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Optimization of the cosmetic appearance of skin scar after caesarean section — part II physiotherapy practice

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ABSTRACT

Scar formation is a natural part of the healing process after CS. This process, lasting up to two years, depends on the number of factors including type of incision, wound size, the person's age, body weight, health condition, and many others. Abnormal scarring should not be treated only as a cosmetic defect or superficial tissue defects. Functional and anatomical considerations must also be considered. Large varieties of non-invasive treatment modalities have been used to enhance wound healing and scar treatment. The article proposes a comprehensive approach to scar prevention and remodeling. The role of manual techniques, dry needling, cupping therapy, compression therapy, Kinesio taping, and physical agents is highlighted.

Keywords: skin scar; caesarean section; management; physical therapy

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INTRODUCTION

Caesarean section (C-section, CS) is a surgical procedure used to deliver a baby through incisions made in the abdomen and uterus. The goal of physiotherapy interventions after CS in the early post-partum period is optimization of functional recovery after surgery and reducing wound healing complications. Postoperative interventions include breathing and mobility exercises, postural care, incision-related pain reduction strategies (bed mobility and transfers, incision support during coughing, moving, or breastfeeding, reduction of surgical wound tension), and pelvic floor exercises. Patient education about correct posture during activities of daily living or childcare, body mechanics instructions, should be carried out [1–3]. The important part of postoperative care is also scar management. The objective of this care is to prevent of abnormal scar formation, alter the physical and mechanical properties of the scar by influencing the scar maturation process, promoting tissue strength and gliding, preventing adhesions. Equally important are pain, discomfort and sensitivity reduction, and cosmetic outcome improvement [4]. The article proposes a comprehensive approach to scar prevention and remodeling. Physical therapists within their scope of practice have a wide variety of non-invasive or minimally invasive treatment options. The role of manual techniques, dry needling, cupping therapy, compression therapy, kinesio taping, and physical agents is highlighted.

SCAR FROM THE PERSPECTIVE OF FASCIAL MODELS

The C-section scar covers the skin, subcutaneous tissue, superficial and deep fascia. Adhesions to healing tissues reduce their extensibility and mobility. The contracted CS scar is most often perceived by patient as a cosmetic defect. However, disorders associated with them may affect deeper anatomical structures, including the musculoskeletal system. The relationship between the presence of scars and pain can be explained based on fascial models: biotensegretive model, fascintegretive model, and myofascial chains. The fascia is an uninterrupted, three-dimensional body-wide web, from the cellular to the organ level. This endless network includes epidermis, dermis, fat, blood, lymph, blood,

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and lymphatic vessels, tissue covering the nervous filaments, voluntary striated muscle fibres and the tissue covering and permeating it, ligaments, tendons, aponeurosis, cartilage, bones, and meninges. The fascia has a high density of nerve endings belonging to the sympathetic, and various sensory receptors for proprioception, nociception, and hormones. Is capable of responding to stimuli. Due to contraction of fibroblasts and myofibroblasts fascia is able to change tension state which has an impact on muscle dynamics, range of motion, and postural patterns [5–8].

According to the biotensegretive model, and the fascintegretive model the fascia and body fluids prevent damage or deformation of the integrity of the body structure and function by transmission of mechanical tension. The equilibrium between constant mechanical tension and non-constant compression is maintained by tension transmission. The fascial connections are not accidental. They are organised in functional systems that maintain the stability and balance of the body. They are called myofascial chains. Many models of myofascial chains have been presented, but according to Wilke et al. [9] there is evidence for only three myofascial chains. The superficial backline (plantar fascia, gastrocnemius, hamstrings, erector spinae), the back functional line (latissimus dorsi, contralateral gluteus maximus, vastus lateralis) and the front functional line (adductor longus, contralateral rectus abdominis, pectoralis major) (Fig. 1). The myofascial chains approach, which stands in opposition to the single muscle theory, has its supporters and opponents. It might help explain the phenomenon of referred pain [5–8, 10].

