A Comparative of Healing Effects of Topical Psyllium (Plantago ovata) Powder and Silver Sulfadiazine (1%) in Second-Degree Burns in Rats

Mohammad Jalilimanesh¹, Maryam Azhdari²*, Sara Azhdari³ and Keramat Teymouri zade⁴

¹Department of Plastic and Reconstructive Surgery, Shohadaye Mehrab Hospital, Yazd, Iran
²PH.D student of nutrition sciences, Nutrition and metabolic Disease Research Center, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran
³Department of Psychology College of Humanities Yazd, Science and Research Branch, Islamic Azad University, Yazd, Iran
⁴Marvast Province Agriculture Jahad Organization, Marvast, Yazd, Iran

ABSTRACT

Background: Burn is regarded not only as a disease but also a disaster. The aim of this study is to compare the effect of silver sulfadiazine (1%) and powdered Plantago ovata on second-degree burn wound within the rats.

Methods: This experimental study was conducted on 30 male Wistar rats with second-degree burn in 3 groups. Group 1 did not receive any treatments, group 2 and group 3 were dressed everyday using silver sulfadiazine ointment (1%) and Plantago ovata powder respectively. The weight, size of burn wound area, Wound Contraction and percentage of wound healing on the 5th, 7th, 10th, 13th, 16th, 19th, 22nd days and histological changes on 22nd days were evaluated. After the data were extracted, Prism software was applied using One-way ANOVA and Tukey test. The staining was performed via Haematoxylin-Eosin as well as Masson's trichrome.

Results: The mean of wound surface area was compared to be significantly different on the 22nd day in three groups. The same results were obtained in the groups treated with silver sulfadiazine and Plantago ovata compared to the control group with respect to fibrosis rate stained with H & E and trichomoson. Angiogenesis was less in the Plantago ovata treated group compared to the control group; this means that treatments were effective in promoting tissue repair.

Conclusions: In general, the findings of present study propose that regarding the examined factors, treatment with Plantago ovata powder seems to result in significant better healing for second-degree burn compared to the other two groups.

INTRODUCTION

Burn is regarded not only as a disease but also a disaster that cannot be merely limited to the patient. In fact, its associated social, economic and psychological effects are far broader than those of other diseases. The injuries caused by burns seem to be devastating [1,2].

Burn can occur in all age groups [3]. Burns are primarily divided into three categories based on thickness of the involved skin, including first-degree burns (superficial burns), second-degree burns, (partial thickness burns), and third-degree burns of the skin (full thickness burns). In addition to the burn thickness, the extent and percentage of burned part play a prominent role in treatment procedure. It is noteworthy that burns in the functional organs should be considerably taken into account and requires more care.

Second-degree burn occurs when the skin's second layer (dermis) is burned, including the following characteristics: red skin,
painful blisters and partial inflammation. In general, if the estimated area of second-degree burn is smaller than 2.3 inches (7 cm), it may be called a minor burn. If the burned area extends more than 7 cm or it involves functional organs of the body such as the legs, face, eyes, ears, groin or the main joints, more intensive medical care is demanded. Second-degree burn is probably one of the most frequent burn types that occurs in the houses and needs a better treatment [4]. Healing the burn wounds is taken into consideration as one of the medical problems, and hence it is valuable to find a medicine or substance to heal the wounds with the minimal side effects [3].

Wounds disrupt the integrity of tissues, lead to cuts in the blood vessels, and makes a direct contact of platelets with the extracellular substance. Natural healing of wounds follows a predictable pattern, that can be divided into overlapping stages based on the cellular population and biochemical activities including hemostasis and inflammation, proliferation, as well as maturation and remodeling [5].

Since a great number of the synthetic medicines, used to treat wounds, are not only considered expensive but also held to cause such complications as allergy and drug resistance, researchers tend to look for medicines that accelerate healing and reduce medical expenses [5]. Today, new economical methods with fewer side effects have been increasingly applied, specifically the use of herbs, due to the high cost in burn treatment as well as side effects of such synthetic medicines [6].

