

Comparing the effectiveness of popular treatments for swelling and scarring

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SUMMARY

Swelling and scarring are expected, yet concerning, aspects of healing tissue after surgery or injury. Though many popular or specialty treatments claim to reduce swelling and scarring (e.g. Epsom salt soaks for swelling or application of commercial scar gels for scarring), it remains unknown whether these treatments are more effective than less expensive treatments (e.g. plain warm water soaks for swelling and petroleum jelly application for scarring). In this study, I compared the effectiveness of such treatments for swelling and scarring on myself after bilateral orthopedic surgery on my feet. I hypothesized that soaks in warm water with Epsom salts would reduce swelling more effectively than soaks in warm water alone. I also hypothesized that application of a commercial scar gel would yield a less visible scar over time than application of petroleum jelly. The results of this study did not support my initial hypotheses and instead suggest that there is no difference in effectiveness between each of the two swelling and scarring treatments. The results of this study highlight the importance of further and larger comparative studies on this subject, especially in a developing country such as mine, due to the widespread promotion of more expensive treatments despite equal effectiveness to less expensive treatments.

INTRODUCTION

Acute damage to connective and epithelial tissues involves increases in soft tissue volumes and disruption of the skin. Injured cells release molecules recognized by cellular receptors that stimulate the release of proinflammatory mediators. These signals are mainly mediated by a group of molecules called cytokines, which include tumor necrosis factors (TNF) and growth factors (GFs) and are recognized by cellular receptors mainly in basophils and mast cells. These cells are triggered to release histamine, which increases vascular permeability (1). If trauma causes bleeding, then platelets can also trigger inflammatory mediators, such as adhesion molecules and chemokines, which attract leukocytes, and platelet-derived growth factor (PDGF), which is further involved in tissue healing.

Leukocytes, mainly neutrophils attracted by these signaling molecules, can migrate through endothelial cell walls due to cytokine-type mediators and TNF. Neutrophils phagocytose devitalize tissue and infectious agents if present

and produce molecules such as proteases and antimicrobial molecules to complete the task. PDGF and diverse GF are mitogen and chemotactic agents for fibroblasts and smooth muscle cells and promote the synthesis of collagen, which is crucial for soft tissue healing (2,3).

When neutrophils migrate to skin, they induce a large transcriptional activation program; this includes the differential expression of certain genes that promote healing, such as molecules that breakdown fibrin clots, degrade cellular matrix and promote angiogenesis. These molecules as well as cytokines promote the proliferation and migration of fibroblasts and keratinocytes, which are crucial in wound healing, to the dermal layer. This cascade of inflammatory and repairing molecules and cells is much more vast and complex and functions properly in a delicate balance. Then, dysregulated inflammation and wound healing after trauma imply improper anatomical and physiological recovery (4).

Clinically, swelling, or inflammation, is the visible manifestation of the initial physiological steps of tissue repair (5). Excessive or long-lasting inflammation may cause discomfort, pain, functional disturbances, or delays in healing. Lower limb swelling, specifically foot swelling, tends to be especially disabling due to its effects on patient mobility and comfort. Scarring is the visible normal manifestation of skin wound healing (6). However, abnormal or excessive scarring can impact both mental and physical health (7). It can produce alterations in self-image perceptions, emotional states, and social relations. Abnormal scarring can also be expressed as physical disturbances such as retraction (scar shortening), hypertrophy (scar enlargement) and atrophy (weak and thin scars) (8).

The treatment of inflammation, especially when localized in the lower limbs, is particularly important because a rapid improvement in foot swelling can lead to shorter hospitalization after surgery, less time off from work or school, and better functional and anatomic outcomes for the affected limb (9). Scar treatment is applied simultaneously to prevent psychological anatomical and physiological sequelae (10).

