

Effect of Onion Extract Nanoparticle Gel Phonophoresis on Postsurgical Scar of Cesarean-Section

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Received: 25th Feb, 2026; Revised: 15th March 2026; Accepted: 10th April, 2026; Available Online: 20th April, 2026

ABSTRACT

Cesarean-section deliveries are often linked to a heightened risk of undesirable scarring, which considerably affects the psychological and social dimensions of life. This paper evaluates the impact of the Onion extract nanoparticle gel phonophoresis on the postsurgical scar resulting from the cesarean section. Forty mothers aged between 20 and 35 years, they experienced postsurgical scars following the cesarean sections and randomly divided into two equal groups. All mothers participated in a 12-week treatment program for 3 sessions per week. Phonophoresis group used the onion extract nanoparticle gel phonophoresis alongside a deep friction massage. Conventional group received a sham treatment of the onion extract nanoparticle gel phonophoresis alongside a deep friction massage. After intervention all outcome measures were evaluated for all mothers using the Schiotz tonometer and the Modified Vancouver scar assessment scale. Concerning baseline data, there was no statistical difference between both groups ($P>0.05$). There was a notable enhancement in the postsurgical scars associated with cesarean sections in both the phonophoresis and conventional groups following the intervention. Nevertheless, a highly significant difference was observed between the phonophoresis group and the conventional group, favoring the phonophoresis group. The mothers in phonophoresis group showed more improvement in tonometer percentage (47.04%) than mothers in conventional group (20.08 %), with a similar trend in pliability, height, vascularity and pigmentation. The findings indicated that onion extract nanoparticle gel phonophoresis is a promising and a non-invasive treatment for enhancing the quality of the post-cesarean scars.

Keywords: Postsurgical scars, Cesarean section, Tonometer, Phonophoresis, Onion extract nanoparticle gel.

How to cite this article: Abbas MAM, Kamar SM, Osman SM, Abuelella KE, Haridy HAAEA. Effect of Onion Extract Nanoparticle Gel Phonophoresis on Postsurgical Scar of Cesarean-Section. Int J Drug Deliv Technol. 2026;16(34s):142-152. DOI: 10.25258/ijddt.16.34s.15

Source of support: Nil.

Conflict of interest: None

INTRODUCTION

Cesarean section is among the most frequently performed abdominal surgeries on women. The rate of cesarean sections is increasing rapidly and consistently in various regions around the globe [1]. During this surgical procedure, a horizontal incision in the skin, typically measuring 10-15 cm, is made. In addition to the skin, the incision extends through the subcutaneous tissue, fascia, peritoneum and uterine muscle, resulting in scars. These scars not only impact on the surrounding area but may also lead to various abnormalities in other parts of the body. Consequently, they can result in pain, tenderness, heightened sensitivity to stimuli and an unsightly

appearance of the abdomen, as well as potential contractures or limitations in tissue mobility, postural asymmetry, gait disturbances and lumbar spine pain. All these elements can negatively affect the mother's quality of life. Furthermore, the presence of an unattractive scar can negatively impact the psychological and social aspects of life [2]. The management of scars remains unresolved; the effectiveness of numerous existing preventive and therapeutic strategies has only been validated through extensive application. Information regarding several methods including topical agents, corticosteroids, excision, cryotherapy, laser therapy and compression therapy, has yielded inconsistent results concerning their

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efficacy and side effects [3]. Transdermal drug delivery via phonophoresis presents a noninvasive alternative that is a viable option for treating abnormal scarring. This method can diminish the formation of postoperative keloids or scars and enhance the penetration of anti-scar medications into the dermis. The phonophoresis benefits include high patient compliance, low cost and minimal gastrointestinal side effects [4]. The ability of onion extract to enhance scar appearance has been demonstrated [5]. Initially, onion extract was utilized for treating full and partial thickness burns due to its content of various phenolic antioxidants and anti-inflammatory compounds; however, more recently, onion extract gel has been employed for the treatment of healing wounds, hypertrophic and keloid scarring. Onion extract is primarily responsible for diminishing scars by inhibiting the proliferation of fibroblasts and the production of collagen [6]. However, there has been no research evaluating the impact of gel containing onion extract phonophoresis on the postsurgical scars resulting from cesarean sections. This study used the onion extract nanoparticle gel phonophoresis to enhance the cesarean section scars appearance and characteristics.

