Treating scars with lasers: everything you need to know

In this article, Samantha Hills explains the benefits of treating various types of scars with different lasers, as well as the additional modalities for scar treatment

The formation of scar tissue is a natural bodily response to a dermal injury (Alster and Handrick, 2000). With most deep wounds, there will be some degree of scar formation, and a variety of different scars can develop following surgery, trauma and cutaneous inflammatory processes (English and Shenefelt, 1999).

Scars are not harmful and do not require removal for medical reasons. However, they can be painful, itchy, limiting and have a significant effect on a person psychologically, prompting patients to seek treatment (Khatri et al, 2011). With the laser and light-based technologies available today, increasing evidence demonstrates the efficacy of these treatments in improving different varieties of scars, including keloid, hypertrophic, atrophic and acne scars (English and Shenefelt, 1999).

Types of lasers

Laser scar therapy uses photothermal energy to target intra- and extra-cellular structures within the scar tissue to improve the colour, and also stimulate the process of neo-collagenesis and dermal remodelling (Rumsey et al, 2003; Manstein et al, 2004; Hantash and Mahmood, 2007). It is rare that a scar can be removed completely using these methods; instead, the aim is to reduce the appearance of scars, as well as any discomfort caused mentally, physically and cosmetically.

Various types of lasers have been used in the treatment of scars for a number of years, including carbon dioxide (CO_2), neodymium-doped yttrium aluminum garnet (Nd:YAG), pulse dye and erbium-doped yttrium aluminium garnet (Er:YAG) lasers (Niwa et al, 2009). Lasers are chosen based on the severity of the scar and patient skin type and work according to the theory of selective photothermolysis (Anderson and Parrish, 1983). Most recently, fractional photothermolysis with ablative and non-ablative fractionated lasers have found use as effective treatments for scars (English and Shenefelt, 1999).

The differences between ablative and non-ablative lasers, as well as fractional and non-fractional delivery, are based on the fundamental process of absorption by the target chromophore and how the energy is delivered to the target area. Ablative lasers are highly absorbed by water and cause the removal of material from the surface of skin by vaporisation. In comparison, non-ablative lasers do not reach temperatures in the tissue to induce vaporisation and, as such, do not remove material, instead causing a controlled zone of thermal damage through epidermal and dermal heating (Alster et al, 2007). Both non-ablative and ablative lasers can then be administered via a fractional delivery system, meaning that the laser beam is divided into an array of microscopic laser beams much smaller in size than the original full beam (*Figure 1*). This fractional delivery can be produced in a number of ways, most commonly via a micro-lens array or a fractional scanner.

Types of scars

A main distinction between scar tissue and normal skin is the amount of collagen that it contains and the manner in which the collagen fibres are produced. The elongated collagen fibres are well arranged in normal skin. On the other hand, the structure of collagen fibres in scars is disorganised and markedly different from the normal surrounding tissue. The collagen fibres become more tightly packed and more resistant to elimination by the natural enzymes released by the body as the scar ages.

The degree of scarring, including the size and depth of the wound, the blood supply to the region, the thickness and colour of the skin and the direction of the scar, can be influenced by several variables. The age of individuals also significantly influences the development of scars. For example, younger skin appears to over-heal, resulting in bigger, darker scars compared to older skin. Additionally, the location on the body where the wound takes place can impact the appearance of the scar, with the sternum being particularly prone to scar formation. Excessive pulling or tension across a healing wound is a factor that may increase inflammation and scar formation, and if healing is

SAMANTHA HILLS

Clinical director, Lynton Lasers
e: info@lynton.co.uk

AdobeStock/Anna

The degree of scarring is influenced by several variables, including the depth of the wound, the thickness and colour of the skin and the direction of the scar

delayed—for example, due to infection—this will increase the risk of build-up of connective fibrous tissue, resulting in an increased likelihood of scarring.

There are numerous types of scars encountered when treating patients, the most common being atrophic, keloid and hypertrophic scars. Acne scars are also common and can present in a number of different ways.

