

# Effect of Nanocrystalline Silver Dressings on Crushed Finger Injury of Upper Limbs

**Arash Yazdanbakhsh, Ali Sarkheil, Morteza Qaribi, Abdolghader Pakniyat, Abolfazl Jokar\***

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## Abstract

**Background:** Dressing is a pad applied directly to a wound in order to support the process of healing and protect the wound from further harm. The aim of this study was to compare the efficacy of nanocrystalline silver dressings as compared to conventional dressings in patients with injured, crushed fingers of the upper limbs. **Materials and Methods:** This single-blind study consisted of clinical trials. A total number of 70 patients with upper limb crushed fingers were studied. Patients were randomly divided into two groups – 35 patients were treated with nanocrystalline silver dressings and the remaining 35 patients with conventional dressings. We followed all patients during Weeks 1, 2, 3, and 4 after treatment, and checked degrees of healing for the wounds. Data were analyzed by SPSS20. **Results:** Degrees of healing for wounds with nanocrystalline silver dressings were more than that for wounds with conventional dressings in four stages. [Week 1: (p=0/011); Week 2 (p=0/000); Week 3 (p=0/051); and Week 4: (0/003)]. There was a significant difference in infection in Week 1 (p=0/04) and Week 2 (p=0/052) between both groups. There was also a significant difference in inflammation in Week 1 and Week 2 between the two groups (p< 0/05); as well as a significant difference in itching in Week 1 and Week 2 between the groups (p< 0/05). **Conclusion:** Nanocrystalline silver dressings lead to an improvement in the degree of wound healing, and reduce infection, inflammation, and itching. Hence, we recommended nanocrystalline silver dressings for patients.

**Key Words:** Crushing Injury, Conventional Dressings, Nanocrystalline Silver Dressings.

## Introduction

Dressing is a pad applied directly to a wound to support the process of healing and prevent the wound from further harm. There are two categories of dressings – conventional dressings and modern dressings. (Velnar et al., 209; Menke et al., 2007) Conventional dressings, also known as non-absorbing dressings, are cellulose derivatives, which are used to prevent external infection from getting into the wound, to absorb exudates, and to create a feeling of comfort for the patient. Gauze dressing comes under this category and is normally used on a layer of antibiotic or antiseptic on the wound. The use of dressings has become more common in the last decades. Modern dressings have some advantages including providing a moist environment to heal the wound that accelerates the process of healing, contrary to conventional perception. A moist environment improves intra-tissue metabolic activities of cells and also, improves inter-cell interactions and activities of growth factors that are prevented due to a dry environment. These modern dressings not only perform the functions of conventional dressings but additionally, provide more protection against trauma and prevent bacteria from getting into the wound. Modern dressings are flexible and easy to use. There are different types of modern dressings including alginate dressings, silver nanocrystalline dressings, hydrogels, hydrochlorides, foams, and electrogels. Silver ion has been listed as medication for more than 100 years. So far, no resistance has been observed against silver ion as an antimicrobial agent in killing bacteria (Guo & DiPietro, 2010; Baker, 2007; Sondi & Salopek-Sondi, 204).

The antibacterial effect of silver is significant since bacteria are common in several wound infections including those caused by burns; bacteria are also resistant to antibiotic treatments like MRSA. Based on the characteristics of silver and silver-impregnated dressings, different studies have been conducted on the function of silver dressings in healing different kind of wounds and levels of infection in wounds. (Slawson et al., 1992; Yahya et al., 1990) In this context, many studies have investigated the efficacy of silver dressings in healing chronic ulcers such as diabetic foot ulcers and bedsores (Lo et al., 2008) as well as burns (Aziz et al., 2012). However, studies on the function of silver dressings in healing acute ulcers like crush injuries are rare. In a study of patients with fingertip injuries, the

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**Arash Yazdanbakhsh, Ali Sarkheil, Morteza Qaribi, Abolfazl Jokar\***

Emergency Medicine department, Arak University of Medical Sciences, Arak, Iran.

**Abdolghader Pakniyat**

Emergency Medicine department, Kurdistan University of Medical Sciences, Sanandaj, Iran.

duration of healing, frequency of wound infection, and time-off for the patients were all significantly lower in the group treated with silver dressings. (De Boer &, Collinson, 1981) This study aimed to compare the efficacy of nanocrystalline silver dressings as compared to conventional dressings in patients with impaired, crushed fingers of the upper limbs.