MATERIALS AND METHODS:

Study Design

This research constitutes a prospective, single-blind, randomized controlled clinical trial. This study was operated after obtaining ethical approval NO. from the Institutional Review Committee of the Faculty of Physical Therapy at 6th of October University (Approval No. OCU.PT.REC/024/002006). Also, we registered the study in the PRS Registry of Clinical Trials.gov (NCT06658444). All mothers provided written informed consent voluntarily. The research was conducted from October 2024 to September 2025 at the Physical Therapy Department of October 6 University Hospital and the research was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki.

Subjects:

Forty mothers experienced the postsurgical scar of cesarean-section were recruited from October 6 University Hospital. We collaborated with a gynecologist to ensure that the participating mothers met the inclusion criteria for the current study. The mothers were medically stable, aged between 20 and 35 years and had undergone a first-ever Pfannenstiel cesarean section, using absorbable suture material [7]. These mothers had been suffering from the cesarean section scar for approximately 2-3 months following the surgery. Mothers were excluded if they had any conditions that could affect the results, skin diseases, or open wounds at or near the treatment site. Additionally, we excluded mothers with implanted electronic devices, such as cardiac pacemakers to prevent ultrasound interference. Those with diabetes, cardiovascular problems, or a history of any disorder that could alter sensation and delay the healing process, which would counteract the study's objectives, were also excluded. Furthermore, mothers with cognitive and psychological impairments, uncooperative, or obese mothers (with a body mass index of 30 or higher) were not included [8].

Lastly, mothers with a history of onion allergies or those who developed postoperative complications were also excluded from the study [7].

Randomization

We initially screened forty-eight mothers and five did not meet the inclusion criteria also three chose not to participate. Forty mothers who participated signed the consent form and then randomized into two equal groups. Twenty mothers enrolled in the Phonophoresis group (Group A), and the same number enrolled in the Conventional group (Group B). For randomization we placed forty folded papers after marking it with A or B letters into a small box and each mother then asked to draw a paper from the box.

Sample size calculation

Sample size estimation was conducted for the study outcomes (Trunk Impairment Scale and trunk control test) utilizing G*Power 3.1.9 version (Heinrich-Heine-University, Düsseldorf, Germany). The calculation of sample size was based on previous research by **Ghareeb et al.** [8]. Utilizing a two-sided independent samples t-test (means: difference between two independent means-two groups) with $\alpha = 0.05$ and power $(1-\beta) = 0.80$, a large effect size (Cohen's $d = 0.9897542$) necessitates approximately 36 participants. Due to the projected 10% dropout rate, we set the adjusted final sample size at the minimum of 40 participants. Also, the study included twenty mothers in both groups to ensure the sufficient statistical power and to identify the clinical significant differences.

MEASUREMENT PROCEDURES

The Schiotz tonometer: The Schiotz tonometer (Riester, Germany, 0124) was used as an objective tool to assess scar elasticity, making it highly practical for clinical evaluations. It provided precise insights into the scar's impact on movement, functional performance, and overall quality of life. The instrument employs a floating plunger, shaped like a rod, enclosed within a barrel. Initially weighing 5.5 grams, the plunger's weight can be adjusted by attaching additional weights of 7.5 or 10 grams. During the evaluation, each participant was asked to lie down in a comfortable position. After calibrating the device, it was held vertically against a designated point on the scar. Then the scar was indented by the plunger due to gravitational force. The resulting reading, displayed on a horizontal scale marked with arbitrary values from 0 to 20, was subsequently converted to mmHg using a calibration chart supplied with the device. [9,10,11].

The Modified Vancouver Scar Scale (MVSS): It is commonly used to evaluate the scars. It measures the height, pliability, pigmentation and vascularity of the scars. Scoring: the vascularity ranges from 0 to 3 (1 Pink color, 2 Red color, 3 Purple color). The pigmentation ranges from 0 till 3 (Hypopigmentation as 1, Mixed as 2 and Hyperpigmentation as 3), regarding the pliability ranges from 0 to 5 (1 represent Supple, 2 represent Yielding, 3 represent Firm, 4 represent Ropes & 5 represent Contracture) and the height ranges from 0 to 3 (1

is less than 2 mm, 2 is between 2 to 5 mm, 3 is more than 5 mm). After conducting the comparison with the normal skin (zero score), we selected the score for each subscale according to the scar status and subsequently, the scores were aggregated to produce a total score. The poorer the status, the greater the total score [10].