The fascia can become strained during wound healing after CS. The ability of transferring forces during movement and tissue gliding may be disturbed. Postoperative adhesions and fascia restrictions can cause disorders of the digestive system, such as meteorism, irregular bowel movements, chronic abdominal pain, digestive disorders, and intestinal obstruction. Menorrhagia, lower abdominal pain, dyspareunia and dysmenorrhea, endometriosis, and pelvic pain are also mentioned [9].

Abdominal fascial connections with other areas of the body (chest, spine, lower limbs) can transfer tension and cause pain syndromes in other places, far from the scar. The thoracolumbar fascia (TLF) along the lateral border meets aponeurosis of the transversus abdominis, creating a connection between the abdominal and paraspinal muscles. The TLF plays an important role in posture, load transfer and respiration, as does the transversus abdominis muscle (TrA) in stability of the lumbar spine. Some studies show that TrA contraction results in tension across the TLF, increasing resistance to spine flexion [11]. The distal rectus abdominis sheath and the pyramidalis muscle have a direct anatomical connection with the gracilis and adductor longus muscle

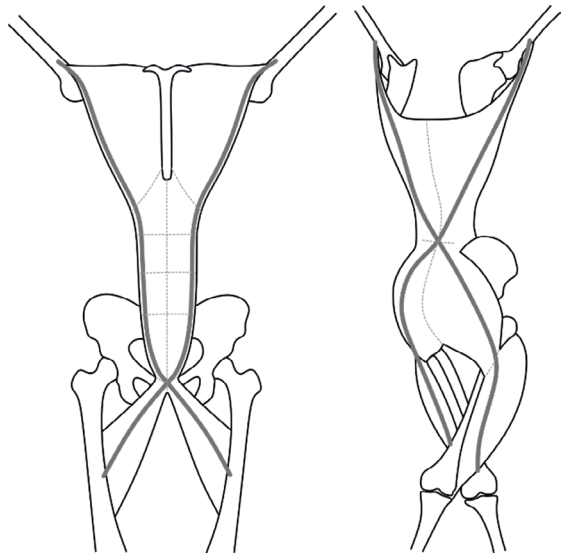

Figure 1. Myofascial chains (the front functional line, the back functional line)

[12, 13] (Fig. 1). This relationship is important to distribute forces between the trunk and the lower limbs (in statics and dynamics, *e.g.* gait). An alteration of the loads can lead to pubalgy, back pain, or knee pain [9, 12].

Scars, similar to fascia, can be reactive to mechanical forces include stretching tension, shear force, scratching, compression, hydrostatic pressure, and osmotic pressure. Hypertrophic scars might be caused by abnormal mechanical wound tension. During the wound healing process myofibroblasts are responsible for the synthesis and deposition of extracellular matrix components. In an abnormal environment, mechanical forces increase myofibroblast activity and result in increased scar formation [14, 15]. The lower abdomen and suprapubic skin regions are stretched many times during everyday physical activities, therefore, scars after CS may be exposed to excessive tension and pathological scarring.

Scars have been recognized as a source of chronic pain, due to peripheral sensitization or central sensitization [13]. Chronic pain after CS is defined as pain that lasts more than 3 months after surgery. The incidence of chronic pain ranges from 4% to 41.8% [16], usually within the range of 20–30% [17–19]. Pain intensity is mild or moderate at rest, increasing to severe with movement [17, 19].

SCAR ASSESSMENT

Evaluation of the wound healing process after CS should always be carried out in the hospital after dressing removal, and after discharge from the hospital, in the period between 4–8 weeks after surgery. Optimal in the sixth week. The scar maturation should also be evaluated to prevent abnormal scar formation [4].