Although many popular or specialty treatments claim to reduce swelling and scarring (e.g., Epsom salt soaks for swelling or the application of commercial scar gels for scarring), it remains unknown whether these treatments are actually more effective than less expensive treatments (e.g., plain warm water soaks for swelling and petroleum jelly application for scarring). Since the human body recovers spontaneously from swelling and scarring with time and rest, it is difficult to compare the effectiveness of treatments for these conditions. A study in which two interventions are

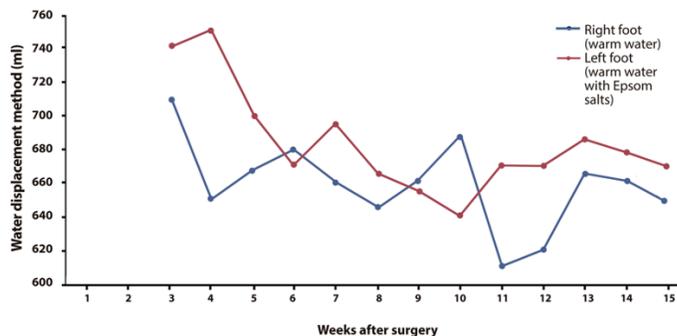
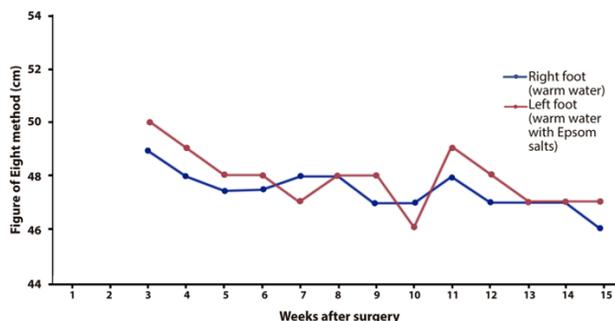


Figure 1: Measurement of inflammation. Inflammation of the right and left foot after orthopedic surgery to correct flat feet, measured with the Figure of Eight method (a), which measured the change in length (cm) with a measuring tape wrapped around the foot, and the water displacement method (b), which measured the volume of water (mL) displaced by the foot. The right foot (red) was treated with immersion in warm water, and the left foot (blue) was treated with immersion in warm water with Epsom salts, daily and simultaneously. The figure shows that the left foot was more swollen than the right foot at the beginning and end of the study, and the right and left foot tended to improve with time, showing a similar tendency of both feet.

compared in a single individual on one side of the body compared to the other uses an ideal experimental setup to determine the relative effectiveness of different treatments for these conditions (11,12). After symmetrical bilateral surgery on my feet, I decided to use my unique position to compare the effectiveness of a popular treatment for swelling (Epson salt soaks) with plain water soaks and a commercial scar gel vs. a less expensive treatment (petroleum jelly) for skin wound healing. I hypothesized that popular or specialty treatments would be more effective than less expensive treatment options.

RESULTS

In this study, I simultaneously compared treatment outcomes (right foot vs. left foot) for swelling and scars after bilateral flat foot corrective surgery known as subtalar arthroereisis (13). This surgery proceeded as expected without any adverse events. As expected, the surgery resulted in bilateral swelling and scarring on my feet.

I independently and randomly assigned my feet to the swelling and scarring treatments to be tested. I assigned the right foot to be treated with plain warm water for swelling and petroleum jelly for scarring and the left foot to be treated with Epsom salt soaks for swelling and a commercial over-the-counter (OTC) scar gel treatment for scarring (known by the brand name Cicatricure® in Colombia). Though the swelling and scarring treatments were administered simultaneously, I will present the results of the swelling and scarring treatments separately in “Part 1: Swelling Treatment” and “Part 2: Scarring Treatment”.

Part 1: Swelling Treatment

After the surgery, the right foot and ankle were treated with plain warm water, and the left foot and ankle were treated with warm water and Epsom salts. I measured changes in foot swelling using two methods: the Figure of Eight method (14) and Archimedes’ principle of water displacement (15). I started recording data on week 3 after surgery and stopped on week 15 after surgery.

The baseline swelling measurements in cm of width measured with the Figure of Eight method and in ml of volume of water displacement, obtained three weeks after surgery, were 49 cm and 710 ml for the right foot and 50.5

cm and 740 ml for the left foot. The final measurements obtained 15 weeks after surgery were 46 cm and 647 ml for the right foot and 47 cm and 669 ml for the left foot (Figure 1). During the four months that I measured swelling, there was an overall trend towards improvement in swelling (i.e., decreasing width and volume measurements).

The total recovery rates (Figure of Eight and water displacement) at the end of the study yielded comparable values: 6.1% and 8.7% on the right and 6.9% and 9.6% on the left foot and ankle (Figure 2).

