ATTWC
Advanced Treatments and Technologies in Wound Care
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Poster Board 1

Aging and Fragility of Skin and Subdermal Tissues and Technologies to Assess Tissue Fragility

Assessing the Impact of the Techniques of Suturing Subcutaneous Tissue on the Course of Healing of Surgical Site in Patients over the Age of 60 Treated Cancers.

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Background

After taking into account long-term forecasts until 2025 the abovementioned number will increase by several percent.

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

The aim of the study is to compare the course of comparison of subcutaneous suturing versus suturing fat tissue sewing for gastrointestinal cancers.

Methods

The material consists of 122 patients treated in the Department of Surgical Oncology of Medical University in Gdansk from March2014 until January 2017. Patients with gastrointestinal cancer were qualified to this research.

In a retrospective study of patients enrolled in the course, wound healing was assessed in groups A (n = 66) after subcutaneous suturing group and group B (n = 66) with suturing fat suturing, i.e. without cutting breaks.

The Trial evaluated the state of local wounds in the postoperative period during 1,2,3 day 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.

Infectious complications of surgical site occurred in the entire group in 6% of patients. In group A, complications constituted 1.5%, while in Group B - 4,5%.

Conclusion

The introduction of navel suturing in elderly patients reduces post-operative complications and does not deteriorate the quality of life.

Poster Board 2

Computer Modelling and Simulations in Wound Prevention and Care

Is Haglund's Deformity a Risk Factor for Pressure Ulcers?

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Background

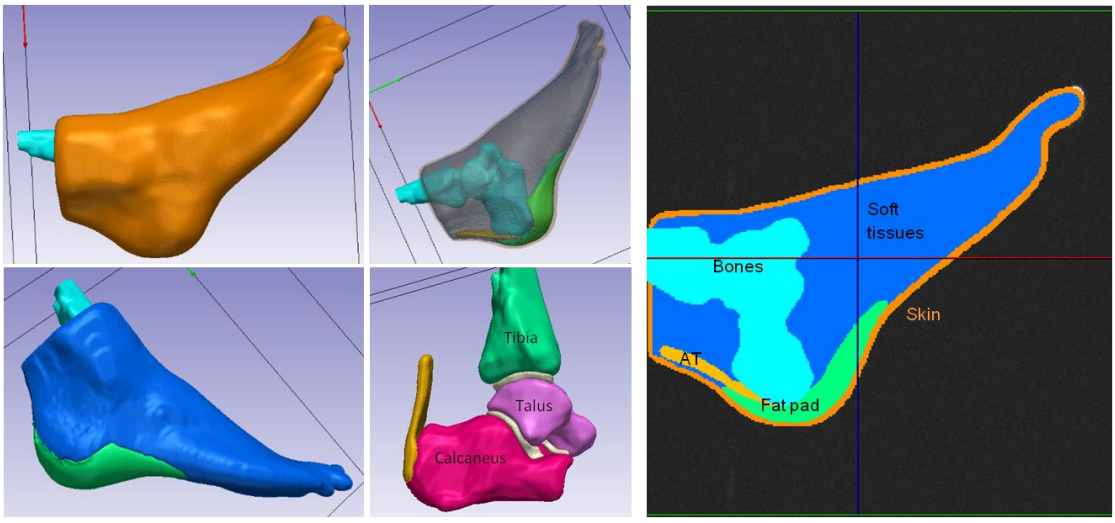
Pressure ulcers (PU) are primarily caused by prolonged pressure to the skin, which limits blood flow and subsequently injures the underlying soft tissue. Current clinical practice to help PU's involves either: repositioning the patient, and/or redistributing the pressure using a support surface. Support surfaces are designed to elevate and cushion the heel whilst restricting pressure, friction and shear from the surface of a bed. A common clinical condition, which is poorly understood is Haglund's deformity – an enlargement of the posterosuperior part of the calcaneus, which leads to bursal inflammation of the Achilles bursa.