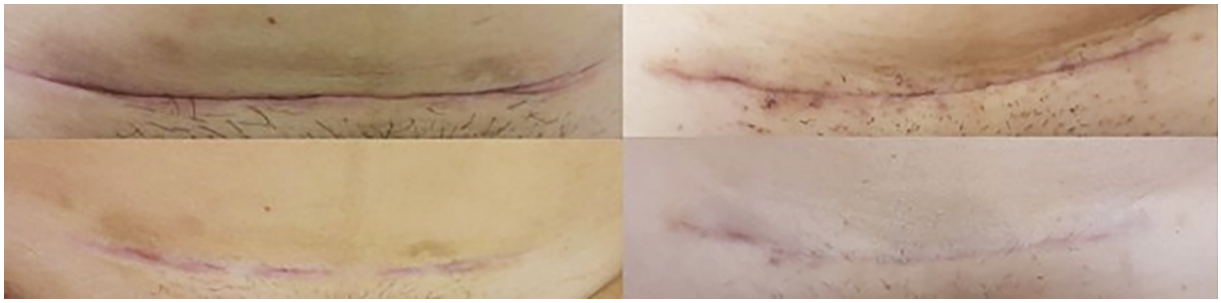

Figure 2. Stages of healing of the linear caesarean section (CS) scar (from the authors' own archives, reprinted with the patient's permission)

The Vancouver Scar Scale (VSS), Manchester Scar Scale (MSS), Patient and Observer Scar Assessment Scale (POSAS), Visual Analogue Scale (VAS), and Stony Brook Scar Evaluation Scale (SBSES) are the most commonly used scar assessment scales. These observer-dependent scales consider factors such as scar height or thickness, pliability, surface area, texture, pigmentation, and vascularity. Vancouver Scar Scale and POSAS are the most widely used. SBSES is used to measure short-term cosmetic wound outcomes (5 to 10 days after injury) [20–22]. The Japan Scar Workshop Scar Scale was created for assess keloids and hypertrophic scars [23]. In 2018 the patient-reported SCAR-Q outcome measure was designed. This scale measures scar appearance, scar symptoms, and psychosocial impact [24].

There is no standard for the assessment of postsurgical scars used in rehabilitation. Vercelli et al. [21] recommended the Patient and Observer Scar Assessment Scale and the Patient-Reported Impact of Scars Measure. Usually, the assessment includes:

— wound healing, scar maturation (complications, uncontrolled scar growth) (Fig. 2);
— scar variables: height, thickness, pliability, adherence, restriction of scar mobility with respect to underlying tissue;
— soft tissue restriction;
— the impact of the scar on posture and movement, pain in static and dynamic assessment;
— skin sensory disruption or damage [19–21].

SCAR PREVENTION

The process of proper wound healing after CS depends on factors related to the patient's health status, proper wound care, and factors that are independent of the patient (CS technique, duration of the procedure, postoperative care). The C-section scar is a linear scar with moderate risk of wound dehiscence and higher risk of wound infection due to the location of the incision. In the case of a transverse abdominal incision in accordance with the skin tension line (the Pfannenstiel incision, the Joel-Cohen incision), the risk of excessive scar formation is lower (Fig. 2). Vertical incision

Figure 3. Caesarean section (CS) scar — vertical incision (from the authors' own archives, reprinted with the patient's permission)

is more often associated with postoperative wound dehiscence, postoperative hernia development, and formation of scar contractures (Fig. 3) [25]. Infected, hard-to- healing wounds requiring re-suturing can also lead to the formation of contracted scars with poor cosmetic outcome (Fig. 4). Surgical site infection (SSI) occurs within 30 days after CS with a reported incidence of 3–15%, usually postoperative days 4–7. The risk of SSI is higher in obese patients, and in the case of emergency CS [26].

Prevention of excessive scarring should be introduced before, during, and after surgery. Wolder et al. [25] present pre-, intra- and postoperative procedures aimed at optimization of the cosmetic appearance of the skin scar after CS. Special attention in postoperative care should be paid to high-risk patients after emergency CS, classical CS with vertical incision for laparotomy, obese patients and patients with a history of abnormal scarring.

Figure 4. Contracted caesarean section (CS) scar after surgical site infection (SSI), wound dehiscence and re-suturing (from the authors' own archives, reprinted with the patient's permission)

