventable amputations.