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Enhancing Athletic Recovery: Scar Treatment Using Microneedling, Dermal Fillers, and Lasers

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ABSTRACT

Introduction and purpose: Scars represent a prevalent skin irregularity encountered by a significant portion of the population. Beyond merely impacting physical appearance, they can also contribute to the onset of depression and anxiety disorders, which may hinder athletic recovery. The treatment landscape for scars is diverse, spanning non-invasive to invasive procedures. This literature review endeavors to explore scar management, particularly focusing on methodologies involving microneedling, dermal fillers, and laser interventions. By examining these innovative approaches, we aim to provide insights into their efficacy and implications for clinical practice, with a particular emphasis on facilitating a faster return to sport and optimal athletic performance.

Material and methods: The literature was conducted using "Pub Med" and "Google Scholar" databases with the keywords „scars", „microneedling", „dermal fillers", „lasers"

Brief description of the state of knowledge: Scar therapy using microneedling, dermal fillers, and lasers has shown high effectiveness and significantly improves the lives of patients undergoing treatment.

Results and conclusions: Treating scars using microneedling, dermal fillers, and laser therapy has led to significant enhancements in both physical functioning and psychological well-being among patients with visible scars. These procedures exert their efficacy by promoting collagen synthesis and facilitating skin regeneration, thereby ameliorating skin redness, erythema, and scar tissue formation. However, it's important to note that the effectiveness of these interventions varies depending on factors such as the type and depth of the scar, as well as the age of the patient.

Keywords: scars; microneedling; dermal fillers; lasers

INTRODUCTION

Scars present a multifaceted challenge for a significant portion of the population, extending beyond mere physical appearance to deeply affect psychological well-being. Among the most vexing are acne scars, which afflict nearly 95% of adolescents grappling with acne. Beyond their cosmetic implications, these scars can precipitate feelings of depression and contribute to the onset of various psychiatric disorders [27]. Individuals bearing visible scars often encounter adverse reactions from their social milieu, compounding their emotional distress and potentially precipitating anxiety-related conditions [28]. The process of scar formation is intricate and

protracted, typically arising from traumas, inflammatory responses associated with acne outbreaks, and as sequelae to surgical interventions [1, 2, 3].

Scars manifest in diverse forms, encompassing erythematous, hypertrophic, hypopigmented, low-tension, high-tension, mature, and immature variations [23].

Scar management entails a spectrum of interventions, spanning from non-invasive to invasive modalities, including surgical procedures. This discourse specifically delves into the treatment of various scar types through modalities such as microneedling, dermal fillers containing assorted substances, and laser therapy.

The comprehensive review presented herein draws from a corpus of extant literature, synthesizing insights and evidence to illuminate effective therapeutic approaches.

THE FORMATION PROCESS OF SCARS

The main cause of scar formation is injuries that disrupt the continuity of the skin, reaching deep layers of the dermis. It is a process in which the deficit in the dermis is replaced by fibrous connective tissue. Scars are also often the consequence of medical procedures or complications thereof [1,2].

The primary purpose of scar formation is to protect and restore the proper integrity of the skin. As the skin is the largest organ in the human body, ensuring its proper protection is crucial [3].

The healing of wounds and the formation of scars are divided into phases, each of which plays a significant role in the final scar formation. These phases are:

1. Hemostasis Phase
2. Inflammatory Phase [Figure 1]
3. Proliferative Phase [Figure 2]
4. Remodeling Phase

Each phase has a specific duration, which will be discussed further in the text [3].

The hemostasis phase occurs immediately after the injury. In this stage, bleeding is stopped through the appropriate contraction of blood vessels, platelet aggregation, and clot formation.

The inflammatory phase occurs approximately 1 to 3 days after the injury. It involves the dilation of blood vessels and the "cleansing" of the wound. Phagocytosis of contaminants and bacteria within the damaged area takes place during this phase. Growth factors, chemokines, and interleukins released mainly from blood platelets and damaged keratinocytes play a role in this phase. Migration of immune system cells to the site of damage results in the production of proteinases and reactive oxygen species, aiding in the fight against microorganisms. The growth

factors, cytokines, and interleukins mentioned earlier also condition the proliferative processes. Both of these phases often accompany symptoms such as skin redness, excessive warmth, and swelling at the site of injury [3,4, 5].