## Methods

This was a single-blind, randomized clinical trial study on 18–70 year old patients with fingers crush injuries involving muscles, who were referred to the emergency room of Vali-e-Asr Hospital. Non-probability available sampling was conducted and 1:1 randomization was applied. This means that patients with even file numbers were included in one group and patients with odd file numbers were included in the other group. All patients received standard wound treatments and care like antibiotics administration.

The Declaration of Helsinki, a statement of ethical principles and minimum ethics, was considered by the Arak University of Medical Sciences (IRCT ID: IRCT2017021520258N33).

Sample size was determined considering first type error rate ( $\alpha$ ) and second type error rate, which were 0.5 and 0.2, respectively. Standard deviation (SD) and effect rate (d) were based on the values of the recovery rate variable in the Dior study (De Boer &, Collinson, 1981). The estimated sample size in each group was 35 patients.

Inclusion criteria were as follows: 18–70 year old patients with trauma of upper limb fingers involving muscle injury; limb crush up to 10–20cm and muscle involvement; and informed consent for participation in the research.

Exclusion criteria were as follows: involvement of tendon, vessels, nerve-muscles and bone fracture in the area of injury; systemic diseases such as cardiovascular diseases, metabolic diseases, vascular collagen, malignant immunosuppression (like diabetes and implants), and comorbid inflammatory and infectious diseases; malnutrition; drug addiction; pregnancy; lactation; need for limb amputation or injuries close to the amputation area; loss of consciousness and traumatic brain damage; need for re-surgery on the wound; history of silver allergy; and infectious wounds before the first stage of dressing application.

All patients included in the study were matched in terms of age, gender, location of lesion, size of lesion and depth of involvement, number of lesions, associated injuries, need for surgical procedure, and antibiotic treatment. It should be noted that only one crush in every patient consistent with inclusion criteria was selected as the target lesion for the study.

Taking into consideration inclusion and exclusion criteria, and obtaining demographic information (age, gender etc.), patients eligible for inclusion after orthopedic surgery of the target lesion were randomly placed in two groups – intervention group (35 patients treated with silver dressings) and control group (35 patients treated with normal dressings). A 1:1 randomization was applied. This means that patients with even file numbers were included in one group and patients with odd file numbers were included in the other group. All patients received standard wound treatments and care like antibiotics administration.

For the process of applying a silver dressing, the dressing was first taken out of the package, moistened with distilled water, and then, the extra water was squeezed out. After this, the dressing was applied directly on the wound that had already been rinsed and cleaned. The silver dressing was applied covering 1 cm out of the peripheral edges of the wound. Finally, it was fixed by wrapping a simple or elastic bandage or tape. Patients were asked to return to the hospital every week to monitor the healing of their wounds. At the end of Weeks 1, 2, 3, and 4 after surgery (four visits), patients were grouped based on the grade of wound healing (Eshghi et al., 2010), as follows:

Grade 1: Serious wound, fresh and inflamed

Grade 2: Granular tissue on the wound

Grade 3: Full wound healing, complete epithelial layer on the wound

After the dressing had been removed by a clinic nurse, an orthopedic specialist (who was uninformed about the study) evaluated the wound (every week up to four times) and diagnosed cases of wound infections; other wound complications like itching and inflammation were documented for every patient. It should be noted that change of dressings for discharged patients was conducted based on standard protocols (daily changes).

Silver dressings were changed every three or six days; also, silver dressings were changed whenever there was a shift in color from dark green to light green, in cases of full saturation of the dressing with blood or exudates, or when wounds started to smell.

Information related to patients was entered using SPSS software. Data analysis was conducted using mean, SD, and standard error and frequency percentage; and analytical probability analysis was conducted using covariance analysis test, chi-squared test, and t-test or its nonparametric equivalence to compare its mean.

**Results**

This was a single-blind, randomized clinical trial study on 70 patients with finger crush injuries. Patients were randomly categorized into two groups – one treated with nanocrystalline silver dressings and the other with normal dressings. Patients were similar in both groups in terms of age and gender ( $p \geq 0.05$ ).