Objective

There is a clear need to better understand the soft tissue mechanics surrounding the heel, when in contact with a support surface for preventing the formation of ulcers. This study investigates the geometric and morphological changes in the healthy and deformed foot, and how the biomechanics of the calcaneal bone and soft tissue is altered in an individual with Haglund's deformity.

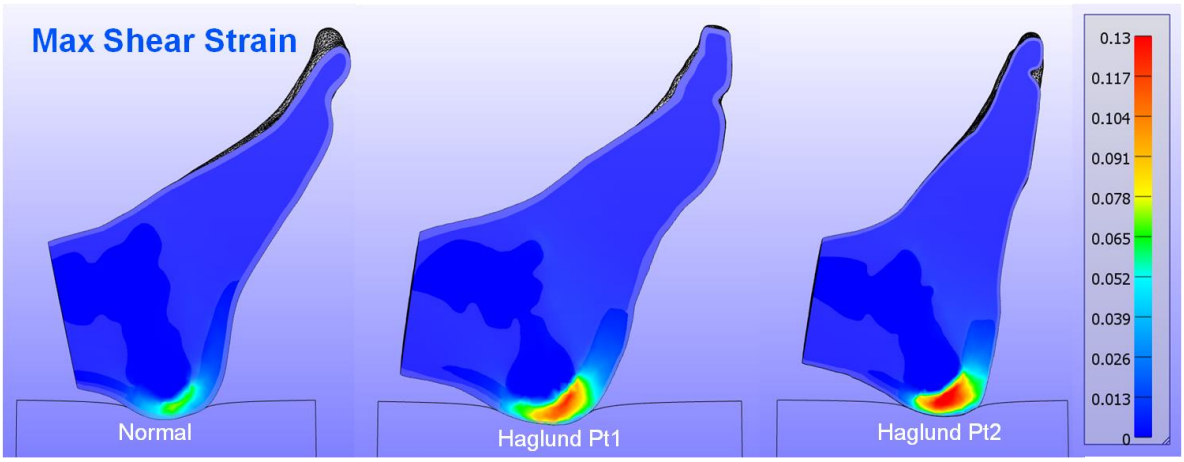
Methods

A novel 3D MRI technique was developed to clearly identify the anatomical geometry in the healthy and deformed foot. A finite element model (FEM) of the heel was created to investigate the internal strains that occur when the weight of the foot is resting on a mattress (Figure1). A series of simulations were run to examine the stress at the point where the calcaneal tuberosity contacts the support surface.



Results

High internal shear strains are observed in the soft tissues of those with Haglund's deformity (Figure2). Patients presenting with Haglund's deformity could therefore be at high risk of PU formation.



Conclusion

This study is part of an ongoing project that will lead to guidelines and/or a test method that can determine who is most at risk of PU formation and which products are effective in preventing ulcers.

Poster Board 3

Design of Clinical Trials for Testing Medical Devices in the Field of Wound Prevention and Care

Biophysical Evaluation of Atopic Dermatitis and Influence of Nonthermal Plasma

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Atopic dermatitis is a chronic and recurrent pruritic skin disease. Existing therapies have limited efficacy and often cause many side effects.

We measured the electrical impedance and other pathophysiological changes and assessed the effect of non-thermal plasma on atopic dermatitis

Atopic dermatitis-induced NC/Nga mice were used to evaluate the efficacy of nonthermal plasma by measuring electrical impedance compared to clinical evaluation (SCORAD index), serum IgE and IFN-γ, and histopathological analysis.

With nonthermal plasma treatment for atopic dermatitis, NC/Nga mice effectively alleviated clinical symptoms quantified by modified SCORAD. Histopathologic analysis showed that nonthermal plasma decreased epidermis thickness and mast cell infiltration in dermis with down-regulation of serum cytokines, IgE and IFN-γ. The result of electrical impedance of atopic dermatitis decrease compared with normal skin. Moreover, there was an improvement in atopic skin after nonthermal plasma treatment and a reversal of impedance indices towards normal.