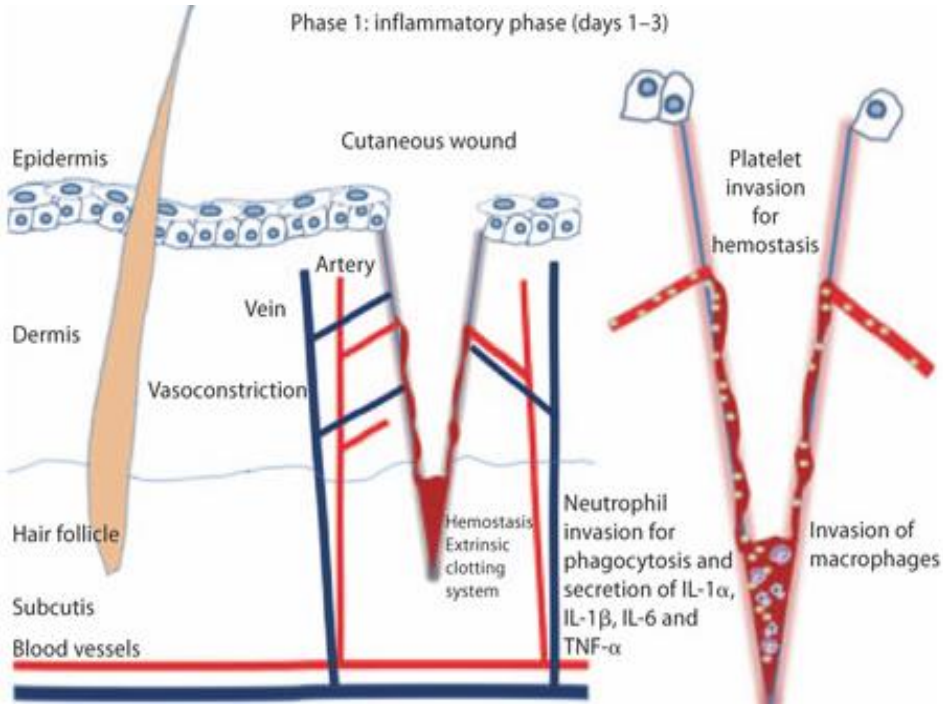

Figure 1. Inflammatory phase [3].