Part 2: Scar Treatment

The subject had almost identical incisions: one straight line approximately 4 cm long on the dorsolateral region of each foot just below the lateral malleolus.

I measured changes in scarring using two methods: the Vancouver Scar Scale (VSS) (16), which is a visual scale that ranges from 0 (normal scarring) to 13 (very pathological scarring), and a medical smartphone application that measures the area of a scar using photography. The VSS scores and scar area baseline values on week three (the baseline values) for the right (petroleum jelly) and left (the commercial OTC scar gel) foot were 6 and 9 and 1.3 cm² and 2.3 cm², respectively. The last measurement six months after surgery showed that the VSS scores and scar areas for the right and left foot decreased to 3 and 5 and 0.5 cm² and 0.7 cm², respectively (Figure 3).

The total percent decrease in scar area (61.3% for the right scar and 59.6% for the left scar) and the total VSS score decreased: 3 for the right scar (initial value of 6, final value of 3) and 4 for the left scar (initial value of 9, final value of 5), which were comparable between the right and left foot (Figure 4).

DISCUSSION

The present study took place after symmetrical bilateral surgery intended to correct the flat foot condition of one subject. Contrary to my initial hypothesis, I observed no difference in the effectiveness of the two treatments tested. Clearly, the commercial OTC scar gel Cicatricure® was not superior to petroleum jelly in terms of making the scar less visible, and Epsom salt water did not show any benefits over plain water in terms of foot swelling throughout the six-month

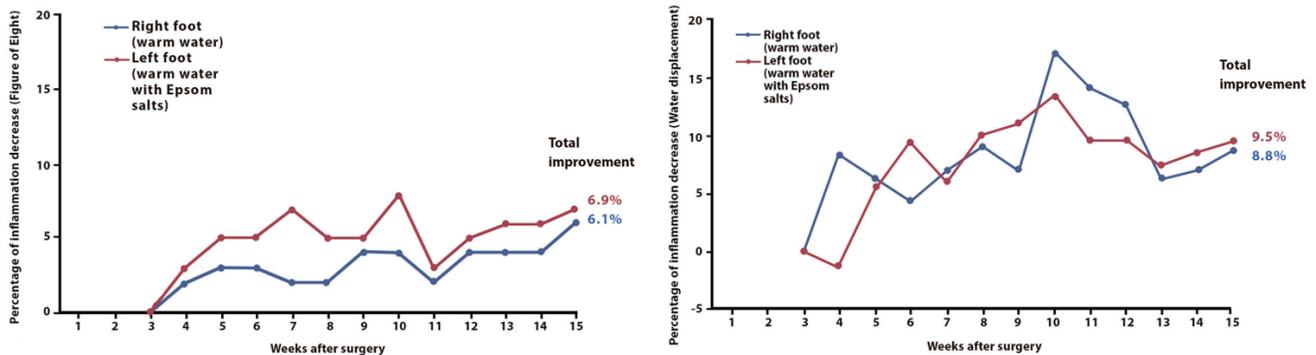


Figure 2: Comparison of the percentage decrease in inflammation between the right and left feet after flat feet corrective surgery. Feet were measured with the Figure of Eight method (a) and the water displacement method (b). The right foot was treated with immersion in warm water, and the left foot was treated with immersion in warm water with Epsom salts, daily and simultaneously. The shown curves are expressed as percentages of decreases in inflammation in both feet with respect to the baseline values, considered as 0% for both. The curves and the final percentage of swelling improvement were very similar, suggesting that there is no real difference in the effectiveness of both treatments.

comparative study.

The idea for this study arose from a personal situation in which I underwent bilateral surgery on my feet. The normal concerns I had about swelling and scars made me pay attention to very popular TV commercials in my country for OTC scar products that alleged effectiveness over other interventions based on advertised studies that did not seem to be based on comparative or objectively measured data. I also became interested in the fact that in Colombia, it is traditional that remedies such as Epsom salts are used for swelling, even in postsurgical conditions without the advice of a doctor. This led me to review the scientific literature before the surgery and decide to conduct a study on myself. After receiving authorization from my doctor, I decided to compare an inexpensive, common treatment such as petroleum jelly with a popular, expensive topical medicine (Cicatricure®) under the same conditions of dosage and method of administration for scars. Both treatments fulfilled the condition of promoting moistening and scar massage. Research has shown that gentle massage and moisturization add significant benefits over non-intervention (17). Therefore, both treatments were theoretically superior

to leaving my scar untreated, and both were adequate interventions in the opinion of my surgeon, independent of a potential additional benefit of one of the treatments over the other.