Atrophic scars

Atrophic scars can occur anywhere on the body, and generally present as an indented scar that heals below the normal layer of skin tissue. The scar may be irregular, with jagged edges and a pitted, sunken appearance. Atrophic scars form when the skin is unable to regenerate tissue. Atrophic scars often appear after severe acne, chickenpox, surgery or accidents that cause underlying trauma to the area.

Keloid scars

Keloid scars are abnormal scars that grow beyond the boundaries of the original injury, resulting from excess collagen at the injury site. They are generally pink to purple in colour or may display hyperpigmentation. In some cases, extra scar tissue grows, forming smooth, hard growths. Often, keloid scars can be much larger than the original wound. The most common areas where keloids form is the anterior chest, shoulders, ear lobes, cheeks and skin overlying joints. Patients will often feel itching, hyperesthesia and pain. Despite the broad range of modalities available to treat scars, the treatment of keloid scars remains a challenging clinical dilemma for both patients and practitioners. Studies have shown that keloid formation can be prevented if anticipated with immediate silicone elastomer sheeting, taping to reduce skin tension, or corticosteroid injections (Tidwell et al, 2016). Cryotherapy may be useful, but it should be reserved for smaller lesions (Juckett and Hartman-Adams, 2009).

Surgical removal of keloids can pose a high risk of recurrence unless combined with one or several modalities, such as silicone elastomer sheeting—a non-invasive but time-intensive, first line option for the treatment of keloids and hypertrophic scars (Berman et al, 2007).

Hypertrophic scars

Hypertrophic scars are widened scars, usually raised and dark in colour, although, unlike a keloid scar, they remain

Andrew Bezear

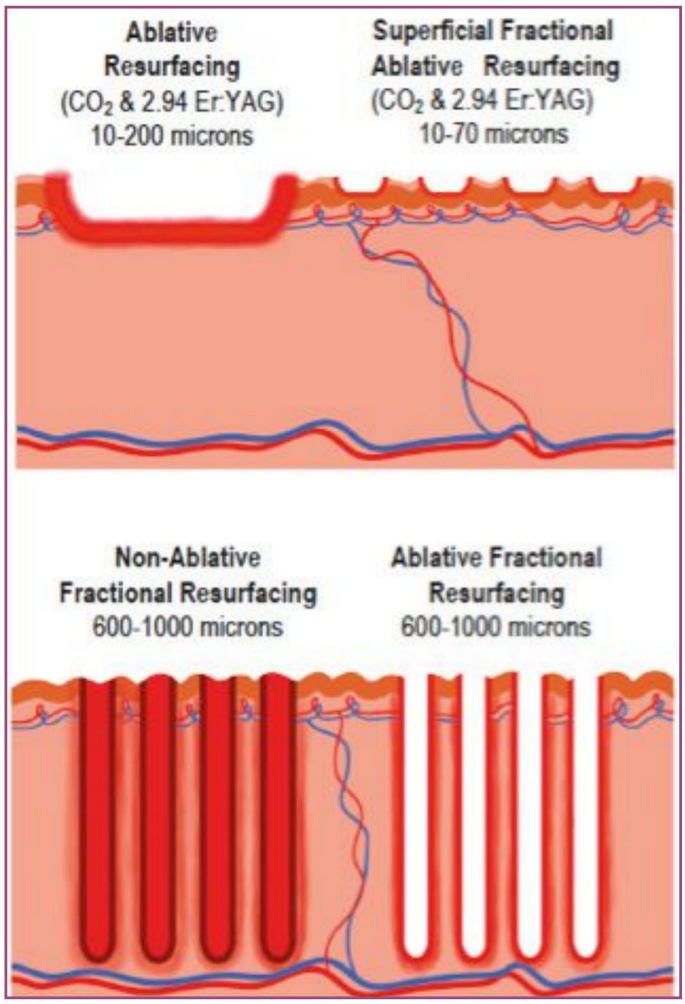


Figure 1. The concept of ablative (top left), fractional ablative (top and bottom right) and non-ablative fractional esurfacing (bottom left)

within the boundaries of the wound. They can continue to thicken for up to 6 months (Waibel et al, 2013). Unlike keloids, hypertrophic scars are smaller, and the colouring can fade over time. Hypertrophic scarring occurs after thermal and/or traumatic injury concerning the reticular dermis. The risk of hypertrophic scars forming, as with keloid scars, can be reduced post-surgery, by the use of silicone elastomer sheeting, pressure dressings or garments. This can especially be the case with burns (Atiyah, 2007).