Our findings demonstrate that the nonthermal plasma used improve atopic dermatitis by modulating immune cells in skin and peripheral blood of NC/Nga mice. Recovery of skin barrier function is observed in nonthermal plasma treated mice compared to atopic dermatitis. In addition, a technique based on electrical impedance appear to provide valuable and objective metrics over SCORAD.

Poster Board 4

Design of Dressings for Prophylaxis and Treatment

In vitro human cord blood platelet lysate characterization with potential application in wound healing.

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Background

Platelets are rich in mediators able to positively affect cell activity in wound healing. Umbilical cord blood platelet derivatives have been demonstrated to be richer in growth factors than peripheral blood derivatives and have been successfully used as serum substitute in human cell expansion.

Objective

Aim of this study was to characterize the effect of human cord blood platelet lysate (PL) on cells involved in wound healing.

Methods

Cord blood PL was obtained by freeze/thaw of platelet concentrate (1.1 x 10^9 platelets/ml). Pro-angiogenic growth factor levels were assessed by ELISA. PL (1, 3, 5, 10 and 20%) was added to basal medium and its effect was studied on human endothelial cells (HUVECs) and mouse fibroblasts (L929), in terms of viability (MTT assay), proliferation (BrdU assay) and migration (scratch test).

Results

Mean content of PDGF-AB and VEGF were about 65 ng/ml and 3.5 ng/ml respectively. 1, 3 and 5% PL increased cell viability and proliferation respect to basal medium and at the same value of complete medium, while 20% PL showed an inhibitor effect. 10% PL showed a positive effect on HUVECs and a negative effect on L929. Scratch wounded L929 incubated with 5% PL for 24 and 48 hours showed a higher scratch closure rate as compared to 1, 3, 10% PL samples and to complete medium.

Conclusion

Although autologous platelets provide safe supplements to treat diseases, the amount of autologous PL is limited and affected by interindividual variability. Cord blood PL may be useful to produce a large amount of standard PL sufficient for several clinical scale expansions. Moreover cord blood PL was successfully incorporated into a fibrin-based scaffold for controlled delivery of bioactive pro-angiogenetic growth factors. These data suggest the possibility of using cord blood PL as a tool for clinical regenerative application for wound healing.

Poster Board 5

Design of Dressings for Prophylaxis and Treatment

Vacuum Assisted Wound Closure in a Trauma Patient with Open Abdomen

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Background

Application of vacuum assisted wound closure (VAWC) systems in the management of open abdominal wound is largely studied and documented method in the medical literature.

Although in complex open abdominal wound with exposed bowel, the use of (VAWC) is not well established due to risk of developing entero-atmospheric fistula.

Objective

Our primary objective was to show the effectiveness of this treatment method by using an additional vaseline gauze layer between exposed bowel and the VAWC sponge. Our secondary aim was to emphasize the importance of a comprehensive wound care team in surgical department in the acceleration of this treatment method.

Methods

A 34 year old male patient, sustained multiple intra-abdominal injuries due to a stab wound. He had penetrating injuries to the large bowel, duodenum and right kidney. He underwent two laparotomies as he was in hemorrhagic and septic shock. The abdominal wound left open with an on-lay vicryl mesh and large portion of the small bowel was exposed. Patient had an end ileostomy in the right lower quadrant of abdomen close to the wound edges. The VAWC treatment was initiated with using additional layer of Vaseline gauze in order to prevent bowel injury.

Results

The initial intra-hospital VAWC treatment was followed by home VAWC and the wound was closed completely without any septic complications or injury to the bowel. We were able to overcome the challenges of this complex abdominal wound, by the aid and creativity of our comprehensive wound care team.

Conclusion

We present a cost effective and feasible adjunct to VAWC by using an additional protective layer with vaseline gauze. The aid and need of a dedicated wound care team in a surgical department has paramount importance.

Poster Board 6

Design of Dressings for Prophylaxis and Treatment

A Fresh '*Spin*' in Chronic Wound Care: Delivering miR-31 via Nanofibres

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Background

MicroRNAs (miRs) act as post-transcriptional regulators of multiple proteins and therefore have immense potential as genetic therapeutics. Electrospinning has been identified as an exciting process to produce ultra-fine fibres, forming the basis of a wound dressing with a high surface area.