The most important prevention methods after wound closure are to reduce the risk of infection, relieve tension, minimize excessive mechanical forces, and properly hydrate by occlusion, which is the basis of the action of scar management products (Tab. 1) [4, 27]. According to international clinical recommendations silicone-based products should be considered as the first-line prophylaxis method for linear scar, and the first-line therapy method for linear hypertrophic scar [4, 27, 28]. Silicone-based products: creams, oils, gels, patches, or sheets are widely used in clinical practice. They inhibit the transepidermal loss of water and ensure sufficient hydration of the skin. A thin layer of cream, oil, and gel can be easily removed from the scar surface by rubbing. Therefore, in the case of CS scar, due to the location of the incision (lower abdomen, covered with underwear and clothes), silicone gel sheets are a better choice. Silicone gel sheeting is a soft and flexible wound dressing that contains an elastic form of silicone. It should be used soon after wound healing, when the incision has fully epithelialized. Sheets or patches should be applied to the washed and dry area of CS scar for 12 to 24 hours per day, with twice a day skin washing. According to the manufacturer's instructions, one patch can be used for up to 3–5 days. Silicone-based products are used prophylactically for one month. If necessary, this period can be extended to six months or even longer [4, 27–29].

In addition to silicone-based products, products containing botanical agents, such as onion extract, are also used to scar prevention and treatment. It has anti-inflammatory, antimicrobial, antiproliferative, and regenerative potential. Products with onion extract (ointments, gels, patches, or sheets) often also contain allantoin or heparin [30, 31]. The results of most studies indicate that onion extract products had a similar effect with silicon-based products [31–33]. According to Song et al. [32] silicone gel and onion extract gel had similar compliance, side effects, and efficacy in the treatment of laparoscopic surgical scars.

SCAR MANAGEMENT

Clinical guidelines for care in uncomplicated and disturbed wound healing are clear, and widely known, while strict guidelines for physiotherapy treatment have not yet been developed. Probably the reason for the lack of guidelines is the fact that physiotherapy is usually used as an optional, adjuvant therapy. The aim of physiotherapy is to control and treat problematic scarring, improve cosmetic outcome, reduce pain, discomfort and sensitivity, change the physical and mechanical properties of the scar and promote tissue remodeling [34, 35]. Physiotherapy in scar management can involve a number of different non-invasive treatments and preventive approaches usually divided into manual therapy (to manipulate the scar and other tissues), and physical agents (to influence the progression of inflammation and tissue repair) (Tab. 1) The selection of physiotherapy methods depends on the course of wound healing and scar maturation process (Tab. 2). In the case of normal wound healing process, proactive management is implemented, named by Fernández-Guarino et al. [36] "assisting with well-scaring". Physiotherapy can be implemented from the moment of wound closure until the formation of a mature scar. The initial treatment methods focus on the area around the scar. Low impact physical agents or manual techniques like lymphatic drainage are used (Tab. 2). After complete wound healing scar therapy might be started.

The approach to scar physiotherapy has changed with understanding of cell biology and biochemistry. A new term "mechanotherapy" was proposed to describe the intentional use of therapeutic mechanical load to stimulate tissue repair

Table 1. Methods of treatment and prevention of excessive scar formation

Early scarring prevention	Physiotherapy management
Optimal surgical technique and wound care Proper hygiene Wound tension relief Appropriate time of suture removal Reduction of mechanical forces- appropriate ways of changing body position, without tensing the abdominal muscles, stabilizing the wound during activities that activate the abdominal pressure (coughing, sneezing, laughing, pushing) Evaluation of the wound healing process (4–8 weeks after surgery) Use silicone-based products or onion extract products Avoiding exposure to sunlight Use sunscreens with a protection Factor > 50 until the scar has matured	Manual techniques (massage, myofascial release, soft tissue release, trigger point release, lymph drainage, active release techniques) Instrument assisted soft tissue mobilization Dry needling Cupping therapy Vacuum massage Compression therapy Kinesio taping Physical agents (electrotherapy, ultrasound therapy, polarized light, LASER, Low Hz magnetic fields, high Hz electromagnetic fields, radiofrequency, deep oscillation, shockwave therapy)

