Comparison of non-surgical methods for the treatment of deep partial thickness skin burns of the hand

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A B S T R A C T

This paper describes a randomized, controlled, parallel-group, single-center clinical trial designed to compare non-surgical treatment methods of deep partial thickness skin burns of the hand.

All patients were scanned with the Laser Doppler Imaging device to determine the depth of the burn wound. Viable keratinocytes sites were determined according to the established Perfusion Units (PU) measurement system. The trial enrolled 87 patients with hand burn wounds in the section of 260-600PU. Hand burn patients were divided into the following four groups: treated with hydrocolloid dressings; treated with mechanical debridement of monofilament polyester fibers pad and then applying silver sulfadiazine; treated with gauze dressings containing enzymatic collagenase preparation. The fourth group of patients was treated with silver sulfadiazine and gauze dressings. This group was considered as the control group. The wound healing status was assessed after 3, 7, 14 and 21 days. Burn scars and injured extremity function were assessed after six months according to the Vancouver Scar Scale and Disabilities of the Arm, Shoulder and Hand Outcome Measure. The fastest epithelialization of hand burn wounds was observed in the patients group treated with hydrocolloid dressings (15, 7 days, p < 0.05). The patients of this group also had less scars and a better hand function.

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1. Introduction

In 1970, the Slovenian doctor Z. Janzekovic described her impressive clinical results using an innovative approach of an early burn wound excision and simultaneous skin grafting for the treatment of deep dermal partial thickness burns in children. Soon this method gained wide popularity and became the treatment standard for burn injuries [1]. A significant number of clinical trials demonstrate clinical advantage of the early burn excision and grafting in comparison with the conservative burn wound management according to the time and quality of healing of burn wounds and patient survival rate [2-5].

Modern treatment tactics for deep hand burns is an early tangential or even fascial excision followed by an immediate
grafting with split thickness non-meshed skin grafts or dermal skin substitutes [6,7]. On the other hand, it is widely accepted that partial thickness skin burns can be debrided and simultaneously covered with non-meshed split skin grafts or temporary skin substitute products when a critical quantity of vital keratinocytes is preserved in a deeper skin layer [8-10]. The introduction of Laser Doppler Imaging to clinical practice has created an opportunity for a more precise assessment of the depth of skin burn injuries based on the number of viable keratinocytes and provides a possibility to make prognosis for qualitative burn wound closure [11].

As burns mostly happen without intent, the burn wounds do not have chronic disease caused wound chronization factors and in most cases the debridement of a necrotic tissue is essential and sufficient to create the basis for a proper wound healing process. The persistence of necrosis and debris in the wound bed or a prolonged debridement process prevent wound from healing and can lead to impaired wound healing [12,13]. In the situation in which the wound has potential for sufficient self-epithelialization, qualitatively performed wound management can reduce the overall need for skin grafting, artificial skin usage, and general hospital cost in selected patients [14-17]. Therefore, modern clinical trials are targeted towards the research of highly selective debridement methods for the treatment of partial thickness skin burns of the hand [18].

2. Materials and methods

A randomized, controlled, parallel-group clinical trial designed to compare particular non surgical methods for the treatment of deep partial thickness skin burns of the hand was conducted at the Department of Plastic and Reconstructive Surgery of the Lithuanian University of Health Sciences Kaunas Clinics from April 1, 2014 to March 1, 2017. The permission from the Lithuanian Biomedical Studies Ethical Committee and Lithuanian State Data Protection Inspection was received to proceed the trial.

Laser Doppler Image (LDI) scanning was performed with the MoorLDLS2 machine strictly on the third day after burn for all patients. The LDI scanning was essential to predict the presence of a sufficient amount of keratinocytes required for the wound qualitative self-epithelialization in three weeks period as maximum. The hand burns with LDI scanning data evaluation from 260 to 600 Perfusion Units (PU) were in line with the above mentioned criteria [11,19-21].

Patients from 18 to 65 years of age with non-extensive burns (Total Body Surface Area TBSA <30%), including deep partial thickness skin burns of the hand (International Burns Classification, IBC — 2B), LDI scanning data evaluation: 260-600PU) and who signed the consent form were included in the trial. Patients with superficial thickness and full thickness skin burns of the hand (IBC — 2A; and IBC — 3; LDI scanning data evaluation: <260PU, >600PU), patients with known pregnancy (pregnancy test was performed for all female patients) and vulnerable persons (based on a psychiatric diagnosis) were excluded from the trial.

The main parameter that characterizes the wound healing process is the measurement of the wound surface size change in time. The necessary minimum quantity of patients in each group for statistical analysis is 20 persons.