Objective

Herein, we aim to develop a treatment that consists of nanoparticles (NPs) designed to deliver DNA encoding miR-31, which regulates multiple proliferative and angiogenic target genes. A novel peptide system '*PEP*' has been designed for the intercellular delivery of the pmiR-31 cargo. The NPs will be loaded onto an electrospun PVA nanofibrous platform (PVA-NF), fabricated to facilitate temporal controlled delivery, and ensure a moist microenvironment.

Methods

NCTC-929 fibroblast, HMEC-1 endothelial and HaCaT keratinocyte cells were transfected with *PEP*/pmiR-31 NPs via PVA-NFs. The functional effects of miR-31 upregulation on cell migration, proliferation and angiogenesis were subsequently assessed via the wound scratch, cell viability and tubule formation assays. The efficacy of the NPs was then tested *in vivo* using C57BL/6N mice via the full-thickness wound model. After seven days wound beds were harvested and examined histologically.

Results

Elevated expression of miR-31 increased migration rates in the HaCaT (**, p=0.0062), HMEC-1 (*, p=0.0286) and NCTC-929 (*, p=0.0454) cells. Treatment increased the proliferative capacity of the HaCaT (**, p=0.0028) and the NCTC-929 (*, p=0.0311) cells, and resulted in a significant increase in angiogenesis (*, p=0.0202) with HMEC-1 cells. *In vivo* application of the NP loaded PVA-NFs resulted in a significant increase in epidermal and stratum corneum thickness, as well as blood vessel size.

Conclusion

Results indicate miR-31 upregulation positively affected cell functionality *in vitro* and *in vivo* thus forming a firm basis in wound repair potential. The next phase of this research will involve functional assessment of the device *in vivo* using a diabetic murine wound model.

Poster Board 7

Microclimate Control

Role of Nutrition and Hydration in Wound Healing

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Background Chronic leg ulcers affect 1% of the adult population and 3-5% of those over 65 years. The microclimate, in particular hydration and nutrition, is important in the prevention and treatment of chronic wounds: malnutrition due to micronutrient and macronutrient deficiency or surplus, favor the delay in the healing process.

Objective The aim of this study was to verify adherence to the Mediterranean diet, through the Mediterranean Diet Score (MDS), and the frequency of consumption of the main Mediterranean nutrients; particular attention was reserved to acquire information about hydration, to relate data to the speed of healing in patients with chronic ulcers of lower limbs. Moreover, a model of hypohydration *in vitro* was set up.

Methods We enrolled in the study 38 patients (20 females; 18 males) afferent to the Wound Healing Ambulatory selected because of chronic ulcers (more than six months) and we evaluated: 1. medical history of patients 2. body mass index. A food frequency questionnaire, based on MDS, including 27 questions was created. To evaluate the role of dehydration, we performed the scratch test using fibroblasts cultured an incubator to which water had previously been removed.

Results Our results showed that 80% of the studied population had a low-medium adherence to the Mediterranean diet and a very low hydration (0.75 cl/ daily) and that scratch wound healing velocity is dramatically reduced in fibroblasts growing in dehydration.

Conclusion Although the study population has a medium - low adherence to the Mediterranean diet, hydration plays a fundamental role in the repair on the speed of healing of ulcers.

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Poster Board 8

Sensor Technologies for Monitoring Tissue Health Status

Biocompatible Textile Organic Electrochemical Transistor as pH Detector for Wound Healing Monitoring

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Background

At the present, no wearable device is available to continuously monitor the ulcer status. For chronic or infected wounds, the literature reports a pH interval between 6.5 and 9.

Objective

The aim was to produce an innovative scaffold capable of monitoring ulcers healing.