Silver sulfadiazine cream (1%), which contains a wide range of antimicrobial properties, is commonly in use in most Rescue centers [6-8], though it can delay the process of wound healing, considering its toxic effect of silver sulfadiazine cream (1%) on keratinocytes reconstruction due to sticking to the wound surface area during dressing and bandaging up [3]. Increased bacterial resistance, electrolyte imbalance, skin necrosis, skin discoloration and leucopenia can be mentioned as other side effects of this medicine [9-11]. Some individuals are sensitive to sulfonamide drugs which needs to be taken into account in their treatment. Regarding the mentioned points, discovering a medicine with minimal side effects for treatment of burn patients seems to be of great prominence [9,11,12].

*Plantago ovata* has been recognized as a medicinal herb by the Muslims of India, which its first seed was collected from the wild species. First, it was cultivated in Lahore and then, in Multan in Pakistan as well as Bangalore, Mysore and Coromandel coast of India. *Plantago ovata* seed has been prescribed as a medical treatment for hundreds of years in the Iranian traditional medicine. Due to pharmaceuticals effects of *Plantago ovata*, foods fortified with its mucilage offer an acceptable priority to their consumers. The term "*Plantago ovata*" can refer to the plant’s husk, seed as well as the whole plant. As a matter of fact, *Plantago ovata* has been introduced as a good source of soluble and insoluble fiber, which contains soluble fiber almost eight times more than that of oat bran. *Plantago ovata* (psyllium) or major L *Plantago* is regarded as a common name referring to several members of this plant family, commercially utilized to produce mucilage. It is a natural concentrated source of soluble fiber derived from the husk, which its husk is the main product of Isabgul. *Plantago ovata* husk is the outermost layer of the grain, destroyed by the mechanical processes [13]. *Plantago ovata* is used in both traditional and modern treatments [14].

*Plantago ovata* is mainly produced for its mucilage content. Mucilage entails a group of plant compounds that yield transparent and colorless gel in contact with water. *Plantago ovata* mucilage is obtained from its seeds [13,15] and its mucilage is conveniently perceived as a thickener. Regarding binding properties, 1.5% (w/v) of *Plantago ovata* mucilage demonstrates higher binding properties compared to 10% (w/v) of starch mucilage. In the East India, it serves to heal such disorders as dysentery, urinary problems, gonorrhea, fever, adverse gastrointestinal function. Moreover, it is used in the treatment of colds, coughs and other respiratory problems, especially within children. *Plantago ovata* seed powder is mixed with water and can be used as a poultice to treat rheumatism, gout, and skin sensitivity [16].

Fiber (especially viscose fiber diet) has a positive effect on the prevention and treatment of chronic diseases. *Plantago ovata* exerts a significant influence in terms of reducing LDL-C plasma [17], insulin resistance, lipid profiles (cholesterol, triglycerides, LDL cholesterol, LDL oxidation), systolic blood pressure [18] and inflammatory bowel disease [19]. The present study has been done due to the mucilage and absorbent properties of *Plantago ovata* (avoids keeping the wound moist) as well as the application of silver sulfadiazine (1%) in the burn treatment which have received scant attention. The aim of this study is to compare the effect of silver sulfadiazine (1%) and powdered *Plantago ovata* on second-degree burn wound within the rats.

**METHODS**

This experimental study was conducted on 30 male Wistar rats with the mean weight of 20 ± 300 g and the mean age of 3-4 months. The studied mice were taken from the animal nests in International Campus of Shahid Sadoughi Medical Campus of Yazd, which were then kept at animal house of the Medical Department at the proper temperature and lighting conditions. All mice were initially weighed and after being generally anesthetized via intraperitoneal injection (xylazine 10 mg/kg, ketamine 50 mg/kg), the area behind the animal’s neck was shaved at a certain level [20]. Then, the burn was made on the shaved area using a rectangular metal plate with an area of 5.35 cm² at a temperature of 80°C for 1 second. It should be noted that the burn was of the second-degree type of burns (superficial) [1,2].