The average age of patients was  $40.1 \pm 5.6$ . The average ages of intervention and control groups were  $42.4 \pm 2.1$  and  $39.8 \pm 4.3$ , respectively. So, the two groups did not differ significantly in terms of age ( $p \geq 0.05$ ). The frequency of males and females in the two groups were 38 (54.28%) and 32 (45.71%), respectively. The intervention group included 20 male patients (57.14%) and 15 female patients (42.85%); and the control group included 19 male patients (54.28%) and 16 female patients (45.71%). Gender distribution of subjects was similar in both groups ( $p \geq 0.05$ ).

Patients were evaluated every week. In the group with nanocrystalline silver dressings, changes in frequencies of Grade 1 ( $p=0.000$ ), Grade 2 ( $p=0.003$ ), and Grade 3 ( $p=0.001$ ) wound healings were significant. So, there was a significant decrease in the frequencies of Grade 1 and Grade 2 wound healings during four weeks; and a significant increase in the frequency of Grade 3 wound healing (complete healing). In the group with normal dressings, changes in frequencies of Grade 1 ( $p=0.005$ ), Grade 2 ( $p=0.041$ ), and Grade 3 ( $p=0.021$ ) wound healings were significant. So, there was a significant decrease in the frequencies of Grade 1 and Grade 2 wound healings during four weeks; and a significant increase in the frequency of Grade 3 wound healing (complete healing) (Table 1).

Table 1: Frequencies of wound healing grades in the group of patients with nanocrystalline silver dressings and in the group of patients with normal dressings.

| healing of ulcer |                       | 1th weak   | 2th         | 3th        | 4th        | P value |
|------------------|-----------------------|------------|-------------|------------|------------|---------|
| 1th degree       | Nano-silver Dressing  | 25(71.42%) | 10(28.57%)  | 3 (8.57%)  | 0(0.0%)    | 0.00    |
|                  | Conventional dressing | 30(85.71%) | 17(48.57%)  | 11(31.42%) | 1(2.5%)    | 0.005   |
| 2th degree       | Nano-silver Dressing  | 3(8.57%)   | 7 (20%)     | 9(25.71%)  | 9(25.71%)  | 0.03    |
|                  | Conventional dressing | 5(14.28%)  | 13(37.14%)  | 15(42.85%) | 18(51.42%) | 0.041   |
| 3th degree       | Nano-silver Dressing  | 7(20%)     | 17 (48.57%) | 23(74.28%) | 26(74.28%) | 0.001   |
|                  | Conventional dressing | 0(0.0%)    | 5(14.28%)   | 9(25.71%)  | 16(45.71%) | 0.021   |

- Grade 1: Serious, fresh, and inflamed wound
- Grade 2: Granular tissue on the wound
- Grade 3: Complete layer of epithelial tissue on the wound

In this study, complete wound healing was higher in the group with nanocrystalline silver dressings than in the group with normal dressings.

Table 2: Comparison of complete wound healing in four follow-up stages between patients in the group with nanocrystalline silver dressings and patients in the group with normal dressings.

|                      | complete healing (n,%) |                       |         |
|----------------------|------------------------|-----------------------|---------|
|                      | Nanosilver Dressing    | Conventional dressing | P value |
| 1 <sup>th</sup> week | 7(20%)                 | 0(0%)                 | 0.011   |
| 2 <sup>th</sup> week | 17 (48.57%)            | 5(14.28 %)            | 0.000   |
| 3 <sup>th</sup> week | 23(65.71%)             | 9(25.71%)             | 0.051   |
| 4 <sup>th</sup> week | 26(74.28%)             | 16 (45.71%)           | 0.003   |

Wound complications were documented during the study and follow-up stages. Although, infection, inflammation, and itching were lower in the silver dressings group during the first to the third week, wound complications were not significantly different between the two groups in the fourth week. Table 3.