Table 2. Caesarean section (CS) scar management

	Aim	Area	Modalities
1st–7th day	Healing stimulation, reduction of pain and swelling	Around the scar	Lymph drainage Kinesio taping — lymphatic application (edema, bruises) Non-contact physical factors (low intensive laser, polarized light) Patient education — wound care, bed mobility and out of bed transfers, incision support during coughing or breastfeeding and reducing of surgical wound tension Patient education regarding correct posture during activities of daily living or childcare, body mechanics Proper hygiene and wound care Wound healing process evaluation
2nd–6th week	Early prevention, minimization of infection, reducing tension, reducing pain	Area around the scar/scar	In the case of healing disorders — the use of physical factors (laser, polarized light, pulsed current) With proper healing: desensitization to the scar Silicone gel patch Pressure Kinesio taping Patient education — scar treatment, self-massage Proper hygiene and wound care Wound healing process evaluation
After 6th week	Reducing tension, reducing pain, increase elasticity	Scar	Manual therapy on the tissues surrounding the scar and on the scar itself to improve blood supply and mobility Pharmacological treatment in this phase (ointments and gels dedicated to the treatment of scars) Kinesio taping Silicone gel patch Pressure Cupping Dry needling Physical factors (ultrasound therapy/low energy laser/polarized light/ES/electromagnetic fields high frequency/SWT) UV protection

ES — electrotherapy stimulation; SWT — shockwave therapy; UV — ultraviolet

and remodeling. Mechanical stress may be recognized by skin cells (endothelial cells, fibroblasts, and myofibroblasts). Mechanoresponsive fibroblasts play an important role during granulation tissue formation. They respond to tension by proliferating and through increased expression of collagen, α-smooth muscle actin, and cytokines. It may result in excessive scar formation. This process by which mechanical stress influences cellular behaviour is called mechanotransduction. The mechanotransduction theory forms the basis of many non-invasive physical therapy methods, including manual techniques, instrument assisted soft tissue mobilization, dry needling, Kinesio taping, compression therapy, or vacuum massage. According to this theory, moderate scar tissue stretch during therapy may down-regulate hypertrophy and scar retraction [34, 37]. Physical agents also play an important role in scar therapy. The application of physical agents results in the modification of tissue inflammation and healing, changing circulation rates, altering cell

Figure 5. Dry needling of caesarean section (CS) scar (from the authors' own archives, reprinted with the patient's permission)

function (membrane permeability and transport, cell chemical reactions), altering of collagen extensibility, alleviating pain or altering muscle tone [36].

Manual techniques

Manual techniques involve myofascial release, soft tissue release, trigger point release, massage, lymph drainage, scar mobilization, skin rolling, punctual crushing, and many other techniques. A special type of manual technique is instrument assisted soft tissue mobilization allowing deeper tissue penetration. This intervention includes the use of specialized tools to manipulate the skin, and scar with the appropriate amount of pressure. Regardless of schools or methods these techniques involve mechanical stimulation of tissues, using appropriate grips and manipulations (a combination of pulling, pressing and lifting) adjusted in terms of strength and direction. Manual techniques are used to restore tissue and fascia gliding, restore the elastic properties of the tissue, increase blood flow to promote healing, and increase sensation. They are used to improve skin flexibility, reduce adhesions and itching, and reduce pain [35, 38]. By releasing adhesions, they can be used to reduce of postnatal abdominal protrusion (the "c-section pouch").

The manual technique depends on the inflammation status of the scar, which can be assessed by vitropressure test. This test is based on observation of skin color after local pressure on the scar. Active, immature scar turns white under pressure (positive test), while stable, mature scar does not change. Color recovery time is also assessed in the test [39]. According to Koller [40] mechanical forces during manual therapy must be adapted to the scar condition, because overloading the tissue can induce a new inflammatory reaction. The author recommended a slight stretching (in the area of the first remarkable increase in connective tissue resistance in the proliferation phase; until the second remarkable increase in connective tissue resistance, in the remodulation phase), adapted to the respective wound healing phase and with intermittent oscillation (0.2 Hz) at the end of the respective amplitude. Optimal application times are one minute per localization, three to five times per therapy unit, and two therapy units per day. Manual scar tissue therapy includes so many techniques, used under different conditions that it is difficult to compare the results of clinical trials. The results of research indicate positive effects on scar elasticity, thickness, regularity, color and mobility [35, 38, 41], and pain reduction [35, 41, 42].