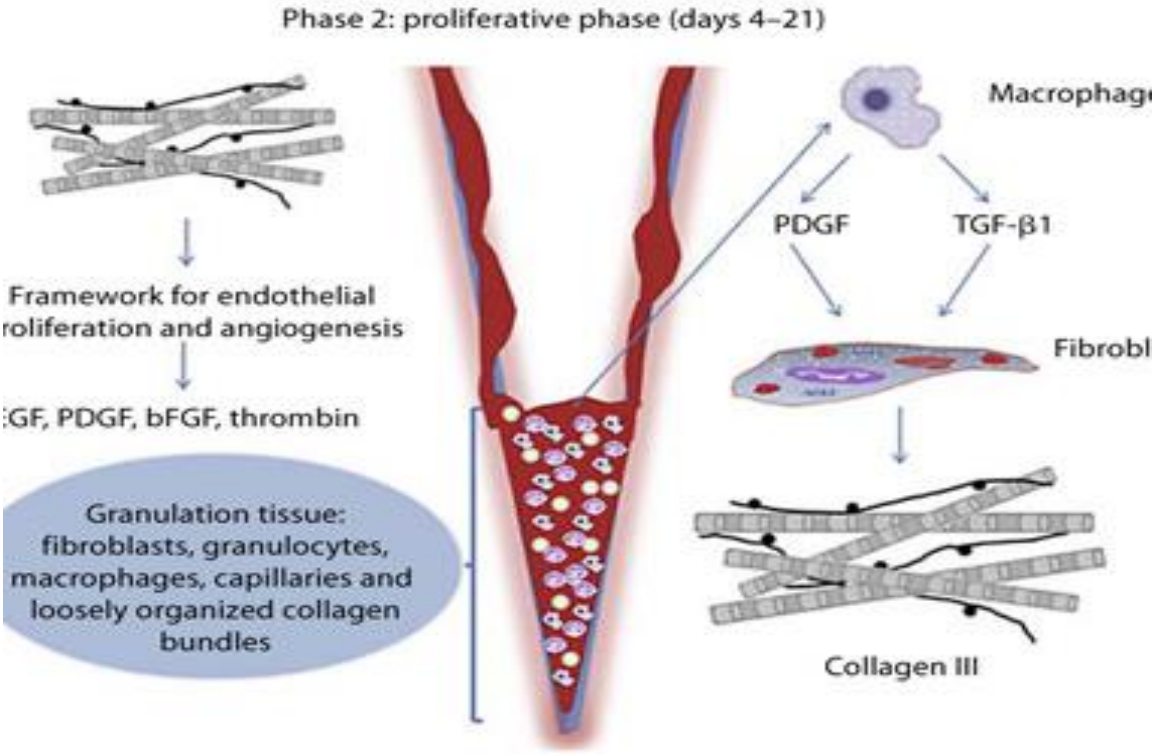

Figure 2. Proliferative phase [3].

The proliferation phase can last up to 3 weeks or longer. During this phase, tissue composed mainly of collagen and other extracellular matrix components forms on the surface of the wound. Fibroblasts play a crucial role in this phase as they migrate to the site of injury, proliferate, and differentiate into myofibroblasts with contractile properties. These myofibroblasts enable wound contraction and the organization of matrix components. Consequently, the repair processes – production of proteins and proteoglycans – significantly exceed their degradation, allowing for the filling of the defect. Over time and as the injury matures, type III collagen is replaced by type I collagen, but its fibers may be improperly arranged, resulting in less stretchable scars [3,4,5].

The remodeling phase is the last and longest stage. It can last for several years. Its aim is to achieve maximum strength and maturity. When this process proceeds correctly, myofibroblasts undergo apoptosis. However, if there are problems with their apoptosis and they remain active, they can cause abnormal scar formation. In this case, excessive tissue growth may occur, characterizing hypertrophic scars and keloids [3,4,5,6].

There are several types of scars. These include:

- Erythematous scars, characterized by a pink or red discoloration of the scar
- Hypertrophic scars, which are raised
- Hypopigmented scars, with white or light discoloration
- Low-tension scars, occurring after incisions, without loss of skin area
- High-tension scars, occurring after loss of skin area, particularly in areas with high tension such as the back, upper chest
- Mature scars, indicating halted growth
- Immature scars, indicating active growth [23].

MICRONEEDLING

Microneedling is a minimally invasive technique used to treat scars and other conditions such as stretch marks, alopecia areata, and many more [7]. This technique involves controlled, repetitive damage to the skin, while mobilizing it for remodeling. Microneedling also facilitates better penetration of substances introduced into the skin after the procedure [7]. Microneedling utilizes sterile micro needles that penetrate the epidermis, creating small openings. This damage provokes the remodeling process, leading to the production of growth factors, collagen, and elastin [8]. There is a wide range of microneedling devices available, categorized based on needle length and diameter. However, devices allowing for the regulation of needle penetration