On the other hand, the swelling and pain adjuvant measures recommended by my surgeon included warm water soaks beginning the third week after surgery. In the previous weeks, I followed his recommendation of applying cold treatment on both of my feet. This initial period was not recorded or analyzed as part of the experiment, in part because swelling tends to vary considerably during the first days after surgery or trauma (18) and because of the pain factor. The addition of Epsom salts to water, in the opinion of my treating doctor, would not do any harm. Therefore, I decided to add this variable to the experiment.

I decided to test the resulting two conditions (scarring and swelling), introducing different interventions for both simultaneously, in opposition to traditional recommendations for carrying out a fair study, in order to take advantage of this unique and unrepeatable experience of having the same surgery performed on both lower extremities at the same time. I also took into account the fact that researchers often

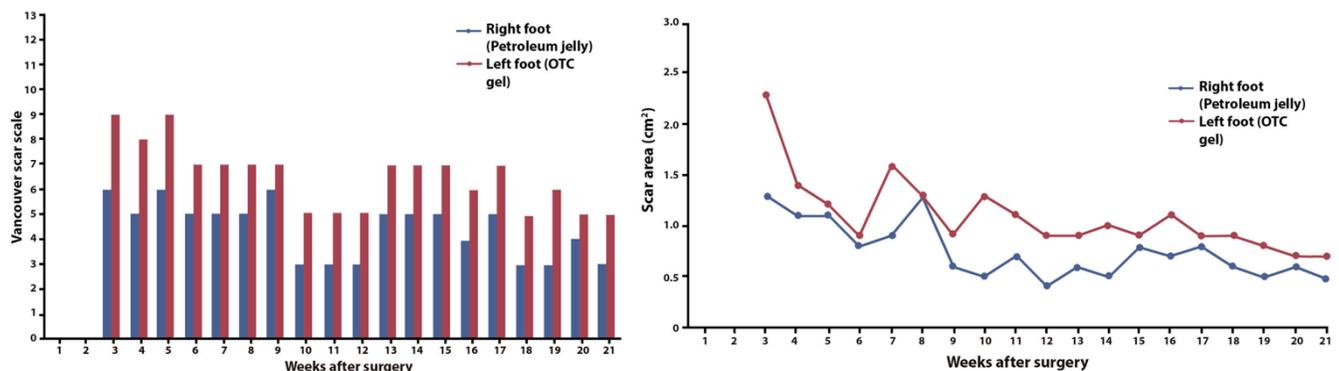


Figure 3: Measurement of scars. Measurements of a scar on the right foot and a similar scar on the left foot (both 4 cm long) produced by bilateral identical flat feet corrective surgery over a period of 21 weeks using the Vancouver Scar Scale (a) and scar area measurement in cm² (b). The scar on the right foot was treated with petroleum jelly, and the scar on the left foot was treated with a popular OTC scar gel. The assessment of both scars in terms of the Vancouver Scar Scale (a visual scale that ranges from 0: normal scarring to 13: very pathological scarring) and objective area measurement with a smartphone application (LesionMeter) showed similar tendencies towards improvement with time, with an apparent worsening from weeks 5 to 7, which was considered part of the normal healing process.