Dry-needling, cupping therapy, vacuum massage

Superficial dry needling is a minimally invasive method in scar treatment. It involves inserting the sterile needle up to 10 mm into the subcutaneous tissue, which reduced the risk of tissue trauma (Fig. 5). Needles could be placed along the entire scar spaced 0.5–1.0 cm from each other or only in the place of restriction. Treatment should be performed once or twice a week. Dry needling may be an effective method to treat scars, but it has low to moderate quality evidence. The probable mechanism of action is based on suppression of systemic and local inflammation, stimulation of epithelialization, and reduction of scar formation [35, 43].

Dry-needling scar therapy can begin after complete wound healing, the same as cupping therapy. Dry cupping therapy is a non-invasive technique that uses glass, rubber, or silicone cups placed over the skin to create negative pressure through suction. The cup can be placed at one point of the scar or after applying of massage oils, can be slide performing a deep tissue massage (sliding cupping). The variation of this technique is vacuum massage performed with a mechanical device. Suction affected by cup, promotes peripheral blood circulation, improves tissue elasticity and laxity, increases pain thresholds, improves local anaerobic metabolism, and reduces inflammation. Therapy should be used with caution because too much negative pressure can induce microtraumatic injures [35, 44].

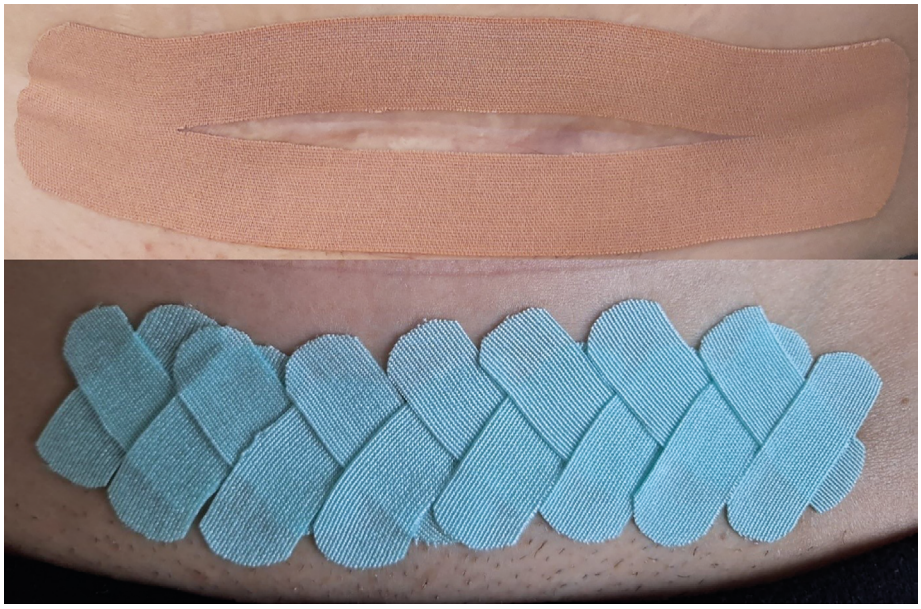

Figure 6. Caesarean section (CS) scar kinesio taping application (from the authors' own archives, reprinted with the patient's permission)

Compression therapy, Kinesio taping

According to the guidelines, compression therapy is one of the components of scar prevention and scar management in the case of linear hypertrophic scars, widespread hypertrophic scars, and keloids. It is used to reduce external mechanical stimuli during wound healing or scarring. Prolonged pressure causes hypoxia and reduces microvascularization, increases dermal fibroblast apoptosis, and changes the orientation of collagen fibers. Flexible materials such as tape, bandages, and garments are used after wound closure, as early as possible, before two months after surgery. Silicone gel sheeting through the scar stabilization effect can be considered a form of compression therapy. Evidence suggests that compression therapy improves scar color, thickness, pain and scar quality in general [27, 28, 45]. This type of therapy may be considered after CS in the case of vertical incision or history of abnormal scarring. Compression belts, shorts, or pants can be used for this scar location. The preventive use of compression belts is not recommended because they increase intra-abdominal pressure and strain the pelvic floor muscles.