depth into the skin are most advantageous. This is particularly important for microneedling around the eyes, where the skin is relatively thin, and for microneedling on the back, where the skin is thicker and requires deeper penetration [7]. The greatest interest in microneedling is in the treatment of acne scars, but this does not mean it is limited only to such conditions. Equally effective results are achieved in the treatment of scars from burns, keloids, or other scars [10]. Due to the minimally invasive nature of microneedling, side effects are rare. However, caution should be exercised in patients with active infections, changes of a neoplastic nature, or sensitivity to the products used. The most commonly reported side effects of microneedling are swelling and redness at the injection site. It is worth noting that a single session of microneedling will not yield therapeutic effects. This procedure should be repeated until satisfactory results are achieved [8]. The typical course of treatment usually involves 1 to 6 monthly sessions, with noticeable improvements often seen after an average of 2.5 treatment sessions. During these sessions, patients often experience significant improvements in their condition, reflecting the effectiveness and progressive nature of the treatment. Extensive prospective studies have shown that microneedling led to at least a 50% improvement in all types of scars after an average of 2.5 treatments. Over 80% of patients experienced a 50-75% improvement in their condition [11].

Even more satisfying therapeutic effects in the treatment of scars are achieved by combining mesotherapy with platelet-rich plasma, especially for atrophic scars [18].

DERMAL FILLERS

Fillers are substances injected into the skin aimed at restoring its volume in specific areas and stimulating collagen production. They have wide applications in aesthetic medicine. Their action is most commonly described in relation to acne scars [14].

They can be divided based on the degree of biodegradation - permanent, semi-permanent, and absorbable.

[The most commonly used fillers are absorbable fillers containing stabilized hyaluronic acid (HA). [12]. HA is a polysaccharide that naturally occurs in the human body. It consists of repeating disaccharide units of N-acetylglucosamine and D-glucuronic acid. As a filler, it is produced through a process of biofermentation using bacteria, followed by chemical stabilization (cross-linking). It was approved for use by the Food and Drug Administration (FDA) in 2003.

In addition to its filling effect and ability to bind water, HA stimulates fibroblasts to produce collagen, enhancing its aesthetic effect. Its effect lasts 6-12 months [13,14,17].

A split-face, blind, randomized placebo-controlled clinical trial published in 2022 analyzing the efficacy and safety of hyaluronic acid-based fillers demonstrated their significant effectiveness in treating atrophic scars [19].

Semi-permanent fillers include poly-L-lactic acid and Calcium Hydroxylapatite.

Poly-L-lactic acid is a polymer belonging to aliphatic polyesters. Like HA, it stimulates collagen production by stimulating fibroblasts, while correcting volume loss in the area. The effect lasts about 2 years [14,15,17].

Calcium Hydroxylapatite is present in bones and teeth, contributing to a lesser immune response and better effect. As a filler, it allows for rapid correction of volume loss. It consists of 30% CaHA microspheres with a diameter of 25-45 μm in a 70% aqueous carboxymethylcellulose gel carrier. The advantage of CaHA over hyaluronic acid is its higher viscosity, which reduces the risk of migration, although there is a greater risk of palpable nodules. Its effect lasts for 18 months [14,16,17].

Permanent fillers include polymethylmethacrylate (PMMA), as well as silicone, polyacrylamide, and polyalkylimide.

PMMA, or polymethylmethacrylate, is composed of small particles not absorbed by the human body. It is suspended in a gel solution based on bovine collagen.

Silicone as a filler has not been approved by the FDA.

Polyacrylamide and polyalkylimide currently have no application in scar treatment [14,17]

LASERS

There are many devices based on emitting energy. Different lasers have different wavelengths of laser light, which are absorbed by specific components. Skin chromophores (melanin, hemoglobin, and intracellular or extracellular water) are the light-absorbing components of lasers [23].

Vascular lasers mainly target vessels within the scar, where we can distinguish between Pulsed Dye Laser (PDL) and Potassium-Titanyl-Phosphate (KTP) laser.

The Pulsed Dye Laser (PDL) has a wavelength of 585 nm or 595 nm, which is absorbed by oxyhemoglobin, effectively acting on microcirculation within the scar, reducing redness around it.

Another type of vascular laser is the Potassium-Titanyl-Phosphate (KTP) laser, which acts similarly to the PDL, although the PDL has a significant advantage in the amount of research conducted when comparing these two lasers [20].