Methods

The scaffold constituted by synthetic biocompatible materials, poly (ether) urethane-polydimethylsiloxane (PU-PDMS), was manufactured by spray, phase-inversion technique. This scaffold has been successfully used in combination with fibrin as delivery system for VEGF, bFGF and platelet lysate in preclinical wound healing experiments. A micro-fibrillar tubular scaffold was obtained using a 1% polymer solution and H_2O as non solvent (I layer) and 2% and H_2O (II layer) and was lyophilized. The morphological analysis of PU-PDMS scaffold surfaces was performed by stereo-microscope after Sudan Black B staining.

A biocompatible conductive polymer (PEDOT: PSS) was used as detector. This polymer presents a high sensitivity to positive ions in liquid environment and allows to determine ions concentration in easy and stable way. The fiber textile electrochemical device has been realized by a dipping process and connected with electric contact to create a channel and a gate electrode to control the modulation changes of the sensor. The device functionality was proved on human serum at different pH (between 4 and 10).

Results

The morphological analysis showed a dense, non-porous surface obtained with the 2% solution, while a porous surface was obtained with the 1% solution where the PEDOT: PSS was positioned. This feature was maintained after lyophilization and re-hydratation.

The characteristic of the device was tested showing the sensitivity to saline concentration and the effective functionality of the device. Moreover the device shows a response to pH variation.

Conclusion

These data suggest the possibility of using this sensorised scaffold as a wearable detector for wound healing monitoring in patients affected by chronic lesions.

Poster Board 9

Smart Materials for Support Surfaces, Overlies and Protective Clothing

Wound Healing Properties of Wild Type Human Angiogenin – Gold Nanoparticles Hybrids

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Since skin wounds are subject to bacterial infection that impedes tissue regeneration, there is demand for biomaterials possessing rapid bactericidal and tissue repair capability. In this work, we addressed the wound healing properties of the wild-type human angiogenin (h-ANG)[1] and its fragments (e.g., the 60-68 sequence mimicking the putative cell binding domain of the protein [2]), in the hybrid assembly with theranostic gold nanoparticles (AuNPs)[3] on a human lung fibroblast cell line. The influence of copper, which is a pivotal co-player of angiogenesis, was also investigated. The hybrid ANG/AuNP/Cu systems were characterized by means of UV-visible, AFM, CD and DLS, to address plasmonic changes, nanoparticle coverage and conformational features at the hybrid biointerface, respectively. Lateral diffusion measurements on model cell membranes made of supported lipid bilayers pointed to a strong membrane interaction of the ANG/AuNP/Cu systems in comparison with the uncoated nanoparticles. *In vitro*, the improvements on wound healing after the fibroblasts treatments with the hybrid nanoassemblies were evaluated by detecting VEGF and TGF-β expression. Results showed that the developed systems had the ability of wound closure by promoting fibroblasts migration. Cell imaging by confocal microscopy evidenced dynamic processes modulated in a synergic way by the different components (protein/peptides, gold nanoparticle, copper) of the hybrid nanoplatforms at the level of the cell membrane (cytoskeleton features observed by actin staining) as well as at the sub-cellular compartments (copper-binding proteins).

Founding from M-ERA.NET project `SmartHyCAR` is acknowledged.

[1] La Mendola D. et al., *Metallomics,* 2016, 8, 118.

[2] Cucci L.M. et al. *Biointerphases*, 2018,13, 03C401.

[3] Di Pietro P. et al., *Curr. Top Medic. Chem*., 2016, 16, 3069.

Poster Board 10

Technologies and Devices for Preventing Pressure Ulcers

Wound Healing Acceleration by Using Platelet-Rich Plasma

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Background: Nowadays, there are significant advances and many possibilities how to accelerate wound healing. One of the possibilities is utilisation of platelet-rich plasma (PRP) locally applied. The authors present first results obtained by using PRP in healing of donor site, to prove that PRP is responsible for better healing.

Patients and methods: The randomised prospective single-centre study included patients with two donor sites on both thighs, after taking of split-thickness skin graft. Autologous PRP was applied on one thigh. We compared healing with contralateral thigh which was treated by our standard method without PRP.