Treatment procedures:

Mothers in both groups completed a treatment program of 12 weeks, which consisted of 3 sessions per week [8]. Mothers in (Phonophoresis group) received onion extract nanoparticle gel phonophoresis alongside deep friction massage. While mothers in (Conventional group) received sham onion extract nanoparticle gel phonophoresis alongside deep friction massage [12].

Onion Extract Nanoparticle Gel Phonophoresis:

Onion extract nanoparticle gel was formulated at the pharmacology laboratory within the Faculty of Pharmacy at October 6 University, located in Giza, Egypt. The methods outlined by **Hashim et al.** [13] and **Ahmadi et al.** [14] were utilized for the preparation of the onion extract-loaded nano-emulsion and the onion extract gel, respectively [13,14]. The thermodynamic stability of the 10% w/w onion extract-loaded nanoemulsion was assessed following the procedure detailed by **Ashagrie et al.** [15]. The resulting formulation was evaluated for fluidity, color, optical clarity, homogeneity and phase separation in accordance with the guidelines provided by **Fañani et al.** [16]. For the determination of onion content, the assay was performed based on the method described by **Marques et al.** [17]. The pH of the 10% w/w drug-loaded nanoemulsion formulation was measured using a calibrated pH meter, following the procedure established by **Gawin-Mikolajewicz et al.** [18]. Spreadability, an essential factor influencing patient compliance and the uniform application on skin, was assessed as per the description by **Kumar et al.** [19]. The average of the droplet size, the polydispersity index (PDI) and the Zeta potential of the prepared nano-emulsion evaluated using the dynamic light scattering (DLS) with the Malvern Zetasizer (Malvern, Worcestershire, UK) as detailed by **Abuelella et al.** [20, 21] studies. The incorporation efficiency (IE) of the onion extract within the nanoemulsion was determined using the direct method as evaluated by **Md Saari et al.** [22]. The morphology of nanoemulsion was analyzed using a transmission electron microscope, as described by **Abuelella et al.** and **Marwa and Jufri** [23, 24]. An in vitro release study of the onion extract-loaded nanoemulsion formulation and the onion extract gel (which served as a control) was conducted using a USP dissolution apparatus II, as per the methodology outlined by **Alsofany et al.** [25]. A skin irritation test was performed to verify the safety of the formulated onion extract-loaded nanoemulsion gel, as described by **Abdelbari et al.** [26]. The cytotoxic effects of the onion extract incorporated nanoemulsion (F1) on human skin cells were assessed through the MTT assay, as outlined by **Almutairi et al.** and **Jayasinghe et al.** [27, 28].

The onion extract loaded nanoemulsion is exceptionally well-suited for use in pharmaceutical and cosmetic fields, owing to its nanoscale droplet size which facilitates improved drug solubilization, enhanced bioavailability and controlled release characteristics [29]. This non-greasy formulation provides several benefits, including rapid drug release directly on the site of action and superior application properties [30].

Mothers in the phonophoresis group were guided to adopt a relaxed position. The scar was prepped for the procedure by spreading a thin layer of coupling gel, followed by applying a suitable amount of onion extract nanoparticle gel over the affected area. For the phonophoresis procedure, the therapeutic ultrasound device used was the Nonius Sonopuls 590 S.N 0.03-202 type 14663.900 (Enraf, Holland). Pulsed ultrasound was administered using a 5 cm² ultrasound head, which kept perpendicular in contact with the skin while moving in a slow circular motion to ensure an overlap of half the width of the sound head. The parameters were as follows: (pulsed mode 25% on-off cycle with a frequency of 1 MHz, 0.5 W/cm² intensity and a duration of 10 minutes). Total treatment duration is 36 sessions at a rate of 3 sessions per week [8,12]. The ultrasound head was sanitized with an alcohol solution before and after each session. Observation were made each visit to monitor for any adverse effects [7]. In contrast, mothers in the conventional group received a sham treatment with onion extract nanoparticle gel phonophoresis, where the same procedure was followed, but the ultrasonic device was set to zero intensity [12].

Deep friction massage:

Deep friction massage is an effective therapy strategy to improve scar pliability and alleviate related symptoms. Deep friction massage was administered using both circular and perpendicular pressure on the scar tissue for 15 minutes at a time, applying sufficient pressure to the skin to cause the scar to whiten. The intensity of the pressure was gradually increased, ensuring that the mothers experienced no discomfort [31, 32].