Kinesio taping can also be considered as a form of compression. In this method elastic tape is applied to the patient's skin with varying degrees of stretch. For scar management application, a stretch of 25–50% is most often performed, and direction of application at an angle of 45 degrees to the scar line (Fig. 6). The tape applied to skin reduces the tensile forces acting on the scar, reduces the oversensitivity of the skin, and correct the position of the fasciae and skin [46, 47]. A new technique for tension-reducing tape was proposed by van Daele et al. [48]. The tape is applied around the scar tissue, approximating the scarred skin from the ends towards the middle, horizontally as well as vertically (Fig. 6). Although according to O'Reilly et al. [47] the occlusive nature of stretch tapes offers increased scar hydration, more research is needed to assess their effectiveness.

Physical modalities

Physical medicine is a part of medical care that offers the impact of parameterized external factors on the multidimensional healing of CS wounds, as highlighted in studies [36, 49]. In clinical management, it adapts different physical modalities (temperature, ultrasound, electromagnetic field, current, and mechanical forces) to achieve the required therapeutic effect depending on the acute or chronic phase of wound healing and scar formation.

Electrotherapy stimulation (ES) is used in pain management and wound healing, including chronic and acute wounds. In the inflammatory phase, electrotherapy increases blood flow, and tissue oxygenation, stimulates fibroblasts whilst reducing oedema and providing an increased antibacterial effect. In the proliferative phase increases membrane transport, collagen matrix organization, wound contraction and the stimulation of DNA and protein synthesis. During the remodeling phase epidermal cell proliferation, and migration are increased, as well as fibroblasts stimulation enabling improved wound closure. Electrotherapy can also reduce inflammation and the risk of infection. In vitro studies have shown a reduction in the number of Staphylococcus aureus, Pseudomonas aeruginosa, and Escherichia coli with ET. Positive ET results have been reported in the reduction of wound area [50, 51].

The therapeutic current flow depends on the voltage applied, the intensity of the constant or pulsed mode, and the duration of use. Several different electrical modalities and waveforms are recommended including direct current (DC), alternating current (AC), high voltage pulsed current (HVPC), and micro current (MC). One of the most well-known types of ES is transcutaneous electrical nerve stimulation (TENS), which is often used for pain control [50]. High-voltage pulsed current electrical stimulation (HVPC) supports wound healing in acute and chronic stages. In the first stage HVPC uses a cathode as the active electrode to promote the growth of granulation tissue. It has antibacterial properties and stimulates fibroblasts proliferation. Affects the shrinkage of the wound ages. In the second stage, the anode, as the active electrode, accelerates granulation, has an analgesic effect, and increases the tensile strength [52]. Microcurrents (MC) deliver current intensities of microamps (μA) so that are better tolerated during therapy, as they remain below the sensitivity threshold without reaching the depolarization of nerve fibres. The endogenous electric fields generated during natural wound healing, which affect cell migration and epithelial wounds healing, are in the order of microcurrents [53, 54]. Direct current (galvanic, ionophoresis) involves stimulating cell migration, increasing the rate of cell proliferation, and the secretion of growth factors by generating an electric current. The anode attracts macrophages, neutrophils. The cathode attracts activated keratinocytes, neutrophils, fibroblasts, myofibroblasts, and endothelial cells [55]. External electrical stimulation in the form of a stretchable bioelectric patch is being tested recently [56].

The Low-Level LASER Therapy (LLLT) is a non-invasive and painless medical treatment. The light energy is absorbed by mitochondria, leading to a cascade of biochemical reactions that promote cell growth, repair, and regeneration. The Low-Level LASER Therapy stimulates fibroblasts, to synthesize more collagen and improves the quality and quantity of scar tissue. The greatest benefits are achieved through a wavelength of 632–1000 nm. The result of the therapy action includes wound contraction and scar reduction [36, 50]. The Low-Level LASER Therapy can also modulate the immune system and reduce levels of pro-inflammatory cytokines such as IL-1 and TNF alpha. LASER increases angiogenesis and improves microcirculation. Coherent stimulation release of endorphins and reduce nerve excitability and sensitivity, which relieves pain and itching associated with hypertrophic scars or keloids [57, 58].

Light-emitting diode (LED) therapy based on wave length 630 nm red range or 830 nm infrared range accelerates the wound healing process by increasing the number of fibroblasts and collagen and decreasing the number of inflammatory cells in the wound site [57].