Results: Of the 24 patients, 3 developed infections and were thus removed from the study. Use of PRP reduced wound healing time of dermo-epidermal graft donor sites by a mean 17.8% and median 18 days (12.0; 17.0). On average, the treated donor sites healed in 14.9 days as compared to 18.4 days for the control group. Thanks to a simple wound-model we proved that using PRP accelerates wound healing. There was no evidence of healing deceleration or disturbance because of using a PRP.

Conclusion: There is clear evidence that application of platelet-rich plasma (PRP) as the source of growth factors accelerates healing process. Several groups of patients can profit from the method using PRP, especially the patients with problematic wound healing and chronic wounds by whom conventional methods have failed.

Poster Board 11

Technologies for 3 Dimensional Imaging and Wound Measurements

Automated Pressure Ulcer Measurement for Veterans with Spinal Cord Injury

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Background

Spinal cord injury (SCI) affects over 275,000 people in the USA with approximately 12,500 new injuries each year. Persons with SCI are at extreme risk for developing pressure ulcers (PrUs) due to immobility, lack of sensation, moisture, and multiple other risk factors. Manual wound assessments are subjective and user-dependent. Given the high prevalence and cost of PrUs in SCI, an objective, valid, and reliable measurement of healing is needed to improve the consistency, quality, and effectiveness of clinical care.

Objective

The objective of this study is to automate PrU measurement to track PrU healing progress for Veterans with SCI through development and evaluation of a computer-aided pressure ulcer monitoring system (PrUMS).

Methods

PrUMS was created to automate the manual SCI PrU Monitoring Tool (SCI-PUMT), the only validated instrument for evaluating PrU healing for Veterans with SCI, which consists of 5 geometric and 2 substance variables that are weighted relative to impact on PrU healing.

PrUMS uses a 3D camera (Intel RealSense SR300) mounted to a tablet (Microsoft Surface Pro 4) to obtain images; a custom interface was created with the RealSense SDK. The algorithm uses wound-region segmentation based on hue and surface gradient of the images. Two PrUs from a life-like training mannequin (sacrum-stage IV; ischium-stage IV) were each tested 50 times with PrUMS; ground-truth measurements were taken by an experienced wound care nurse (sacrum-108x126x18mm; ischium-63x67x16mm).

Results

PrUMS measurements for length (L), width (W), and depth (D) for the sacral and ischial PrUs, respectively, had standard deviations of 3.28mm-L, 0.83mm-W, 2.76mm-D, and 3.26mm-L, 1.22mm-W, 0.82mm-D. The absolute error rates compared to ground-truth were 1.76%-L, 0.45%-W, 12.86%-D, and 4.08%-L, 1.63%-W, 5.92%-D, respectively.

Conclusion

PrUMS demonstrated accurate and precise automated PrU measurements. Error rates were 2-4%, 0-2%, and 6-13% in length, width, and depth, respectively, which are better than reported manual linear measurement errors of approximately 15%. PrUMS is a promising system to objectively measure PrU healing in Veterans with SCI.

Poster Board 12

Technologies for Training and Education in Wound Prevention and Care

Irrigation of Amphotericin B is Useful on the Treatment of Rhino-Orbito-Cerebral Mucormycosis

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Rhino-orbital-cerebral mucormycosis (ROCM) is a rare, opportunistic and severe angioinvasive fungal infection that despite relevant treatment has high mortality. Here, I describe a patient with ROCM unresponsive to surgical debridement who has treated successfully with irrigation of Amphotericin B (AmB) and ALT free composite flap.

I present the case of a 69-year-old Korean diabetic male with ectropion, epiphora, hemifacial deformity with foul odor from fungal ball at March, 2017 (Fig. 1).

He was diagnosed with ROCM due to Aspergillus and Mucor spp. and underwent maxillectomy in January 2016. Despite the surgical debridement, the ROCM was not regulated and all of the soft tissues covering the cheek were lost. To treatment of the ROCM, 25 mg (6 ml) of liposomal AmB was injected directly into the wound for 4 weeks, and 25 mg (6 ml) of remaining AmB was used for irrigation. At the same time, intravenous AmB (1.5 mg/kg/day) was administered.