Outcome measures

The Schiotz tonometer pressure load and MVSS scores were used as outcome measures. Before the evaluation, the examined area had been thoroughly cleaned and all mothers were assessed in a comfortable position. All mothers in both groups (phonophoresis group and conventional group) had measurements taken by the same therapist at baseline (pre-treatment) and after the 12-week treatment program was accomplished (post-treatment).

Statistical analysis

The data were screened to assess the normality assumption and the homogeneity of variance. Shapiro-Wilk test was used to evaluate the normality of the data, which indicated that the data were normally distributed ($P > 0.05$) following the removal of outliers identified by box and whisker plots. Furthermore, Levene's test for homogeneity of variance cleared that there was no significant difference ($P > 0.05$). The results permitted the execution of both parametric and non-parametric analyses. Data for the

tonometer variable were normally distributed and parametric, whereas data for the modified Vancouver scale were non-normally distributed and non-parametric.

The statistical analysis was performed using SPSS statistical software (version 25; SPSS, Chicago, Ill). For the parametric data (tonometer variable), results are presented as mean and standard deviation and statistical comparisons between pre- and post-treatment within each group were conducted using the paired t-test. Additionally, an independent t-test was employed to compare both groups at pre- and post-treatment for the tonometer variable and demographic data. For the non-parametric data (modified Vancouver scale variable), results are expressed as median (interquartile range) and statistical

comparisons between pre- and post-treatment within each group were made using the Wilcoxon signed-rank test. Moreover, the Mann-Whitney U test was utilized to compare between the two groups at pre- and post-treatment. All statistical analyses were considered significant at a probability level of ($P \leq 0.05$).

RESULTS

Table 1 shows the descriptive characteristics of the participated mothers in both groups. The results of the demographic data show that there are no significant differences ($P > 0.05$) in average values of the mother’s age ($P = 0.957$), the weight ($P = 0.809$), height ($P = 0.983$) and the Body Mass Index (BMI) with P value = 0.313 between the phonophoresis and conventional group.

Table 1. Mother’s demographic data in both groups

characteristics	Groups (Mean ±SD)		P-value
	Phonophoresis group (n=20)	Conventional group (n=20)	
Age (year)	28.90 ±3.34	28.95 ±2.41	0.957
Weight (kg)	67.05 ±5.21	67.40 ±3.73	0.809
Height (m)	1.71 ±0.08	1.71 ±0.06	0.983
BMI (kg/m ²)	23.19 ±1.87	22.81 ±1.41	0.313

1 Quantitative data (age, weight, height and BMI) are written as mean ±standard deviation and compared by t-independent test.

2 P-value: probability value P-value > 0.05: non-significant

The statistical analysis comparison tests for tonometer between both groups are shown in Table (2) and Figure (1). No significant statistical difference ($P > 0.05$) between phonophoresis group and conventional group at pre-treatment in tonometer ($P = 0.566$). However, after treatment there was significant statistical difference ($P < 0.05$) between phonophoresis group and conventional group in tonometer ($P = 0.0001$), Furthermore, taking into

account the impact of the tested group, the significant reductions in the average tonometer values observed post-treatment are more advantageous for mothers in the phonophoresis group compared to those in the conventional group.

The statistical analysis comparisons test for tonometer within each group is presented in Table (2) and Figure (1). There was a significant decrease ($P < 0.05$) in tonometer readings post-treatment when compared to pre-treatment within phonophoresis group ($P = 0.0001$) and conventional group ($P = 0.0001$). Furthermore, the mothers in the phonophoresis group demonstrated a greater enhancement in tonometer percentage (47.04%) than mothers in conventional group (20.08 %).

Table 2: Within and between groups comparison for tonometer

Items	Groups		Change	P-value ¹
	Phonophoresis group (n=20)	Conventional group (n=20)		
Pre-treatment	12.65 ±2.45	12.20 ±2.46	0.45	0.566
Post-treatment	6.70 ±1.38	9.75 ±2.17	3.05	0.0001*
Change	5.95	2.45		
Improvement %	47.04%	20.08%		
P-value ²	0.0001*	0.0001*		

- Data are expressed as mean ± standard deviation P-value: probability value * Significant ($P < 0.05$)
- P-value¹: Probability value between both groups at pre- and post-treatment and compared statistically by independent t test

- P-value²: Probability value between pre-and post-treatment within each group and compared statistically by paired t test