A specialist also confirmed the second-degree burn when the mentioned burn procedure was done. The rats were randomly
divided into three groups of 10 and then, were kept in the separate cages. Group 1 or control group did not receive any treatments, and their burn was simply rinsed with physiologic saline per day. The burns in group 2 and group 3 were bandaged (dressed) everyday using silver sulfadiazine ointment (1%) and Plantago ovata powder respectively. For the present study, a 22-day course was adopted, and when burning was made was considered as the beginning day of experiment. The rats were kept under a 12-hour period of darkness and 12-hour period of light without any food restrictions. All the ethical principles adopted in the current study was in accordance with the principles adopted by Shahid Sadoughi University of Medical Sciences as well as international laws of animal rights [1].

In all three groups, the burn wound was washed daily via physiologic saline, dried by sterilized gauze and, then dressed in groups 3 and 4. Plantago ovata seeds were purchased from the local market of Yazd, which was confirmed by a botanist at the University of Yazd. Then, they were milled and transformed into the powder. The prepared powder was kept in a cool and dry place throughout the 22-day course of the study, and the wound was dressed by a few grams of powdered Plantago ovata.

Analysis method

The weight, size of burn wound area, percentage of wound healing (qualitative) and histological changes were evaluated. Imaging was performed using a digital camera (Canon 1DS Mark) with auto Flash of 17 Mega pixels, on the 5th, 7th, 10th, 13th, 16th, 19th, 22nd days, and then, the surface of wounds was measured applying ImageJ software on the related days.

A small part of Wound Contraction and wound healing percentage were possible to be calculated by the following formulas since the wound surface area was available on the related days.

\[
\text{Wound Contraction} = \text{wound area on the first day} - \text{wound surface area on the related day (cm}^2)\]

\[
\text{Wound healing percentage} = \frac{\text{Wound Contraction/wound surface area on the first day}}{\times 100} \quad [1,7,21].
\]

During the 22-day course of treatment, healing of burn wounds was qualitatively observed by a burn reconstructive surgery specialist (unaware of rats’ classification groups). Lack of healing based on the related day of the unhealed wound), partial healing (based on the related day of partially-healed wound), and full healing (complete wound healing) were entered into the tables based on the percentage. After the data were extracted, Prism software was applied using one-way analysis of variance (One-way ANOVA) and Tukey test (post-test).

Method of analysis and tissue staining

On the final day (22nd day), in order to prepare the tissue samples, 6 rats were randomly selected from each group, and skin samples were taken out of the burn surface area. The staining was performed via Haematoxylin-Eosin (H & E) as well as Masson's trichrome, and the samples were qualitatively compared [22].

Animals were anesthetized with Diethyl ether in a special container and then, they were placed in a stable condition on a board. Burned skin and a little of the surrounding healthy skin were put in a container of 10% formalin fixative. After passing 48 hours of fixing the tissue, tissue passaging stages were performed via a tissue processor unit (Co: Did Sabz, Model: DS 2028 / H, Iran). In order to provide microscopic slices, microtome device (Co: Did Sabz, Model: DS 8402, Iran) was used.

The degree of neutrophilic infiltration, regeneration of the epidermis fibrosis and angiogenesis (neovascularization) were investigated after H&E staining. Collagen-specific staining (Masson's trichrome) was employed to more accurately determine the amount of fibrosis. The slides, prepared by an optical microscope (Co: Medline Scientific, Model: Magnum-T, Country: UK) with a magnification of 40-400, were studied by an experienced pathologist (unaware of the rats’ classification groups).

Histologic examination

Microscopic examination of the skin biopsies (obtained at the day 22) was performed by an experienced pathologist who was not aware (unaware of the treatment applied to each group of rats). The 3 criteria of evaluation in H&E-stained sections included fibrosis, angiogenesis (neovascularization) and the degree of neutrophilic infiltration (all in dermis, with comparing to the unaffected normal surrounding skin). Also, the integrity of epidermis (repair by proliferation of keratinocytes) was checked. Trichrome-stained slides were also assessed regarding the degree of fibrous tissue formation in dermis. A subjective grading system of 4 bands (1+ to 4+) was used to compare each histologic parameter, and the mean score of each parameter was obtained.

RESULTS

The rats’ mean weight was not significantly different in these three groups on the first day (P value=0.95), whereas on the 22nd day, mean weight was demonstrated to be significantly different among the three groups (P value=0.008). In addition, mean weight in the group treated by silver sulfadiazine was increased significantly compared to the Plantago ovata
treated group (Table 1).