Photodynamic therapy (PDT) has also been shown to be effective in wound healing. However, it seems to show the best results when used in conjunction with LASERS [57].

The effect of **ultraviolet therapy (UV)** on wound healing seems not promising and may even delay the process as it has been shown to affect dynamics of focal adhesion. On the other hand, ultraviolet range C (UVC) can be beneficial in expediting wound healing with antibacterial effects [56–58].

Pulsed radiofrequency energy also promotes chronic wound healing by shrinking wounds and reducing wound pain. Radiofrequency (RF) therapies involve the use of a high-frequency electromagnetic field (3 kHz and 300 GHz) that induces oscillations and friction in tissue molecules, which increases the temperature. This may cause collagen degradation, which stimulates neocollagenogenesis and tissue remodeling. Many studies emphasize the pain relief and effectiveness of RF in the treatment of wound healing. RF technology is combined with new micro needling devices and fractionated delivery to improve the effectiveness of the scar treatment [50, 59].

Radiofrequency Electric current (RFEC), Capacitive Resistive Electric Transfer (CRET) (note that this is the English translation from Spanish and Italian TECAR). Capacitive Resistive Electric Transfer is a therapeutic modality of diathermy using high-frequency currents in the range of 300 kHz to 1 MHz. Under the influence of a high Hz alternating electromagnetic field, endogenous heat is generated in tissues depending on their dielectric properties and mode of energy transfer. The capacitive mode is used for tissues with higher electrolyte content (soft tissues and muscles) and the resistive mode affects tissues with higher resistance (joints, bones, tendons). The range of frequency 448 kHz delivers a sub-thermal treatment and the energy applied does not increase the local tissue temperature, which promotes stem cells stimulation for tissue regeneration and wound healing [60, 61].

Shockwave therapy (SWT) has proven to be beneficial in overcoming chronic and intractable wounds with minimal adverse effects and long-lasting results. SWT shows a significant improvement in the appearance of keloids with mismatch color, greater flattening, softer texture, and greater elasticity. Moreover, SWT results in a significant reduction of collagen fibres and an increase in the level of the matrix metalloproteinase-13 degrading enzyme [62, 63].

Low frequency pulsed electromagnetic fields can accelerate wound healing, generating connective tissue, enhancing the production of type I collagen [50].

Ultrasound therapy (UT) is based on sound waves that cause thermal and non-thermal effects in tissues such as increasing blood flow, promoting collagen synthesis and soft tissue regeneration. Additionally UT has anti-inflammatory properties. Ultrasound therapy accelerates wound

area reduction and is approved as an adjuvant therapy. Ultrasound therapy combined with substances input into the skin (ointments, gels with onion extract) has a softening and stretching effect on the scars [36].

Deep oscillation is based on the transformation of an electrostatic field into kinetic energy modulated over a range of frequencies (5–250 Hz) which produces resonant vibrations deep in the tissues, also known as tissue oscillation. The vibrations cause movement of inter-tissue fluids so that inter-tissue compression can be reduced, nutrients delivered, and metabolic debris removed. This action reduces swelling and improves tissue trophism at many layers, which aids tissue healing and scar formation. Due to its non-invasive action the therapy could be performed in the remodeling phase of CS scars but there is no available research on its use [63].

CONCLUSIONS

Caesarean section is the most frequently performed obstetric surgery. The wound healing and scar formation processes after CS take up to two years. Abnormal scars: contracture, hypertrophic, atrophic, keloid scars can occur after four weeks, up to months after surgery in approximately 15% of wound cases [4]. Excessive scars should not only be considered an aesthetic problem. Its consequences may affect other structures, tissues, and systems of the body, reducing the quality of life in physical, mental, and social domains.

Scar treatment requires a multiple approach. Physiotherapy modalities play an important role in healing promotion, scarring prevention, and treatment. They are based on recent scientific evidence according to the principles of mechanotransduction and mechanomodulation. They are considered minimally- or non-invasive, and low-cost methods. Many physical management techniques still have limited data to support their use. Therefore future randomized, controlled trials are needed to confirm their effectiveness, and to establish guidelines for interventions.

Article information and declarations

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Conflict of interest

The authors declare no conflict of interest.

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