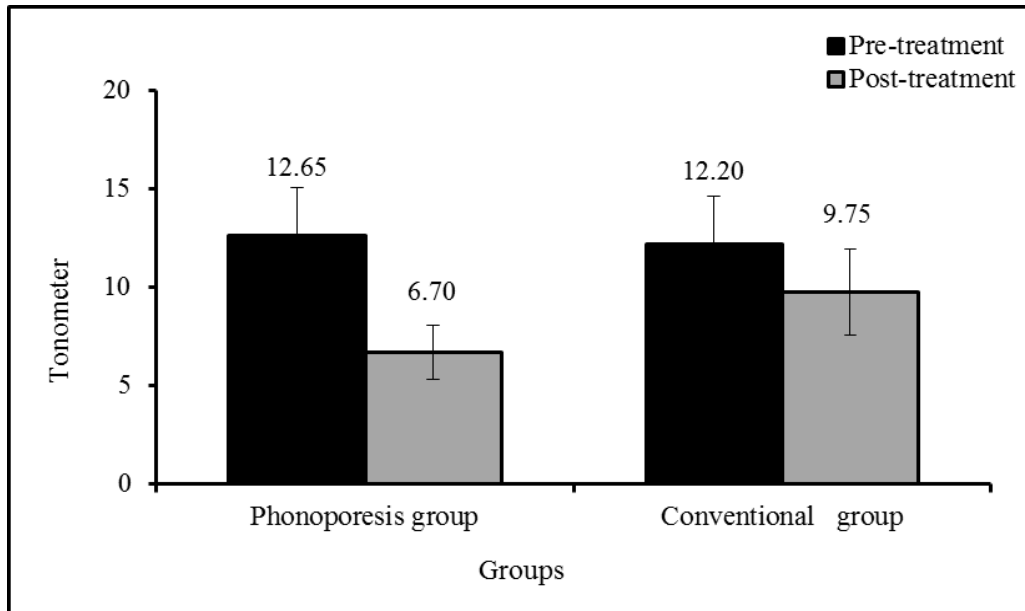


Figure 1. Pre- and post-treatment of tonometer

The statistical analysis comparison test for modified Vancouver scale within each group is presented in Table (3). The pliability decreased significantly as shown in (Table 3 and Figure 2), the height (Table 3 and Figure 3), the vascularity (Table 3 and Figure 4) and the pigmentation (Table 2 and Figure 5) comparing post-treatment to pre-treatment within phonophoresis group (P value=0.0001 in all properties) and conventional group (P=0.0001, P=0.014, P=0.025 and P=0.046, respectively). Furthermore, the mothers in the phonophoresis group demonstrated greater enhancement in pliability, height, vascularity and pigmentation percentages (50.00, 50.00, 33.33 and 66.67%, respectively) than mothers in conventional group (25.00, 16.67, 0.00 and 33.33%, respectively)

(3). No significant statistical difference between the phonophoresis group and the conventional group at the pre-treatment in pliability (P value=0.930; Figure 2), height (P value=0.727; Figure 3), vascularity (P value=0.681; Figure 4) and pigmentation (P value=0.513; Figure 5). Nonetheless, there were significant statistical differences (P value<0.05) observed between the phonophoresis group and the conventional group post-treatment pliability (P=0.006), height (P=0.0001), vascularity (P=0.0001) and pigmentation (P=0.0001). Furthermore, taking into account the impact of the tested group, the significant reductions in the average values of the modified Vancouver scale are more advantageous for mothers in the phonophoresis group compared to those in the conventional group.

The statistical analysis comparisons test for modified Vancouver scale between both groups is shown in Table

Table 3: Within and between groups comparison for modified Vancouver scale

Variables	Items	Groups		Change	P-value ¹
		Phonoporesis group (n=20)	Conventional group (n=20)		
Pliability	Pre-treatment	4.00 (4.00 , 5.00)	4.00 (4.00 , 5.00)	0.00	0.930
	Post-treatment	2.00 (2.00 , 3.00)	3.00 (2.00 , 4.00)	1.00	0.006*
	Change	2.00	1.00		
	Improvement %	50.00%	25.00%		
	P-value ²	0.0001*	0.0001*		
Height	Pre-treatment	3.00 (2.25 , 3.00)	3.00 (2.00 , 3.00)	0.00	0.727
	Post-treatment	1.50 (1.00 , 2.00)	2.50 (2.00 , 3.00)	1.00	0.0001*
	Change	1.50	0.50		
	Improvement %	50.00%	16.67%		
	P-value ²	0.0001*	0.014*		