Table 1. Mean weight on the first day and 22nd day.

<table>
<thead>
<tr>
<th>Group</th>
<th>First day</th>
<th>22nd day</th>
<th>P*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physiologic saline treated group (g) n=10</td>
<td>306.4</td>
<td>313.7</td>
<td>0.339</td>
</tr>
<tr>
<td>Weight of silver sulfadiazine treated group (g) n=10</td>
<td>307.2</td>
<td>330.2</td>
<td><strong>0.001</strong>*</td>
</tr>
<tr>
<td>Weight of Plantago ovata treated group (g) n=10</td>
<td>308.2</td>
<td>308.3</td>
<td>0.984</td>
</tr>
</tbody>
</table>

*The mean weight of the group treated with the silver sulfadiazine ointment was significantly higher on the first day compared to the 22nd day (P Value =0.001***).

The mean weight of the group treated with the silver sulfadiazine ointment was significantly higher on the 22nd day compared to the Plantago ovata treated group (P Value = 0.008**).

Mean weight on the first day and on the 22nd day was compared in each group. In the control and Plantago ovata treated groups, no significant difference was shown. In fact, weight was increased in the control group, though it was not significant, but mean weight did not change in the Plantago ovata treated group. In the group treated with silver sulfadiazine ointment, mean weight on the 22nd day was increased significantly compared to the first day (P value =0.001).

As it is indicated in Table 2, the mean of wound surface area was compared in three groups on 5th, 7th, 10th, 13th, 16th, 19th and 22nd days, which was only reported to be significantly different on the 22nd day (P Value=0.008**). The mean wound area decreased significantly in the Plantago ovata treated group, in which a better healing was reported in comparison with the control group (P Value =0.001***).

Table 2. Comparison of the wound surface mean (cm²) on different days, based on the separate study groups.

<table>
<thead>
<tr>
<th>22nd day</th>
<th>19th day</th>
<th>16th day</th>
<th>13th day</th>
<th>10th day</th>
<th>7th day</th>
</tr>
</thead>
<tbody>
<tr>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.13</td>
<td>0.10</td>
<td>0.44</td>
<td>0.81</td>
<td>1.13</td>
<td>3.12</td>
</tr>
<tr>
<td>0.19</td>
<td>0.10</td>
<td>0.44</td>
<td>0.81</td>
<td>1.13</td>
<td>3.12</td>
</tr>
<tr>
<td>0.10</td>
<td>0.098</td>
<td>0.25</td>
<td>0.83</td>
<td>0.287</td>
<td>0.934</td>
</tr>
</tbody>
</table>

*Mean of wound area showed significant difference in both the silver sulfadiazine and Plantago ovata treated groups in comparison with the control group (P value= 0.001***).

Moreover, a significant difference was observed between the silver sulfadiazine and control groups in regard to the mean of wound area (P value = 0.00***). Wound area reduction and wound healing were more observed in the Plantago ovata treated group compared to other groups, though no significant difference was shown in the silver sulfadiazine treated group.

The images taken on different days were clinically evaluated by a dermatologist. As it is reported in Table 3, percentage of complete wound healing, and partial healing were respectively reported to be 20, 50 and 60 in the control, silver sulfadiazine and Plantago ovata treated groups that was indicative of a better healing in the Plantago ovata treated group. In the control group, one rat was not healed on the 22nd.

Table 3. Qualitative comparison of wound healing percentage on different days, based on the separate study groups.

<table>
<thead>
<tr>
<th>2nd day</th>
<th>19th day</th>
<th>16th day</th>
<th>13th day</th>
<th>10th day</th>
<th>7th day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partial wound healing</td>
<td>Complete wound healing</td>
<td>Partial wound healing</td>
<td>Complete wound healing</td>
<td>Partial wound healing</td>
<td>Complete wound healing</td>
</tr>
<tr>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
Histological results

Microscopic examination of the skin biopsies was performed in H&E-stained sections and also in trichrome-stained sections regarding the degree of fibrosis, angiogenesis and neutrophilic infiltration in dermis. Also, the integrity of epidermis (repair by proliferation of keratinocytes) was checked. A small erosion (focal absence of epidermis) was found in 2 (out of 18) rats (one in the control group and another one in Plantago ovata treated group), and a larger ulceration of epidermis in another 2 (similarly, one in the control group and another one in Plantago ovata treated group). These four samples were excluded from the calculation of mean of parameters since they were associated with marked neutrophilic inflammation and also due to the fact that they indicated traumatic injury after the intervention. Among the remaining rats, the findings are summarized in the Table 4.