Table 3: Wound complications in the group with nanocrystalline silver dressings and patients in the group with normal dressings.

| Complication |                       | Time                 |                      |                      |                      |
|--------------|-----------------------|----------------------|----------------------|----------------------|----------------------|
|              |                       | 1 <sup>th</sup> week | 2 <sup>th</sup> week | 3 <sup>th</sup> week | 4 <sup>th</sup> week |
| infection    | Conventional dressing | 5 (14.28%)           | 3 (8.57%)            | 2 (5.71%)            | 0(0)                 |
|              | Nano-silver Dressing  | 0 (0)                | 0 (0)                | 0 (0)                | 0 (0)                |
| P value      |                       | 0.04                 | 0.051                | 0.061                | 0.05 <               |
| Inflammation | Conventional dressing | 7(20%)               | 7 (20)               | 2 (5.71%)            | 0(0)                 |

|         |                       |          |           |         |        |
|---------|-----------------------|----------|-----------|---------|--------|
|         | Nano-silver Dressing  | 1(2.87)  | 2(5.71)   | 0(0)    | 0(0)   |
|         | P value               | 0.027    | 0.032     | 0.05 <  | 0.05 < |
| itching | Conventional dressing | 7(20%)   | 5(14.28%) | 3(8.57) | 0(0)   |
|         | Nano-silver Dressing  | 1(2.87%) | 0(0)      | 0(0)    | 0(0)   |
|         | P value               | 0.027    | 0.05 >    | 0.05 >  | 0.05 < |

## Discussion

Complete healings of patients in the group with silver dressings in all four follow-up stages were significantly higher than of patients in the group with normal dressings. There was a significant difference in infection between the two groups in the first week and in the second week; however, the difference was not significant in the third week and in the fourth week. Although two cases of infection were reported for the group with normal dressings in the third week, it was observed that the two groups had a significant difference in inflammation in the first and second weeks; however, there was no significant difference in the fourth week. As evident, there was a significant difference in itching between the two groups in the first, second, and third weeks; but this difference was insignificant in the fourth week.

Seyed-Mire et al. conducted a study investigating the effect of nanocrystalline silver dressing on ulcers developed in laboratory white mice. They found that applying nanocrystalline silver dressings may be effective in controlling infections of superficial wounds, and suggested that these dressings may also be significantly useful in healing deep infections caused by thermal, chemical, and electrical burns (Seyyedmir et al., 2012). Results of their study are consistent with the results of our study; although, their sample included mice and our sample included humans.

Buckley et al. studied the effect of silver dressings on healing traumatic injuries on fingertips. They suggested that long-term and short-term therapeutic results of applying silver dressings were significant; and finally, recommended that these dressings may be applied on traumatic injuries on fingertips to accelerate the process of healing (Buckley et al., 2000). Results of their study are consistent with the results of our study as treatment with nanocrystalline silver dressings in our study reduced infection and accelerated healing.

Deborah et al. studied the effect of silver dressings on healing and infection of traumatic fingertip injuries. They suggested that silver dressings may significantly reduce wound healing time, infection, and time-off for patients ( $p < 0.05$ ). They also indicated that silver dressings are not only significantly effective in minor injuries, but also in the faster healing and reducing of infection in very serious injuries ( $p < 0.05$ ). None of the patients in their study were infected in treatments with silver dressings (De Boer P, Collinson, 1981), which is consistent with the results of our study.

Lu et al. studied the effect of silver dressings on controlling chronic infectious wounds. They suggested that patients with silver dressings had more optimal outcomes. They also pointed toward proper tolerance of patients against silver dressings. However, due to bias and lack of sufficient details, they recommended reviews and meta-analysis research in future studies (Lo et al., 2008). Their results are also consistent with our results.

## Conclusion

During the four-week wound healing period, changes in frequencies of Grade 1, Grade 2, and Grade 3 wound healings were significant in the group with nanocrystalline silver dressings; and in the group with normal dressings, the changes in frequencies of Grade 1, Grade 2, and Grade 3 wound healings were also significant during the four weeks. Complete healing of patients in the group with silver dressings was significantly higher in all four follow-up stages than of patients in the group with normal dressings. There was a significant difference in infection between the two groups in the first and second weeks; however, this difference was not significant in the third and fourth weeks. Although two cases of infection were reported in the group with normal dressings in the third week, the two groups had a significant difference in inflammation (as indicated) in the first and second weeks; however, there was no significant difference in the fourth week. As evident, there was a significant difference in itching between the two groups in the first, second, and third weeks; but the difference was insignificant in the fourth week.

It was proposed that future studies should focus on other organs, as well as on diabetic patients or patients with immune deficiencies with longer follow-up periods.

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