Vascularity	Pre-treatment	3.00 (3.00 , 3.00)	3.00 (3.00 , 3.00)	0.00	0.681
	Post-treatment	2.00 (1.00 , 2.00)	3.00 (2.00 , 3.00)	1.00	0.0001*
	Change	1.00	0.00		
	Improvement %	33.33%	0.00%		
	P-value ²	0.0001*	0.025*		
Pigmentation	Pre-treatment	3.00 (2.00 , 3.00)	3.00 (2.00 , 3.00)	0.00	0.513
	Post-treatment	1.00 (0.25 , 2.00)	2.00 (2.00 , 3.00)	1.00	0.0001*
	Change	2.00	1.00		
	Improvement %	66.67%	33.33%		
	P-value ²	0.0001*	0.046*		

Data are expressed as median (interquartile range) P-value: probability value * Significant (P<0.05)

P-value²: Probability value between pre-and post-treatment within each group Wilcoxon signed ranked test

P-value¹: Probability value between both groups at pre- and post-treatment and compared statistically by Mann-Whitney U test

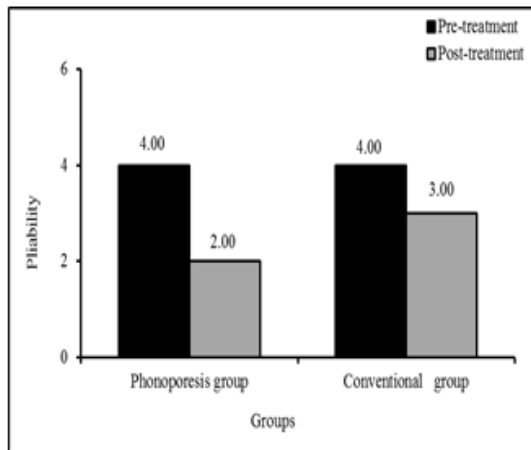


Figure 2. Pre- and post-treatment of pliability.

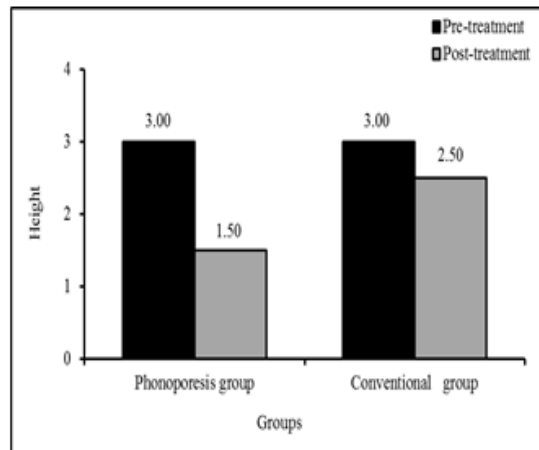


Figure 3. Pre- and post-treatment of height.

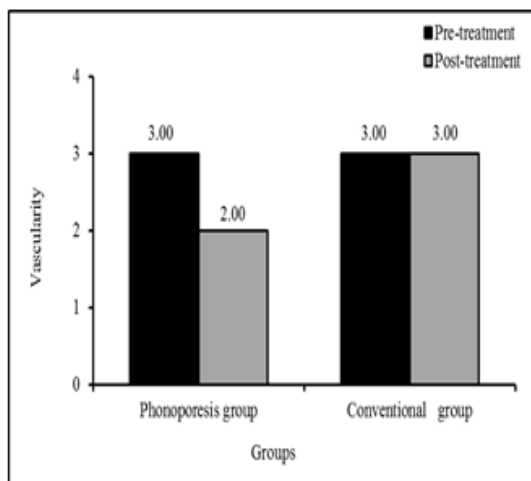


Figure 4. Pre- and post-treatment of vascularity.

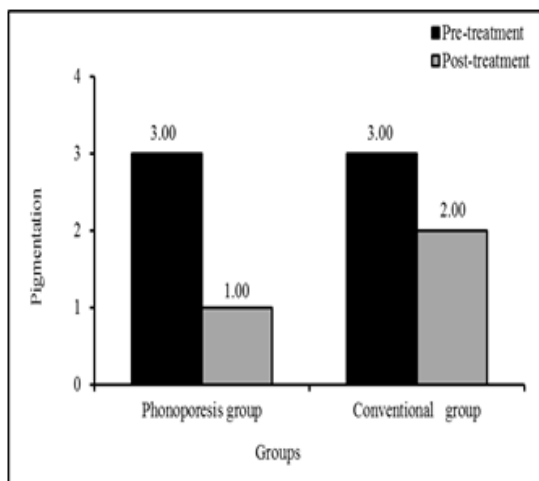


Figure 5. Pre- and post-treatment of pigmentation.