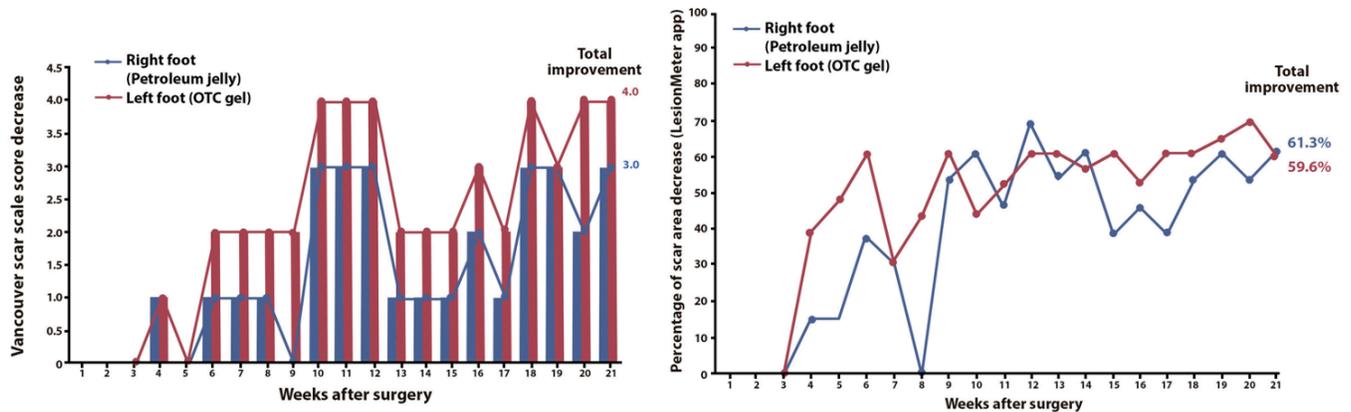


Figure 4: Measurement of scar improvement. Vancouver Scar Scale score decreased (a) and the scar area decreased (b) when comparing between a scar on the right foot and a similar scar on the left foot, both produced by symmetrical flat feet surgical correction. The scar on the right foot was treated with petroleum jelly, and the scar on the left foot was treated with a popular OTC scar gel. The improvement is shown as a decrease in the Vancouver Scar Scale scores as well as in the percentage of decrease in the scar area with respect to the baseline values, considered as 0% for both feet. The curves and the final values of scar improvement were very similar, suggesting that there is no real difference in the effectiveness of both treatments.

include, in special cases, multiple independent variables in their studies, even in single-case designs (19). Furthermore, I took into consideration that both variables studied are, in my opinion, nearly equally relevant for patients undergoing extremity surgeries.

In theory, there might be a potential effect of swelling on scarring: swelling can add tension to the edges of the scar and lead to a less favorable result. In the present case, the scars were located on an area of the feet where the skin and soft tissues are not considerably elastic and expandable by soft tissue swelling (20), and the swelling was similar and not severe on both sides. Therefore, I expected the effect of swelling on scarring, if any, to be both mild and similar on both sides. Furthermore I did not find any data (consulting PubMed) that suggested any confounding effects between these variables. While this does not preclude confounding, it supports the assumption that scar treatment on a very small area of the foot would not influence the severity of inflammation of the foot or ankle and that water soaks with or without Epsom salts would not unduly influence scar healing. Indeed, it is unlikely that magnesium, which is the principle active ingredient in Epsom salts, had an effect on the scar of the foot assigned to this intervention for swelling; although magnesium has been described to have potential beneficial effects on scars when present in the blood after oral or intravenous administration (21), there is a wealth of evidence that suggests that magnesium does not penetrate through or affect the skin (22).

On the other hand, there is a compressive force exerted by the hydrostatic pressure generated during immersion that could theoretically favor a decrease in inflammation on both feet (23). This effect was expected to be symmetrical because the conditions of the immersions were the same for both feet.

An important limitation described for comparative studies of treatments for swelling and scarring is the natural tendency of the body to improve with time without any intervention (6,10). Scars also evolve differently, even in a single individual, depending on the region of the body in which the disruption of skin and soft tissue

occurs (24). Therefore, the scenario of symmetrical and simultaneous injuries in one individual is near ideal in terms of comparative observations (11,12,25), though obviously not in terms of statistics.

Since this study, by necessity, has a very small sample size, there are many variables that could possibly have affected the results. Before the surgery, I was a healthy and active 14-year-old who exercised eight hours a week. Another individual who does not share these characteristics (for example, someone with pre-existing conditions, a local infection, or swelling and scarring in a different part of the body) may not have had the same outcomes. It would have been ideal to include more individuals in this experiment, but unfortunately, it was not possible to find more individuals with symmetrical scars and surgery/trauma on both sides of their bodies to make a rigorous, larger comparison.

For the results to be comparable when measuring improvement and comparing the treatment effectiveness of the right and left sides, I normalized the data by also expressing the results in terms of percentage of improvement (percentage of decrease in the values of swelling, scar visibility and size) beginning with a baseline value of zero percent improvement corresponding to the baseline measurement performed at week three after surgery and ending with the final total percent improvement at the end of the study.