Acne scars

There are three main types of acne scars: ice pick scars, rolling scars and boxcar scars. Ice pick scars are very small, deep holes in the surface of the skin that look like the skin has been punctured with a sharp object, leaving behind what look like little holes on the face. Rolling scars are caused by bands of scar tissue that form under the skin, giving the surface of the skin a rolling and uneven appearance—the skin can be seen to visibly dip. Boxcar scars are round or oval depressions or craters in the skin with parallel side walls. Despite the psychological stress that acne scarring can place on an individual, treatment is generally regarded as cosmetic surgery and is not usually available on the NHS. Therefore, demand is high for effective treatment within private clinics.

Other scars

Other specific types of scars include post-operative scars, post-trauma scars, burn scars, post-infective scars or diabetic wound scars. In some instances, it is possible to encounter combination scars, such as hypertrophied post-operative scars or keloid trauma wounds.

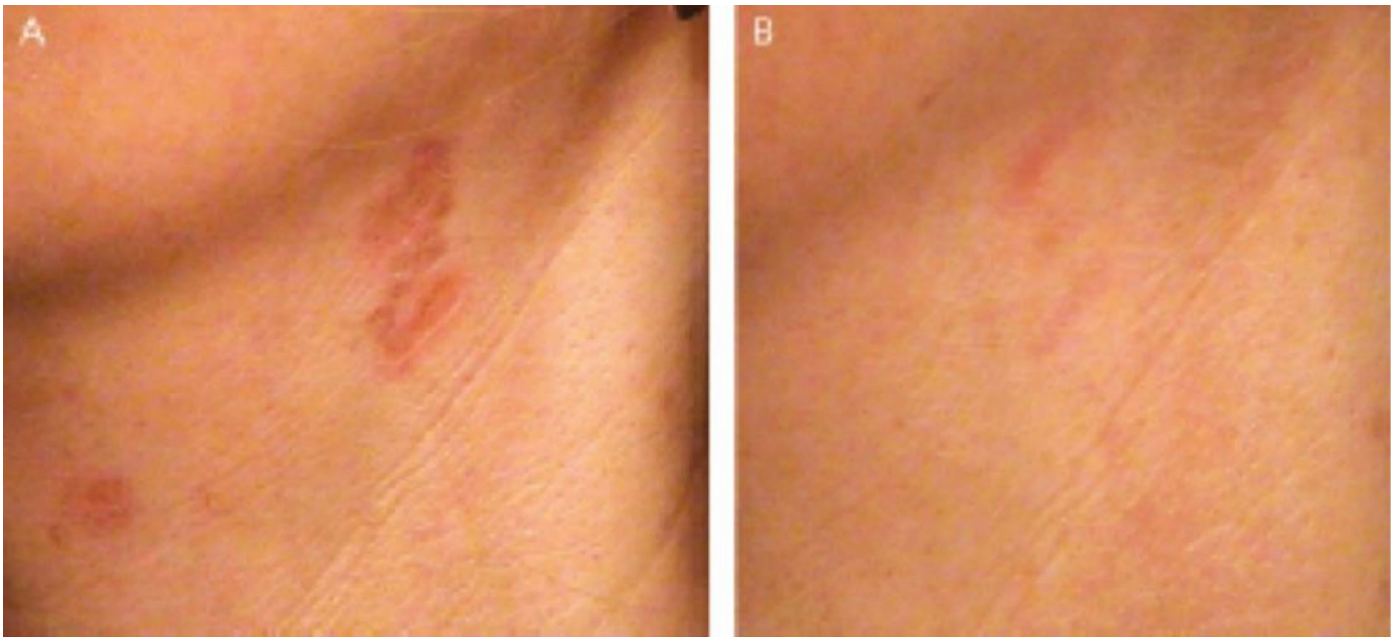
Treating scars

For the application of lasers for scar treatments, the theory of selective photothermolysis describes the means by which the skin's chromophores (water, melanin and haemoglobin) are targeted by use of an appropriate wavelength and pulse duration of a laser or light source. Generally, this is done to produce thermal damage of the target area, without damage to the surrounding tissues and structures.