DISCUSSION

An increased risk of severe or unpleasant scarring is often linked to cesarean-section deliveries. Scars result in pain,

discomfort, itching, contracture, functional impairment and aesthetic concerns. Scarring reduces range of motion and makes daily tasks more difficult [2]. Phonophoresis is

a quick, painless and noninvasive technique that enhances percutaneous drug delivery and increases transdermal drug absorption [3]. Due to its ease of use and lack of adverse effects, onion extract gel is a primary topical medication recommended for the management and prevention of hypertrophic scars [33].

No study has examined the impact of gel containing onion extract phonophoresis on postsurgical scar after cesarean section, despite some earlier research evaluating the gel's effect on scar following cesarean section [7, 34, 35]. Therefore, this study was conducted to inquire how onion extract nanoparticle gel phonophoresis affected the scarring that occurred after cesarean-section.

The findings of the current study indicated a remarkable improvement in the characteristics of postsurgical scar of cesarean-section in both the phonophoresis and conventional groups following the intervention. Nevertheless, a highly significant difference was observed between the phonophoresis group and the conventional group, favoring the phonophoresis group. Consistent with the findings of this study, **Lee and Zhou** [36] reported that phonophoresis is purported to enhance the percutaneous absorption of pharmacological agents into the underlying subcutaneous tissues using ultrasound, thereby augmenting their efficacy. Additionally, **Park et al.** [37] discovered that the disruption of stratum corneum lipids facilitates the transdermal passage of drugs, which is the underlying mechanism of transdermal permeation. Following cavitation, microstreaming and the generation of heat, a corresponding reduction in skin resistance was noted [37]. Furthermore, our findings agreed by earlier research, which indicated that onion extract is effective in diminishing inflammation associated with hypertrophic scars and that ultrasound enhances this effect by facilitating improved dermal penetration [38,39].

Also, **Abdalla et al.** [10] reported that the use of contractubex (a gel containing onion extract) through phonophoresis over a period of six weeks, with a frequency of three sessions per week, can enhance erythema, pruritus, healing, appearance and flexibility of hypertrophic scars, compared to the use of topical medications alone. Additionally, **Bokaee** [3] investigated the impact of Contractubex phonophoresis on postsurgical scars resulting from carpal tunnel release. The phonophoresis treatment was conducted for 10 sessions, with a frequency of three times per week. The author indicated that Contractubex phonophoresis may be effective in managing scars by improving their height, pliability and tenderness [3].

In line with this, **Sobh et al.** [33] determined that phonophoresis serves as an effective therapeutic approach, successfully applicable in the treatment of hypertrophic scars. The transdermal delivery of drugs via phonophoresis can surmount the skin's resistance, enhancing the transdermal absorption of medication through thermal effects, connective transport and mechanical stresses. The authors demonstrated the efficacy of phonophoresis using Cybele scapel, which can

enhance vascularity, pigmentation, thickness and pliability of hypertrophic scars [33]. Additionally, **Rahbar et al.** [40] reported that Dexamethasone phonophoresis is a safe and effective treatment option for pruritus associated with burn hypertrophic scars [40].

This is consistent with the study by **Koeke et al.** [41], which contrasted the effects of hydrocortisone phonophoresis, therapeutic ultrasound and the topical hydrocortisone administration on the Achilles tendon healing process in forty male rats after tenotomy. When compared to the control group, the ultrasound and the hydrocortisone phonophoresis groups both showed a substantial improvement, however the hydrocortisone phonophoresis group outperformed and was more significant than the ultrasound group. These results reflected the piezoelectric characteristics of the ultrasonic vibrations, which cause the collagen tissues to produce a low amplitude electrical potential. The process of tissue repair stimulated by the interaction between the ultrasonic-waves and the collagen molecules, which increases the fibroblast activity, stimulates the collagen synthesis and facilitates the fiber deposition at the site of damage. During the phonophoresis process, the transdermal medication distribution is greatly aided by the processes of heat and cavitation. Heat can dilate the sweat glands and the hair follicles, improve circulation in the treated areas and increase the kinetic energy of the medication molecules. These physiological changes may help the medication molecules diffuse and permeate the stratum corneum layers. Additionally, cavitation can induce structural disruptions in the epidermis layer, further facilitating the penetration and diffusion of drug molecules [42].