The hand burns of the second group of patients were covered with hydrocolloid dressings (GranulFlex™, ConvaTec, Greensboro, NC, USA) changed every three days.

The second group patients’ hand burns were treated by applying proteolytic enzyme complex gel (“Streptomyces flavus 197 Ferment”, Biocentras, LTU, Vilnius, Lithuania) and then covering them with the gauze dressings once daily.

The third patient group received a combination of treatment – mechanical debridement with single-use pad of monofilament polyester fibers (“Debrisoft” Lohmann&Rauscher GmbH & Co, Vienna, Austria) and then applying Silver Sulfadiazine SSD 1% ointment covered with gauze dressings once daily for the first four-five days. Later these patients were treated with SSD 1% ointment and gauze dressings only.

The forth (control) group of patients was treated with well established burns treatment in Lithuania – SSD 1% ointment (“Sulfargin”, Grindes AS, Riga, Latvia) which was applied once daily on burn wounds and covered with gauze dressings.

The patients’ clinical condition and burn wounds were evaluated after 3, 7, 14 and 21days after burn. All burn wounds were evaluated to their total epithelialization. In case this process exceeded 21days the remaining areas of burn wound were covered with split skin grafts.

No antibiotics were administered to the treated patients as a prophylactic in order to assess wound healing under similar conditions. In case of symptoms of systemic inflammation because of infection the patient was administered an appropriate treatment and each case was registered.

Physiotherapy procedures of burned hands were started on a daily basis mostly on day 3 after burn under the physiotherapist surveillance.

The burn wound size was estimated by placing on it a transparent film containing measurement in square centimeters “OpSite” (Smith&Nephew Medical Limited, UK) and calculating them.

The intensity of pain was evaluated after 10min of the change of dressings according to the pain Visual Analog Scale (VAS).

Clinical wound conditions — persistence of necrosis, amount of fibrin, granulation tissue, and epithelialization process were evaluated as a percentage from the total wound area by the same physician according to the trial measurement parameters.

To identify the burn wound contamination after 3, 7 and 14days post after swabs were taken by using the Levine methodology [22,23].

During the first evaluation patients were also asked to fill in the Disabilities of the Arm, Shoulder and Hand (DASH) Outcome Measure with researcher assistance as the patients’ health condition was reflected better closer to and it was easier to remember the hand function they had before the burn accident.

The patients’ assessment after six months was performed to evaluate the quality of after burn scars according to the Vancouver Scar Scale (VSS) and functional recovery according to DASH. VSS mostly offered data on the scar appearance. Together with DASH information collected on hand
functionality level the complementary objective evaluation of burn scars was received from patients’ data (Fig. 1).

After the discharge all patients were recommended to continue rehabilitation of scars in outpatient departments.

3. Results

Over the course of nearly three years 93 patients with deep partial thickness skin burns of the hand were observed and 87 of these patients were included in the trial and randomized among groups. Three patients had evident psychiatric disorders. Two patients refused to be included in the trial and the remaining patients moved to another hospital over the course of treatment.

61% of burns were flame burns, 28% — scalds, 6% — contact burns, and 5% were burns of other etiologies (Table 1). The mean of the burn surface was 17% TBSA. No antibiotics were admitted to any patient in the trial prophylactically or because of infection.

Groups were homogeneous according to the patient age, gender, burn wound area size, etiology of burns, clinical and LDI burn-depth evaluation and primary DASH value before the burn accident (p > 0.05) (Fig. 2).

The highest speed of burn wound healing was observed in the patients’ group (n=22 patients, 15.9±2.6 days), in comparison with the control group (n=22 patients, 19.8±2.9 days), combination treatment group (n=21 patients, 18.8±2.5 days), and enzymatic dressings group (n=22 patients, 19.5±2.3 days) (p < 0.05) (Table 2).

No difference was detected according to the pain Visual Analog Scale (VAS) among groups after a 10-min after dressing changing procedure during the evaluation at 3, 7, 14 and 21 days after burn (Table 3).

The necrotic tissue and wound debris was reduced more rapidly in the hydrocolloid dressings group during first week after the burn injury (p < 0.05) (Table 4). The amount of fibrin in burn wounds during the evaluation after 7 days after burn was

![Fig. 1 – Trial protocol.](http://dx.doi.org/10.1016/j.burns.2017.08.002)
statistically higher in the control and combined treatment groups due to SSD induced pseudoeschar formation (p<0.05) [24,25] (Table 5). As seen in the graph, in the combined treatment group a mechanical debridement with the pad of monofilament polyester fibers has not demonstrated a good fibrin layer clearance effect.