<table>
<thead>
<tr>
<th>Group (each n=6)</th>
<th>Angiogenesis</th>
<th>Neutrophilic infiltration</th>
<th>Fibrosis in H&amp;E</th>
<th>Fibrosis in Trichrome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>3.2 (31.2)</td>
<td>1 (100)</td>
<td>2.2 (55)</td>
<td>2 (50)</td>
</tr>
<tr>
<td>Silver sulfadiazine</td>
<td>2.5 (40)</td>
<td>1.3 (77)</td>
<td>3.7 (92.5)</td>
<td>4 (100)</td>
</tr>
<tr>
<td>Plantago ovata</td>
<td>2 (50)</td>
<td>1.5 (67)</td>
<td>3.7 (92.5)</td>
<td>4 (100)</td>
</tr>
<tr>
<td>P value</td>
<td>0.60</td>
<td>0.36</td>
<td>0.85</td>
<td>0.53</td>
</tr>
</tbody>
</table>

The same results were obtained in the groups treated with silver sulfadiazine and Plantago ovata with respect to fibrosis rate stained with H & E and hence, a better recovery was observed in the both mentioned groups compared to the control group (P value=0.000***). The results of fibrosis evaluation by trichomoson staining in the groups treated with silver sulfadiazine and Plantago ovata were same but revealed better healing than the control group (P value=0.000***). In terms of angiogenesis results revealed no significant recovery in the Plantago ovata treated group compared to silver sulfadiazine and control groups (P value=0.60). It is worth mentioning that neutrophilic infiltration did not differ significantly between the three groups (P value=0.36). As it is seen, angiogenesis was less in the Plantago ovata treated group compared to the control group; this means that treatments were effective in promoting tissue repair. The severity of accumulation of neutrophils in dermis was not so different among groups, and by taking the exclusive cases into consideration (which had ulceration or erosion of epidermis) might be better to disregard it in interpretation. The degree of collagenous/ elastic/ reticulin tissue formation according to the H&E staining, perhaps the most important indicator of long-term healing, was significantly more in the treatment groups (without any difference between the silver sulfadiazine and Plantago ovata treated groups) in comparison with the control group (P=0.85) (Figures 1A-C).
Weighing of the healing indices

To reach a general conclusion on the overall healing of burns, we used an arbitrary weighing system (1 to 10) which includes all of the indices of wound repair, consisting of wound surface area reduction, subjective healing by observation, microscopic fibrosis (both on H&E-stained slides and on Trichrome-stained slides), angiogenesis, and neutrophilic infiltration, all assessed at the final day of experiment, i.e., day 22. For each parameter, the percentage of goal achievement (i.e., ideal complete healing) was multiplied by its weight.

The suggestive formulas for each index are as follows:

- **Wound Contraction** = mean surface at day 7 / mean area at day 22
- **Subjective healing** = mean percentage of complete healing
Fibrosis on H&E-stained slides= mean of fibrosis × 100/4
Fibrosis on Trichrome-stained slides= mean of fibrosis × 100/4
Angiogenesis= (4/mean of angiogenesis) × 100/4
Neutrophilic infiltration= (4/mean of neutrophilic infiltration) × 100/4.

**DISCUSSION**

Although no study has been conducted on the application of *Plantago ovata* for the treatment of burn wounds, numerous studies have examined effect of different medicinal herbs on the treatment of burn wounds compared to silver sulfadiazine (1%) ointment.

Numerous old reports have confirmed the use of medicinal herbs in regard to dressing (bandaging) the wounds, described in Avicenna’s book named Canon of Medicine. Medicinal herbs have a moderate effect, but without toxicity or with low toxicity and they are more inexpensive compared to synthetic drugs [23].