Concerning the Onion, scientifically known as *Allium cepa*, it enhances the appearance and texture of surgical scars [3]. Onion extract exhibits the anti-inflammatory, antiproliferative, bacteriostatic and collagen downregulatory properties. Also, quercetin, the primary ingredient, can reduce the fibroblast proliferation, inflammation, extracellular matrix deposition and stabilize mast cells [7].

Draelos [43] discovered that *Allium cepa* extract offers several health advantages, such as anticarcinogenic properties, antiplatelet activity, antithrombotic effects, antihistamine effects and antibiotic properties. In later research by **Draelos et al.** [44] a randomized, controlled, blinded-investigator trial was conducted comparing onion extract gel to no treatment for new scars, revealing that onion extract gel enhanced the appearance of new scars. **Boots et al.** [45] indicated that the quercetin has the ability to inhibit the production of the tumor necrosis factors a (TNF-a) which may induced by lipopolysaccharides and demonstrating the quercetin anti-inflammatory properties. These findings agree with **Cho et al.** [46] who stated that the effects of the quercetin on the cells proliferation vary based on its concentration and the duration of exposure leading to a decrease in the cell protein contents and cause a reduction in the mitotic index. Also, the onion extract shown to upregulate the expression of the matrix

metalloproteinase-1 (MMP-1) depends on the dose. Based on these results, the onion extract seems to be one of the promising tools for reducing the scars appearance [46]. **Campanati et al.** [47] and **Sahin et al.** [48] stated that applying the onion extract 2–3 times daily for 3–6 months enhanced the quality of the postsurgical scars and the hypertrophic scars [47,48]. These findings align with **Chanprapaph et al.** [7] who studied the impact of the onion extract on the scars following the Pfannenstiel's cesarean section applied after 7 days post-surgery three times a day per 12 weeks. The results indicated a noticed difference in the average scar height and the symptoms between both control and treatment groups at four and twelve weeks. Also, **Napavichayanun et al.** [35] reported that a gel containing onion extract can be safely utilized not only to minimize scars but also to enhance the appearance of the post-cesarean scars after a minimum of one month of treatment. Furthermore, **Ocampo-Candiani et al.** [34] stated that the contractubex gel containing *Allium cepa*, uses as a well-tolerated preventative tool that rapidly improve the color and the stiffness of the cesarean scars. Additionally, they were similar to **Wananukul et al.** [49] study who stated that applying 5% onion extract silicone gel to the hypertrophic scars effectively reduced the severity of hypertrophic scars from median sternotomy wounds within six months. However, **Jackson and Shelton** [50] assessed the efficacy of the topical onion extract gel for enhancing the appearance and the alleviating symptoms of the postsurgical scars when it compared to the topical emollient in 17 patients had an undergone Mohs surgery. Each patient used a specified topical product three times a day for one month. They did not observe any significant differences between the pretreatment and the posttreatment assessments regarding to the scar erythema and pruritus in the subjects who used the topical onion extracted gel [50].

Chung et al. [51] treated surgical wounds with onion extract gel/petrolatum ointment over two months through a randomized split-blind scar study. The findings revealed no statistically significant differences in scar symptoms, erythema, hypertrophy, or overall cosmetic enhancement between the sides treated with onion extract and those treated with petrolatum [51]. Similarly, **Zurada et al.** [52] reported no significant alterations in erythema and pruritus of hypertrophic scars following the application of onion extract gel.

The discrepancies in results may stem from variations in treatment duration. In the current study, a longer treatment period was employed, whereas the previous studies utilized shorter durations [50,51,52]. Additionally, while those studies relied solely on a topical gel, the present study incorporated phonophoresis as well.

LIMITATIONS OF THE STUDY

Significant effort was invested with each mother to reduce the impact of any errors that might arise from the inherent nature of the study. We chose Pfannenstiel's cesarean section scar over the midline scar to minimize the anatomical variations. Nonetheless, the faced limitations including small sample size, potential human error of

diagnostic or treatment procedures administration and the level of cooperation from mothers during the treatment. Further research involving a larger participant is essential to yield more comprehensive insights.

CONCLUSION

The study showed that the use of onion extract nanoparticle gel phonophoresis can be a safe and non-invasive treatment option to enhance the characteristics of the postsurgical scar resulting from the cesarean section, enhancing the scars overall quality and appearance.

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