The epithelialization process was statistically slower during the evaluation after 14 days for the enzymatic treatment group (p<0.05), but later the situation improved and all wounds healed with this method of debridement in three weeks (Table 6).

The quality of scars evaluated after six months after burn according to VSS and the hand function according to DASH were assessed for the hydrocolloid dressings group by averages 1.36 and 1.6, respectively; in the control group — 4.19 and 16.3, respectively; in the combined treatment group — 3.0 and 9.7 respectively; in enzymatic dressing group — 4.9 and 11.0 respectively (Tables 7 and 8).

The difference in averages of the wound healing speed and VSS among groups was statistically significant when valued by ANOVA (p<0.05). Moderate correlations were found between the fastest wound healing time and the best VSS values (R=0.51; p<0.01) and the fastest wound healing time and DASH alteration after six months after burn (R=0.5; p<0.01) among the patients of all groups.

Semi quantitative swab tests for all burn wounds during healing time were performed. Burn wound contamination occurred more often in the hydrocolloid dressings group, but no significant difference was found among groups and none of the patients were excluded from the study because of burn wound infection. The most common microorganism, detected by swabs, was Staphylococcus aureus (methicillin-sensitive strains).

![Table 2 - Healing time of hand burns.](image)

![Table 3 - Assessment of pain according to Visual Analog Scale (VAS).](image)
4. Discussion

An acceptable period for burn wound self-epithelialization is approximately three weeks. Several scientific reviews indicate that burn wounds which took longer than 21 days to heal posed hypertrophic scar development risk of nearly 80% and profound functional disability [26-28].

A perfect instrument for the burn depth evaluation is the Laser Doppler Imaging which produces a color-coded image of dermal blood flow. This can then be used to quantify the inflammatory response in a burn wound and predict burn wound outcome and healing time with high accuracy [19-21,29]. The LDI scanning result is described by PU and then is defined by ranges for the three healing time categories by Healing Potential (HP):

- HP 14 days: color coded pink and red, >600PU;
- HP 14-21 days: green and yellow, 260-600PU;
- HP >21 days: blue and dark blue, <260PU.

Several studies have compared LDI’s ability to predict healing outcomes in line with clinical investigation. These studies confirm LDI’s utility in assessing the burn wound depth and show that it has an increased accuracy over clinical assessment [11,30-32]. The accuracy of LDI in the assessment of burn depth was 95% on the third day after burn and 97% on the fifth day, compared with 60-80% for established clinical methods [21,32].

4.1. Silver sulfadiazine

SSD cream 1% is still one of the most commonly used burn wounds treatments in Lithuania. This type of treatment was chosen for the control group in the represented study. According to recommendations, this medication is applied once daily. SSD cream is distinguished for the antibacterial activity as demonstrated by decreased colonization of burn

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wounds. However, SSD impedes epithelialization process in the wounds and forms a pseudoeschar, which can promote bacterial proliferation. The pseudoeschar benefits from removal or debridement to improve the ability to monitor the wound state and facilitate reepithelialization [25,51].

4.2. **Accelerated autolytic debridement**

The discovery of wound treatment in a moist environment was manifested by Sir G. Winter back in 1962 and became revolutionary in the wound healing science [33]. Moist wound environment promotes autolysis during which wounds are naturally cleaned from necrotic masses as a result of the impact of endogenous phagocyte cells and proteolytic enzymes [34,35]. Autolytic debridement is comparatively selective compared with other types of debridement and commonly is achieved by using hydrocolloid dressings [36,37]. During the treatment we observed already confirmed features of hydrocolloid dressings to maintain moist environment for wound healing and at the same time partially capturing exudation and also reducing pain.

4.3. **Mechanical debridement with “Debrisoft”**

For mechanical debridement we used an innovative single-use pad of monofilament polyester fibers. The pad is moistened with saline and then is folded and wiped across the wound with light pressure. Dead tissues become integrated into monofilaments and are therefore removed from the procedure site [38]. “Debrisoft” is intended for use without analgesia and the process takes, on average, 2-4 min. There is a strong manufacturer recommendation to wash emollients from the skin before applying the device. A new pad is required for each separate area of the skin being treated. For large areas more than one pad may be required [38-41].

Burn treatment with SSD leads to pseudoeschar formation during first week after burn [24,42], whereas the combination with “Debrisoft” seemed to be a good decision for improving the ability to examine the wound surface and remove debris more quickly and promote the epithelialization process.