Infection was controlled and granulation tissue began to appear within the maxillary sinus (Fig. 2).

On the MRI, infection was no longer spread and stable. ALT-FL free flap was performed to reconstruct the defect in the face, intravenous liposomal AmB was administered for 4 weeks. After that, the patient is survived without complication such as ectropion as well as infection (Fig. 3).

The aggressive nature of this disease requires rapid diagnosis, early intervention with antifungal therapy, and the reversal of the underlying immunocompromising conditions. As in this case, following debridement of necrotic tissue, local irrigation and injection of AmB may be meaningful in the success of treatment for ROCM.

Poster Board 13

Tissue Engineering Based Treatments of Burns, Acute and Chronic Wounds

Biomaterials for Regenerative Cell Therapy

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Cells live in an intricate and dynamic extracellular matrix (ECM) where they intermingle with a host of biophysical and biochemical signals that guide their function, regulation, and wound repair. Numerous efforts have been made to engineer biomaterials, based on both natural and synthetic polymers, in order to simulate the ECM microenvironment. Hydrogels, cross-linked macromolecules that absorb large amounts of water, have received widespread interest due to their relevant soft tissue mechanics, biocompatibility, and tunability. An overview of developed and several examples of ongoing biomaterials and 3D biofabrication projects with the primary goal of building functional, clinically relevant, regenerative tissues of the future are presented. These include the development of an FDA-approved, commercialized chitosan/dextran-based (CD) hydrogel, Chitogel™, for adhesion prevention in sinus surgeries, the development of a dual peptide functionalized CD hydrogel as a stem cell delivery vehicle and bio-ink for 3D bioprinting, 3D printed polycaprolactone (PCL)/ milk protein scaffolds via melt electrowriting (MEW) for skin regeneration, and a novel gelatin methacrylate (Gel-MA)/protein nanofibril hydrogel for potential cell therapy applications. Our studies indicate that CD hydrogel is biocompatible, biodegradable, and an appropriate delivery vehicle for adult stem cell therapy applications. Other suitable biomaterials developed include a biocompatible, PCL/milk protein MEW scaffolds, and a novel Gel-MA/protein nanofibril, hydrogel as scaffolds for cell growth. Both natural and synthetic polymer components and their composites were found to be appropriate ECM biomimics and able to act as substrates in the creation of regenerative constructs for potential cell therapy applications.

Poster Board 14

Wound Databases and Big-Data Analyses

Delayed Wound Healing in Lower Extremity Amputees:

A Regional Canadian Perspective

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Introduction

Delayed stump wound healing in lower extremity amputees remains a common complication leading to increased morbidity and healthcare costs. The wound healing is considered delayed when it prevents prosthesis fitting for greater than 3 months in an otherwise eligible prosthetic candidate. The majority of lower limb amputations occurring in Canada are related to vascular causes, specifically diabetes and peripheral vascular disease. The incidence of amputation in Manitoba per 100,000 has been reducing from 51.64 in 1991 to 35.36 in 2016 with 90% of these procedures related to vascular complications.

Objectives

Due to the paucity in literature concerning time frames and rates of delayed stump wound healing, we performed a retrospective review of our database from 2014 to 2017 with primary end point of healing time; secondary end points including gender, age, community of residence, and other comorbidities.

Methods

This paper is a retrospective database review of our academic tertiary centre (2014-2017) of 273 individuals of major lower extremity amputations. Delayed wound healing was treated with mechanical, chemical debridement, and antibiotics for infected wounds.

Results

Age range of amputees was 25 to 85. Mean age was 58.23, overall 87.60% of patients had dysvascular causes while 12.40% were non-dysvascular. 73.79% were males and there was overall evidence of delayed stump wound healing in 53% of amputees.

Conclusions

Delayed wound healing is a common complication which warrants a need for further prospective studies to re-visit our treatment approaches as well as comparative studies with other regions.