This normalization by percentages is certainly not perfect; it is intended to be only an approximation, since pathological processes such as inflammation and scarring tend to have a course that cannot be fully compared by using ratios, considering the physiological differences between a major and a minor alteration (26). Fortunately, in the present study, there were no prominent differences in the baseline values of swelling or scarring between the right and left feet and ankles.

Although the same surgical procedure was performed on both feet, in the deep soft tissues as well as on the skin, and although there were no complications, the initial values for both swelling and scarring measurements using different methods were different (Figure 1,2). The human body is not



Figure 5: Sutured incision on the lateral side of the right foot a few days after surgery. The procedure was intended to correct flat feet deformity and is known as subtalar arthroereisis. It was performed on a 14-year-old female subject (myself).

fully symmetric, and its early tissue response to trauma is also frequently asymmetric (27).

It was interesting to note the presence of a modest peak of apparent worsening of inflammation in both feet on week 11 according to the Figure of Eight method (**Figure 1a**) and on week 10 according to the water volume displacement method after surgery (**Figure 1b**), which is likely related to an increase in my mobility at that time. Physical activity, although necessary to a certain extent for the proper rehabilitation of an extremity, frequently involves a transient worsening of swelling (6). This phenomenon is likely the explanation for the sudden rise in the swelling curve in the present study, as it correlates with a rise in physical activity, which was advised by my doctor and did not do any harm in the long term.

The general progression of the decrease in volume consisted of small increases and decreases, but there was an overall decreasing tendency. There was an increase of unknown cause in the swelling of the left foot on the fourth week detected by the water displacement method. This might be related to the more swollen state of the left foot from the beginning, which could make it more susceptible to transitory volume increases (26).

These changes are not rare in the evolution of physiopathological conditions such as edema (28). This variability is also a characteristic of physical phenomena in a setting that is not fully controlled, such as the recovery process from surgery at home, which has numerous variables, such as physical activity, hormonal changes, salt intake, and daily activities (28). Nevertheless, the foot that started the process with more swelling (right foot) remained more swollen than the other foot until the end of the process, and the difference between the feet remained approximately the same. The comparison of the change in swelling expressed in the percentage of the decrease in volume related to the initial result, established as the baseline value (0%), yielded curves that were similar to each other. Both curves showed a very clear general tendency towards improvement.

Although the surgical procedures were performed

in a symmetrical manner, in general, the right scar had better VSS scores and a smaller area than the other side throughout the study. Both the right and left foot scars had a general tendency towards improvement over time. During the entire six-month process, there were no significant incongruences or contradictions between the two scar measurement tools.

The side that scored worse in terms of the scar characteristics at the very beginning improved constantly with time and treatment but maintained a parallel and less favorable curve than the less severe scarred side, even at the end of the study. An interesting theory is that the initial phases of healing, rather than the later phases, may determine the final result of a skin scar. This theory has been described by some researchers, but it is not widely accepted (29). There was a peak of apparent worsening of the scars on both feet around the fifth week after surgery as assessed by the VSS and around the seventh week as assessed by scar area measurements. This could be a consequence of the normal proliferative healing stage characterized by an enhancement in the granulation tissue and in the network of collagen fibers. In contrast, in later phases of the study, a more sustained improvement was evident and compatible with the maturation stage of wound healing (5,30).

The measurements of the scars on the right and left foot by different methods yielded curves that were similar to each other. Both curves showed a very clear general tendency towards improvement. This part of the study therefore suggests that inexpensive, traditional remedies such as petroleum jelly are equally as effective as a very expensive, OTC commercial gel, as long as the treatment is applied frequently, consistently, and with a gentle rubbing motion. This conclusion may be important if it is confirmed by additional and larger comparative studies because of the relevance it will have in lower-income communities and developing countries in general.

The outcomes of this study are compatible with previous research that suggests that synthetic medications do not make a significant difference in the adequate evolution of a scar (31,32).

On the other hand, it is important to note that although swelling or inflammation is a normal stage in the healing process of tissue injuries, people often self-medicate with OTC anti-inflammatory drugs that carry potential risks for human health (33). Local remedies, if effective, can be a much safer alternative, so they should be scientifically tested.