With the treatment of scars, ablative Er:YAG (1540-nm) and CO2 (10 600-nm) lasers are commonly selected, with water being the target chromophore. CO2 and Er:YAG lasers are particularly effective in the treatment of scars due to their ability to smooth scar texture and stimulate collagen production (Waibel et al, 2013), although patients and practitioners must consider the potential for significant downtime, as re-epithelialisation typically takes 4–7 days with Er:YAG and 7–10 days with the CO2 laser. While inducing more downtime than non-ablative lasers, they usually produce a higher degree of clinical improvement.

Particularly for the treatment of acne scars, previous head-to-head studies have suggested that CO2 laser produces superior results, while Er:YAG is better tolerated with less downtime (Alexiades, 2017). Raised and shallow boxcar scars improve the most with laser resurfacing, while ice pick scars are more challenging to treat and may necessitate secondary resurfacing (Tierney et al, 2009).

More recently, fractional ablative laser resurfacing has emerged as a popular treatment modality for scar therapy. In fractional ablative resurfacing, columns of energy create heat in the dermis, which works on the principle of injury and repair, leading to reversible necrosis and resulting in collagenases, angiogenesis and structural changes within the dermis and scar tissue. The microscopic thermal treatment zones are separated by the surrounding untreated skin, resulting in rapid re-epithelialisation and reduced downtime, as only a fraction of the skin is altered. (Niwa et al, 2009). A double-blind split-scar study by Tidwell et al (2016) reported a significantly superior outcome with fractionated Er:YAG laser compared to fully ablative Er:YAG laser for surgical scar revision, with 94% of patients preferring the side of the scar treated with fractional ablative resurfacing.



Supplied by the author

Figure 2. Prescars on the neck before (A) and after (B) pulse dye laser treatment

Another study showed fractional CO2 laser to be effective in treating atrophic traumatic scars in 70% of patients treated with six monthly sessions of fractional CO2 laser treatment (Keen et al, 2018).

Non-ablative fractional lasers have also been shown to significantly improve the pigmentation and thickness of surgical, atrophic, hypertrophic and hypopigmented scars (Alexiades, 2017). A study by Tierney et al (2011) comparing 1550-nm non-ablative fractional laser to 595-nm pulse dye laser for the treatment of surgical scars showed that non-ablative fractional laser outperformed pulse dye laser, and 83% of patients preferred the half of the scar treated with a non-ablative fractional laser. Furthermore, Niwa et al (2009) examined a non-ablative fractional laser in the treatment of hypertrophic scars and found a 26–75% clinical improvement after two to three treatment sessions at 4-week intervals. For vascular scars, the pulsed dye laser is particularly useful, and it has been shown to improve the scar's appearance by reducing the redness that is associated with certain types of scarring (Khatri et al, 2011).

Intense pulsed light for scars

Alongside lasers, high-intensity, non-coherent light sources have been shown to be useful for the treatment of scars. A study by Kontoes et al (2003) found that intense pulsed light (IPL) sources, which emit noncoherent, broadband, pulsed light, can treat a range of scarring. IPL sources are commonly used in the treatment of vascular and pigmented lesions by targeting haemoglobin and melanin chromophores in accordance with the theory of selective photothermolysis. Therefore, they can act on the vasculature and the pigmentation of a scar to improve its appearance and/or the symptoms that may coexist. Over a 3-year period, it was found that patient satisfaction was high following IPL treatment in the majority of cases and yielded the best results when used in combination with other treatments (Kontoes et al, 2003). This study demonstrated that IPL treatments are applicable to, and effective in, the treatment of almost all types of scars, and can easily be combined with other treatment methods, such as microneedling and silicone dressings (Kontoes et al, 2003).