Fractional lasers can be divided into ablative and non-ablative types. Ablative fractional lasers (AFL) act on the epidermis and dermis, whereas non-ablative fractional lasers (NAFL) act without affecting the epidermis [21].

Non-ablative lasers cause irreversible protein coagulation by heating the dermis to 50-70 degrees Celsius. Ablative lasers, on the other hand, utilize temperatures above 100 degrees Celsius, resulting in tissue vaporization [23].

Some of the latest studies comparing the efficacy of NAFL and AFL in treating acne scars have shown similar effectiveness of both methods, with NAFL demonstrating fewer side effects [22].

In relation to the action of both lasers, studies have been conducted showing significantly better performance of AFL compared to hypertrophic scars, while NAFL showed better performance in fresh scars with erythematous backgrounds [23].

The selection of the appropriate laser device largely depends on the type of scar. For burn scars, treatments using AFL are particularly useful, effective for both adults and children. Oral administration of corticosteroids may improve scar reduction but requires specialized consultation [23, 24].

In the treatment of hypertrophic scars and keloids, the "laser-assisted topical corticosteroid delivery" method is increasingly being used, which combines laser therapy with corticosteroid administration. The effects of this therapy seem to be satisfactory for patients [23, 25].

Atrophic scars respond well to AFL. This is especially important in the case of acne scars, where fractional laser therapy helps fill in atrophic depressions. Stem cell treatments can be added to AFL procedures to enhance therapeutic effects [23, 26].

DISCUSSION

The last decade has been a breakthrough period in scar treatment. In addition to the methods we have discussed, such as microneedling, skin fillers, and laser devices, there are many other approaches. These include surgical methods involving excision and scar revision, compression therapy, corticosteroid use, cryotherapy, immunosuppressive treatment, and radiotherapy. Selecting the appropriate treatment method should be tailored to both the scar and the patient, which can often pose a therapeutic challenge [29].

Patients with scars face numerous issues, especially when scars are visible, such as on the face. In this regard, there is increasing interest in non-invasive methods, such as scar camouflage with cosmetics. However, this method does not allow for complete scar removal. It is important to remember that proper scar preparation, moisturization, skincare, and the use of vitamin A-containing cosmetics can also expedite the scar removal therapeutic process [30].

Despite the growing interest in scar therapy and the increasing expertise of personnel in this field, problems still persist in some cases. Recent years have shown that the quality of life for patients with scars has significantly improved due to increasingly newer methods used in scar therapy. However, there is still a lack of a specific algorithm that would help tailor the appropriate treatment to the patient and their scar [29].

CONCLUSION

Scars are a common concern affecting a significant portion of the population, including athletes. Aside from their obvious physical appearance, scars can also have profound psychological effects, contributing to depression and other mental health disorders, which may impede an athlete's recovery and delay their return to physical activity.

The process of scar formation is intricate and protracted, typically arising from injuries, inflammatory responses such as those seen in acne, or surgical interventions.

Treating scars involves a wide array of both non-invasive and invasive procedures. Among these, microneedling stands out as a minimally invasive technique that triggers controlled skin damage, prompting the skin to undergo a remodeling process.

Skin fillers, another treatment option, are substances injected into the skin to restore volume in specific areas and stimulate collagen production. They have found extensive use in aesthetic medicine, especially in addressing acne scars.

Laser therapy represents another significant approach to scar treatment, leveraging the energy emitted by lasers to target specific components of the skin, such as pigments and blood vessels.

Despite advancements in scar therapy and the increasing expertise of medical professionals in this field, there remains a need for a standardized approach to tailor treatment to individual patients and their specific scar characteristics. Nonetheless, the overall outlook for scar management continues to improve, offering hope for those grappling with the physical and emotional burdens of scar tissue.

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Conceptualization: KK

Methodology:EHM

Software:EJ

Check: MG

Formal analysis: AP

Investigation: JŚ

Resources: EKC

Data curation: KB

Writing - rough preparation: KK

Writing - review and editing: JŚ

Visualization: IS and KB

Supervision: JŚ and EHM

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