Local treatments for swelling that are scientifically supported rely on physical rather than chemical interventions, such as manipulations of temperature, hydrostatic pressure, and the position of the affected extremity (33). Temperature treatment has been proven to decrease inflammation. Cold is generally recommended for swelling in the early stages of recovery (the first days or weeks) because its vasoconstrictive effect is associated with a decrease in the volume of fluids in the tissues where it is applied. However, in a more advanced phase of recovery, warm temperature produces arterial vasodilation, which increases the transportation of healing and anti-inflammatory factors to swollen tissues. Lymphatic vasodilation favored by warm temperature treatment promotes fluid absorption

a.



b.



Figure 6: Foot inflammation measurement technique. Inflammation was measured using the water volume displacement method (a) and the Figure of Eight method (b). The water displacement method to measure volume is based on Archimedes' principle. When a foot is submerged into a basin filled to the top with water, the volume of the displaced water corresponds to the volume of the foot, and its change over time gives us an idea of the evolution of inflammation. The Figure of Eight method involves wrapping a soft measuring tape around the foot and ankle in a standardized and reproducible manner and is widely used in physical therapy settings. The values are expressed in cm, and the change over time correlates with swelling changes in the foot and ankle.

and cellular waste product removal. This translates to improvement in delayed inflammation (34,35).

Epsom salts have been used for many years as topical anti-inflammatory agents in cases involving muscular pain and swelling and are one of the most commonly used traditional remedies, recommended even by doctors (36). Epsom salts are composed of magnesium sulfate heptahydrate, usually referred to as magnesium sulfate. It was originally obtained by boiling down mineral waters in Epsom, England (37).

Surprisingly, there are very few or no scientific studies involving Epsom salts as a topical treatment for soft tissue or muscle swelling (37,38). Nevertheless, in the present study, I hypothesized that soaks in warm water with Epsom salts would prove to be superior to the control treatment (soaks in warm water alone). I took into consideration the fact that Epsom salt soaks are advised by many health professionals as a treatment for swelling and, based on my initial literature search, that the lack of scientific evidence might be due to researchers not conducting many studies on OTC medications such as Epsom salts (37).

The outcomes of this study didn't support my initial hypothesis. They suggest that there is no difference in swelling with the use of soaks in warm water with Epsom salts compared to soaks in warm water alone. This can be explained by the fact that Epsom salt does not act on deep tissues since it does not absorb significantly through the skin (22,39). Even so, their use continues to be very frequent,

possibly because they are considered to be harmless (40). The use of Epsom salts in evidence-based medicine is via a different route of administration. A good example of this is its oral use as a laxative, which is based on scientific evidence (41).

In contrast, the external use of Epsom salts is not supported by scientific evidence. It appears that their use in water soaks for inflammation offers no added benefits over warm water alone and is therefore an additional unnecessary expense.

The present study raises questions about the legitimacy of publicity and the sale of OTC medications that lack independent scientific testing. This is of special concern for low-income patients who could opt for less expensive, less advertised medications. On the other hand, there are also questions about the validity of the use of some traditional and folk remedies that lack scientifically tested efficacy. In my opinion, the "time tested" call of these remedies should change to a "scientifically tested" fact.

In the end, I think it is important to be well informed on treatment options whether they are OTC medications or home remedies in order to be proactive in taking care of your health and to be better prepared to discuss treatment options with your doctor.

MATERIALS AND METHODS

Before the beginning of the study, during the first three weeks after surgery, there were no other interventions other than stitch removal on week two and frequent cleansing of the wound with water and soap as recommended by the doctor. The study started with the collection of the baseline data on week three after surgery, which was the time in the recovery process recommended by the surgeon to start applying topical agents on the scars. One foot (left) was treated with a commercial OTC scar gel, and the other was treated with petroleum jelly three times a day from week three after surgery to approximately six months after surgery. The scar component of the study was conducted for a longer period of time than the swelling component, considering that observational studies of wound healing are usually conducted for at least six months in order to observe scars in a more mature and stable stage (12). Measurements



Figure 7: LesionMeter application. Evgeny Ilyukhin Medical developed this application for smart phones to measure the area of small lesions of the skin. The evaluator takes a photo and "draws" the lesion, which in this case was a scar. A credit card placed next to the lesion is used as a reference to calculate the area that has been demarcated.