Scar prevention

Using lasers to prevent the formation of scars is a relatively new concept that is gaining popularity in the aesthetics field. Wound edges can be vaporised with either a CO2 or an Er:YAG laser before primary surgical closure to enhance ultimate cosmesis (Alster et al, 2007). Alternatively, a 585-nm pulse dye laser system can be used to treat surgical sites, traumatic wounds or ulcerations to reduce the risk of scarring and prevent excessive scar formation (McCraw et al, 1999; Nouri et al, 2003; Bowes and Alster, 2004) (*Figure 2*).

Additional modalities for scar treatments

There are multiple modalities that aim to reduce and improve the appearance of scars that do not use lasers or light, including microneedling, topicals, injectables and more. A brief review of these treatments is listed below.

Microneedling

Microneedling treatment uses needles to create tiny punctures in the skin to initiate the wound healing response. The needles break collagen bundles in the superficial layer of the dermis that are responsible for scars,

» Traditional treatments, such as silicone dressings and intralesional steroid injections, still have an important role to play, but optimal results can be obtained when combing these methods with other modalities, such as laser and light sources «

with the subsequent induction of better-structured collagen to reduce the appearance of the scar. Often, patients see an improvement in skin appearance and texture. This treatment can be used for most kinds of scarring.

Surgery

Scar revision surgery—where existing scar tissue is surgically removed—can be an effective modality that can improve the appearance of scars, transform the shape of the scar and increase functionality, for example, by releasing a tight scar that is close to a joint to improve movement and decrease patient discomfort. Surgical excision of hypertrophic or keloid scars is often used in conjunction with other treatment modalities, such as silicone gel sheeting. The key problem with performing surgery on a scar already formed is that there is also an increased risk of further keloid and hypertrophic scarring following surgery. After surgery, the recurrence rate for keloid scarring is approximately 50–80% (Ogawa, 2019).

Scarring is inevitably unpredictable, and excision has an associated downtime and a requirement for local anaesthetic.

Chemical peels

Chemical peels are most commonly used for the treatment of acne scars, although they can be used for any type of scar that has an element of hypertrophy, as it enables the smoothing of the scar to the skin's surface. Examples include raised scars created after burns, surgery or trauma. Trichloroacetic acid (TCA)- and phenol-strength peels are better suited for deeper scarring; however, a lengthy downtime is experienced by patients with stronger peels. Dot peeling with these acids can be used to directly target ice pick or small box scars. Salicylic acid peels are currently the most frequently used and tend to be combined with other treatments, such as microneedling, IPL and laser, for the best results. Currently, there appears to be no consensus on the best combination of treatments. However, a series of chemical peels can lead to significant improvement over a short period, leading to patient satisfaction and maintenance of clinical results (Kontochristopoulos and Platsidak, 2017).

Platelet-rich plasma

Autologous platelet-rich plasma contains a higher concentration of platelets than normally found, so as to enhance wound healing (Fennis et al, 2002; Carter et al, 2003). Derived by spinning the patient's blood and injecting it back into the area of scarring, practitioners are able to deliver a high concentration of growth factors, platelets and cytokines to the target tissue. In response to platelet activation, the alpha granules of the platelets release growth factors and induce cell proliferation and cell differentiation for tissue regeneration. These growth factors play an important role in controlling and proliferating mesenchymal stem cells, including fibroblasts, and have been shown to induce collagen and matrix component synthesis, which is expected to boost atrophic scars (Ibrahim et al, 2017).

Additionally, the application of platelet-rich plasma to surgical wounds post-surgery has been shown as an effective pre-scar solution, for the acceleration of tissue repair and for the reduction of postoperative pain (Gardner et al, 2007). This treatment can be used alongside other scar treatment methods that are mentioned in this article.