Comparing the mean weight of the studied animals on the first and 22nd day, a significant increase was illustrated in the group treated with silver sulfadiazine (P value=0.001 **). In addition, in the group treated with *Plantago ovata*, weight did not change (P value=0.984) and in the control group, the increase was not reported to be significant (P value=0.339).

Healing analysis of wound surface area (using Image J software) on 5th, 7th, 10th, 13th, 16th, 19th and 22nd days showed no significant difference in the three groups, though on the 22nd day of the study, treated group with *Plantago ovata* powder showed a significant difference compared to the control group (P value=0.00”). A significant difference was observed in the silver sulfadiazine treated group compared to the control group, as well (P value=0.000***). However, the treated group with *Plantago ovata* powder did not reveal any significant changes comparing to silver sulfadiazine treated group.

Complete healing of the wound surface area (according to a (plastic surgeon) skin restoration surgeon’s opinion based on the taken images) was reported to be, respectively, 20%, 50% and 60% on the 22nd day in the control group, Silver Sulfadiazine treated group and *Plantago ovata* treated group, which can be related to better healing of the burn wound on the 22nd day in the treated group with *Plantago ovata* powder compared to the other groups.

In a study conducted by Akbari et al., the effect of Nettle extract was studied on deep second-degree burns within the rats compared to the treatment with silver sulfadiazine (1%) ointment. Forty rats were divided into 4 groups with second-degree burn created on the neck of animals. Animals in group 1, group 2, and group 3 were respectively treated with Nettle extract daily, silver sulfadiazine (1%), Vaseline, whereas group 4 were considered as untreated control group. The study results revealed a statistically significant healing in the first group (treatment with Nettle extract) compared to other groups, especially the control group. Regarding the difference in the level of burn wounds at the same time, the maximum healing belonged to the first group (treated with Nettle extract), whereas the least healing was devoted to the control group. Moreover, a significant difference was reported in regard to fibrosis after 42 days [20].

Akhoondinasab et al. [23] investigated the effect of three herbs (Aloe Vera, Robacin and Rimojen) on the simultaneous deep second and third-degree burns of 40 rats in comparison with silver sulfadiazine (1%). The burn wounds were daily dressed applying Robacin (group 1), silver sulfadiazine (1%) ointment (group 2), Aloe Vera (group 3) and Rimojen (group 4). The burn wound area was evaluated via a digital camera up to 32nd day. Image-based results revealed the better wound healing in the group treated with Robacin compared to other groups. In addition, the rate of wound healing in Aloe Vera group was demonstrated to be higher than Rimojen and silver sulfadiazine groups. At the same time, the maximum healing of the second and third-degree burn wounds was reported in Robacin group, and the maximum healing of the second degree burn wounds was observed in Rimojen and Aloe Vera groups. Moreover, the maximum healing of the third degree burn wounds was found in Aloe Vera and silver sulfadiazine groups. In the histological analysis, the minimum speed of angiogenesis and fibrosis was attributed to Robacin group, and it was also reported that less scar was observed in this group. Burn wound healing rate was also demonstrated to be higher in the Robacin group [24].

In a study conducted by Malek Hosseini et al. in Valiasr hospital of Arak, the effect of Aloe Vera and silver sulfadiazine (1%) ointment on patients with second-degree burns was compared, which Aloe Vera gel was held to speed up the wound healing [6].

Fahimi et al., in an experimental research, studied a cream prepared from aqueous extracts of three plants (Poly Herbal Cream or PHC) compared to silver sulfadiazine ointment (1%) for 14 days in order to treat second-degree burn wounds in rats. The three plants applied in this study consisted of Malva sylvestris and Solanum nigrum leaves as well as oily extract of Rosa damascena petals. Group 1 did not receive any treatments while groups 2, 3 and 4, were respectively dressed using an ointment base, silver sulfadiazine (1%) and PHC. Percentage of wound healing was assessed on the 2nd, 6th, 10th and 14th days and pathology parameters of the healed wounds were evaluated on the 14th day. The antioxidant and antimicrobial activities of PHC were also examined. PHC showed better results than the use of silver sulfadiazine (1%), which can be resulted from its antioxidant, anti-inflammatory and antimicrobial effects [24].
In another study carried out by Avsar et al. at the University of Ataturk in Turkey, the effects of Argan oil and silver sulfadiazine (1%) cream was examined on 30 rats classified into five groups (group 1: placebo, group 2: control without any treatments, group 3: received Argan oil every other day, group 4: received two-days-in-between Argan oil treatment, and group 5 received silver sulfadiazine ointment (1%) every other day. Wound shrinkage illustrated a significant increase in the groups treated with Argan oil compared to the other groups. The results of wound shrinkage in the group receiving Argan oil twice daily (31% on 7th day, 76% on 14th day) was much better than that of silver sulfadiazine group (22% on 7th day, 69% on 14th day). Histology evaluation on 3rd, 7th and 14th days revealed better wound healing and wound shrinkage in both Argan oil and silver sulfadiazine (1%) groups compared to the control group. These results suggest that Argan oil seem to be effective in healing the burns in rats [25].