Vascularity	Normal	0
	Pink	1
	Red	2
	Purple	3
Pigmentation	Normal	0
	Hypopigmentation	1
	Hyperpigmentation	2
Pliability	Normal	0
	Supple	1
	Yielding	2
	Firm	3
	Ropes	4
Height	Contracture	5
	Flat	0
	<2 mm	1
	2-5 mm	2
	>5 mm	3
Total score		13

The Vancouver Scar Scale Scar characteristic Score

Figure 7: The Vancouver Scar Scale. The Vancouver Scar Scale is a validated scoring method whose reproducibility has been confirmed in numerous scientific studies. It is a visual subjective scoring system that ranges from 0 (normal skin) to 13 (a scar that is disfigured or severely distorts the appearance of the skin).

were made every week for 19 weeks.

Subject and surgical procedure

Subtalar arthroereisis was performed on a 14-year-old female subject in Fundación Santa Fé de Bogotá, Colombia. This technique involved the bilateral insertion of rigid titanium implants between the tarsal bones. The implants used were exactly identical in shape and size, as confirmed by the operating surgeon. The orthopedic surgeon performed similar incisions on both feet: one straight line approximately 4 cm long on the dorsolateral region of each foot just below the lateral malleolus (**Figure 5**). The reported suturing technique used on both sides was layered tissue suturing and subdermal continuous sutures with 4-0 Prolene. There were no reports of complications during this surgery. The plans for the experiments were discussed with the orthopedic surgeon, and even though no negative side effects were predicted, the subject undertook these experiments with fully informed consent as to the possible outcomes and assumed all risks in the approaches undertaken, including the parents' consent as the subject was a minor.

Swelling treatment: Warm water

Treatments began immediately after the initial evaluations were made exactly three weeks postsurgery. Evaluations continued every week for 12 weeks, for a total of 13 measurements, including the initial baseline measurements. The treatment was as follows: the right and left feet were treated with complete soaking in warm water (100°F) for 15 minutes every night for 12 weeks.

Swelling treatment: Warm water with Epsom salts

The warm water for treatment of the left foot and ankle was prepared by adding one ounce of Epsom salts, forming a homogeneous solution. For this purpose, a nonmedical plastic, transparent, square basin with sharp edges was used. The volume of water used was the necessary amount to completely immerse the feet, covering the medial and lateral malleolus: 2 L.

Swelling evaluation: Water displacement volume measurement

For the water displacement volume measurement, the same basin was utilized that was used for foot immersion. This time, it was completely filled with warm water. This receptacle was placed into a larger basin (4 L). The foot to be evaluated was immersed slowly into the smaller basin. The water displaced by the foot fell into the larger receptacle. The foot was not removed until the flux of water stopped completely.

The displaced water was collected in a 500 ml calibrated container and measured by volume (**Figure 6a**). The measurements were always made by the same adult.

Swelling evaluation: Figure of Eight method

The Figure of Eight method was applied, using a soft tape measure marked in both inches and centimeters and following the instructions described in the literature (14,42) (**Figure 6b**). This measurement was always made by the same person (an adult family member and healthcare worker).

Scar treatment: Petroleum jelly and OTC scar treatment

Treatments began immediately after baseline evaluations were made exactly three weeks postsurgery. Evaluations continued every week for 18 weeks, for a total of 19 measurements. The treatments were petroleum jelly (Vaseline®) on the scar of the right foot and a commercial OTC scar treatment gel (Cicatricure®) on the scar of the left foot. The components listed on the tube of this product included water, glycerin, Chamomilla recutita extract, Allium cepa extract, carbomer, and approximately 20 other compounds. The method of applying the products tested was to gently rub a fingertip's worth (no more than 1 ml) of both topical treatments on both sides by the subject with the tip of her index fingers at the same time for five minutes, three times a day.

Scar evaluation: Area measurement

The area of the scar was measured by using a smartphone app (LesionMeter). LesionMeter is an iOS and Android medical app developed by Evgeny Ilyukhin Medical. It is designed to measure the surface area of skin lesions, ulcers, and new growth elements of any shape. The measurement involves selecting the edges of the scar so that the application can calculate the area by placing a standard credit card next to the lesion for scale. The same phone was used during the whole process, and the same person performed all the measurements (**Figure 7**).

Scar evaluation: VSS

On each day that the area of the scar was measured, the VSS (**Figure 8**) was also used by the same observer (an adult family member and healthcare worker). Scar

evaluations were made on the same day as the swelling evaluations but in the morning, whereas the swelling evaluations were performed in the evening.

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