Dermabrasion and microdermabrasion

Dermabrasion and microdermabrasion were the first major advanced treatments for acne scarring (Goodman, 2000; 2003). Dermabrasion and microdermabrasion are both facial resurfacing techniques that mechanically remove damaged skin to promote the remodelling of the skin's structural proteins. Dermabrasion is ablative, induces more downtime and requires anaesthesia. It eliminates the epidermis entirely and penetrates to the level of the papillary or reticular dermis, causing structural protein remodelling of the skin (Fabbrocini et al, 2010). A more superficial variation of dermabrasion, microdermabrasion only removes the outer layer of the epidermis, which accelerates the natural exfoliation process (Fernandes et al, 2014). Dermabrasion techniques can be effective in the treatment of scars and produce clinically significant improvements in skin appearance. However, practitioners are unable to treat deep wounds with microdermabrasion procedures (Fernandes et al, 2014). Additionally, dermabrasion does not optimally enhance ice selection or deep boxcar scars (Thiboutot and Gollnick, 2009), and although microdermabrasion may help those with uneven skin texture or congested skin, it has limited efficacy in the treatment of scars.

Steroid injections

Steroid injections are often the first line of defence in the prevention and treatment of keloids and hypertrophic scars from a medical perspective (Carroll and Patel, 2015). Usually,

triamcinolone is injected along the length of the wound. The result is a reduction in the redness of the scar and then the slowing of growth, followed, in most cases, by a regression of the bulk of the lesion. Corticosteroid injections can have improved efficacy when combined with other therapies, including lasers (Davison et al, 2009). Furthermore, triamcinolone injections have been shown to improve scars via the inhibition of fibroblast proliferation, decreased collagen synthesis and collagenase inhibitors (Huang et al, 2013). While triamcinolone's side effects, including skin atrophy, telangiectasia and hypopigmentation, are well-known, lower doses of steroids can decrease these effects.

Psychological considerations when treating scars

Finally, aesthetic practitioners should consider the psychological implications of treating scars for patients. Patients with facial scars such as acne scarring appear to experience low self-esteem, be nervous about their condition and to be unrealistic about treatment results. As practitioners, it is crucial to have a mindful discussion with a thorough description of the treatment, its consequences and the potential results when treating any form of scars (Castillo and Keri, 2018).

Through doing this, the practitioner can gain the patient's confidence and strengthen the relationship between the medic and the patient. For the effectiveness of the process, this relationship is important. Therefore, when reviewing a patient's expectations and concerns and past experiences of treating scars using a variety of modalities, all aesthetic practitioners must be cautious and must be pragmatic about outcomes and complications to maximise patient satisfaction.

Conclusion

With the range of modalities available for the treatment of scars, practitioners have the ability to create a treatment plan tailored to the patient's needs, which may use a combination of treatments. Traditional treatments, such as silicone dressings and intralesional steroid injections, still have an important role to play, but optimal results can be obtained when combining these methods with other modalities, such as laser and light sources.

References

Alexiades M. Laser and light-based treatments of acne and acne scarring. Clin Dermatol. 2017; 35(2):183–189. https://doi.org/10.1016/j.clindermatol.2016.10.012

Alster TS, Handrick C. Laser treatment of hypertrophic scars, keloids,and striae. Semin Cutan Med Surg. 2000; 19:287–292. https://doi.org/10.1016/s0733-8635(05)70451-4

Alster TS, Tanzi EL, Lazarus M. The use of fractional laser photothermolysis for the treatment of atrophic scars. Dermatol Surg. 2007; 33(3):295–299. https://doi.org/10.1111/j.1524-4725.2007.33059.x

Anderson RR, Parrish JA. Selective photothermolysis: precise microsurgery by selective absorption of pulsed radiation. Science. 1983; 220(4596):524–527. https://doi.org/10.1126/science.6836297

Atiyah BS. Nonsurgical management of hypertrophic scars: evidence-based therapies, standard practices, and emerging methods. Aesthetic Plast Surg. 2007; 31(5):468–492. https://doi.org/10.1007/s00266-006-0253-y

Berman B, Perez OA, Konda S et al. A review of the biologic effects, clinical efficacy, and safety of silicone elastomer sheeting for hypertrophic and keloid scar treatment and management. Dermatol Surg. 2007; 33(11):1291–1302. https://doi.org/10.1111/j.1524-4725.2007.33280.x