In 2014, Fatemi et al. examined the effect of green tea on the second-degree burns in mice. In this study, after the burns were made on the behind of the mice, they were classified into four groups consisting of one control group and three treatment groups receiving green tea, Vaseline, and silver sulfadiazine (1%). It should be noted that the treatment began after 15 minutes since the burns were made. Macroscopic study was performed on 1st, 3rd, 7th and 14th days using a digital camera applying Image J software. Pathological assessment (epithelization, inflammatory cells, and vascularity) was carried out on samples of burned skin on the 14th day. The study findings indicated that the use of green tea significantly reduced burn wound size compared to the control group (P=0.004) [26].

Kwansang investigated the effect of Thunbergia laurifolia (Thai tea), as a topical treatment of the burns, which resulted in reduced inflammatory phase, increased content of collagen tissue, increased fibroblast of tissue as well as better burn healing [27].

In another study conducted by Khalili et al., effectiveness of Onosma stenosiphon Boiss was assessed with respect to second-degree burn on the dorsal part of flank as well as the left and right side and skin of the scrotum in rats. To study the histological changes, respectively, on 7th, 14th and 21st days after the burn, 7 rats were selected per group. Animals were first killed, and samples were taken from the burn on the right treated with ointment and left without applying ointment and testicular tissue. Then, the samples were qualitatively compared with the samples taken from control rats in terms of wound level, tissue healing at the dorsal region, and changes of the testicular tissue. The identical results were revealed in the first week after burn in regard to histopathological changes in epidermal samples of both groups (ointment use vs. absence of ointment use). In the second week, the epidermis was restored to some extent and in the superficial dermis, inflammatory infiltration of mononuclear inflammatory cells and fibrosis were observed. In the third week, the epidermis was thoroughly reconstructed, inflammation disappeared in the dermis and fibrosis was detected only in the region that have been earlier necrotized. The study findings demonstrated that this plant exerted no influence on the healing of second-degree burns [28].

Rastegar et al. examined the yolk oil on healing of third-degree burn wound in rats. In fact, the mean size of wounds was compared among three different groups (yolk oil treatment, silver sulfadiazine (1%) treatment and control group) on 7th, 14th and 30th days, that on the 7th day, a significant decrease was observed in the wound size in the group treated with yolk oil in comparison with other two groups. Furthermore, on 14th and 30th days, wound size was reported to be significantly smaller in the group treated with yolk oil compared to other groups [29].

CONCLUSIONS

In general, the findings of present study propose that regarding the examined factors, treatment with Plantago ovata powder seems to result in significant better healing for second-degree burn compared to the other two groups.

Evaluating the therapeutic effects of Plantago ovata powder on the treatment of second-degree burn wounds necessitates conducting more detailed comprehensive studies using components analysis of Plantago ovata. Moreover, commonly used approved drugs are recommended to be exploited so as careful, detailed and complete studies can be carried out on the effect of different types of materials with the mucilage properties in regard to burn healing.

AUTHORS’ CONTRIBUTION

Mohammad Jalilimanesh and Maryam Azhdari designed the work and wrote the manuscript. Imaging and applying ImageJ software were performed by Sara Azhdari. Keramat Teymourizade analyzed the data. Maryam Azhdari and Majid Karandish revisied the manuscript. All of authors approved the final version of the manuscript. There is also a consensus between four authors for all aspects of the work.

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