4.4. **Enzymatic debridement**

Proteolytic enzymes have the ability to hydrolase collagen molecules and other proteins’ peptide bonds. Therefore, debris loses attachments to the wound and is removed from the wound surface. Enzymatic debridement has a highly-selective mode of action. However this kind of debridement is quite sensitive to the wound environment, temperature, and other treatment agents which can reduce and even block relatively slow active proteolytic enzymes activity. Moreover, some theoretical and practical knowledge is essential to use this instrument properly [43,44] as understanding that different enzymes have certain potential of debridement. Several new articles describe the benefit of the new bromelain debriding agent usage for extremely fast and selective debridment of burns [45,46].

An enzymatic collagenase preparation “Streptomyces flavus 197 Ferment” was included in the prospective clinical trial for burn wounds debridement. Mostly, before in clinical practice it was ordered from producer for burns and ulcers single cases treatment. The enzyme complex is obtained from actinomycetes “Streptomyces flavus 197” strain. The enzyme complex has proteolytic and collagenase activities. Preparation is stabilized with glycerin. Actinomycetes are non-pathogenic microorganisms, assigned to the first biological agent risk group. According to preclinical studies, there was no evidence of illnesses triggered in humans and irritation of healthy tissues using this method [47]. Medication was applied on gauze dressings and the wound was covered once daily. This preparation is similar to the “Iruxol Mono” ointment (Smith & Nephew Medical Limited, UK) for burns treatment, which is used widely throughout the world [48].

All non-surgical methods chosen for the study had a positive effect on bio burden elimination from the wound surface and on promotion of the burn wound epithelialization process. We excluded surgical debridement because it requires simultaneous skin grafting or replacement with artificial skin.

LDI showed excellent results in the burn wound healing prediction. The majority of deep burn wounds according to LDI examination were found more superficial burned than initially assessed clinically and therefore healed spontaneously with appropriate treatment. SSD had a little negative effect on epithelialization from wound edges and deep skin layers [49,50].

Wounds react specifically to different debridement strategies and it is important to know specific wound variability for every type of debridement to detect and stop complications as soon as possible. For example, hydrocolloids accumulate exudation and keep wounds in a moist environment. During the first week after the burn autolytic debridement is very active and exudation and autolysis products can mimic purulent infection. Sometimes in ambulatory clinical practices hydrocolloid dressing therapy is unnecessarily canceled because of a bad smell and excess of opaque liquid though no signs of real infection were detected in the wound and surrounding tissues. In these cases patients often receive additional treatment with antibiotics and strong antiseptics locally on the wound which block epithelialization.

According to our experience, it is also important to use very light pressure operating with a single-use pad of monofilament polyester fibers. Immoderate pressure to the “Debrisoft” causes scratches to the wound surface with consequent massive capillary bleeding and aggravation of pain according to VAS. Inappropriate “Debrisoft” use would increase patient’s stress with a chance they might refuse the next debridement procedure.

In cases with enzymatic debridement the wound surface looks dry and sleek. Enzyme preparation used in the study was stabilized with glycerin, and this is the impact of the aforementioned substance. Glycerin itself has an antimicrobial effect on wounds but the drying effect is not beneficial to the epithelialization process.

In the clinical trial two new products were used for the evaluation of wound healing. However the best results were achieved with hydrocolloid dressings. The environment supplied with hydrocolloids is beneficial for the autolytic debridement — optimal wound pH, temperature, and humidity gives a better opportunity for granulocytes migration,
endogonic enzymes activation and wound epithelialization. These conditions are the most natural and support the fastest burn wounds regeneration with lesser scar possibility. As soon as it occurs, with even a few days’ difference, aesthetic and functional results are improved. This shows the correlation between the fastest wound healing time and the best VSS values and DASH alteration.

Comparing cost effectiveness of applied treatment methods, SSD is the cheapest among similar products on the market. Hydrocolloids are more expensive, but taking into account the duration of stay at hospital, less frequent dressing change and less pain — moist wound treatment and autolytic debridement in total has a positive economic effect on the treatment plan. There is no marketing information about the cost of enzymatic product we used as it is in clinical survey stage for industrial manufacturing. In addition, the use of monofilament polyester fiber pads does not increase significantly general treatment costs.

5. Conclusion

All patients in the study who suffered from deep partial thickness skin burns of the hand with LDI prediction of 260-600 PU were treated non-surgically and healed in three weeks period. The fastest epithelialization of deep partial thickness skin burns of the hand was observed in the patients group treated with hydrocolloid dressings. The patients of this group also had less scars and better hand function.

Conflict of interest

None.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.burns.2017.08.002.

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