Bowes LE, Alster TS. Treatment of facial scarring and ulceration resulting from acne excorie´e with 585-nm pulsed dye laser irradiation and cognitive psychotherapy. Dermatol Surg. 2004; 30(6):934–938. https://doi.org/10.1111/j.1524-4725.2004.30266.x

Carroll W, Patel K. Steroids and fluorouracil for keloids and hypertrophic and scars. JAMA Facial Plast Surg. 2015; 17:77–79. https://doi.org/10.1001/jamafacial.2014.1355

Carter CA, Jolly DG, Worden CE. Platelet-rich plasma gel promotes differentiation and regeneration during equine wound healing. Exp Mol Pathol. 2003; 74(3):244–255. https://doi.org/10.1016/s0014-4800(03)00017-0

Castillo DE, Keri JE. Chemical peels in the treatment of acne: patient selection and perspectives. Clin Cosmet Investig Dermatol. 2018; 11:365–372. https://doi.org/10.2147/ccid.s137788

Davison SP, Dayan JH, Clemens MW, Sonni S, Wang A, Crane A. Efficacy of intralesional 5-fluorouracil and triamcinolone in the treatment of keloids. Aesthet Surg J. 2009; 29(1):40–46. https://doi.org/10.1016/j.asj.2008.11.006

English RS, Shenefelt PD. Keloids and hypertrophic scars. Dermatol Surg.1999; 25(8):631–638. https://doi.org/10.1046/j.1524-4725.1999.98257.x

Fabbrocini G, Annunziata MC, D'Arco V et al. Acne scars: pathogenesis, classification and treatment. Dermatol Res Pract. 2010; 893080. https://doi.org/10.1155/2010/893080

Fennis JP, Stoelinga PJ, Jansen JA. Mandibular reconstruction: a clinical and radiographic animal study on the use of autogenous scaffolds and platelet-rich plasma. Int J Oral Maxillofac Surg. 2002; 31(3):281–286. https://doi.org/10.1054/ijom.2002.0151

Fernandes M, Pinheiro NM, Crema VO, Mendonça AC. Effects of microdermabrasion on skin rejuvenation. J Cosmet Laser Ther. 2014; 16(1):26–31. https://doi.org/10.3109/14764172.2013.854120

Gardner MJ, Demetrakopoulos D, Klepchick PR. The efficacy of autologous platelet gel in pain control and blood loss in total knee arthroplasty: an analysis of the hemoglobin, narcotic requirement and range of motion. Int Orthop. 2007; 31(3):309–313. https://doi.org/10.1007/s00264-006-0174-z

Goodman GJ. Postacne scarring: a review of its pathophysiology and treatment. Dermatol Surg. 2000; 26(9):857–871. https://doi.org/10.1046/j.1524-4725.2000.99232.x

Goodman GJ. Post acne scarring: a review. J Cosmet Laser Ther. 2003; 5:77–95. https://doi.org/10.1080/14764170310001258

Hantash BM, Mahmood MB. Fractional photothermolysis: a novel aesthetic laser surgery modality. Dermatol Surg. 2007; 33(5):525–534. https://doi.org/10.1111/j.1524-4725.2007.33110.x

Huang L, Cai YJ, Lung I, Leung BCS, Burd A. A study of the combination of triamcinolone and 5-fluorouracil in modulating keloid fibroblasts in vitro. J Plast Reconstr Aesthet Surg. 2013; 66:e251–259. https://doi.org/10.1016/j.bjps.2013.06.004

Ibrahim ZA, El-Ashmawy AA, Shora OA. Therapeutic effect of microneedling and autologous platelet-rich plasma in the treatment of atrophic scars: a randomized study. J Cosmet Dermatol. 2017; 16(3):388–399. https://doi.org/10.1111/jocd.12356

Juckett, G, Hartman-Adams, H. Management of keloids and hypertrophic scars. Am Fam Physician. 2009; 80:253–260

Keen A, Sheikh G, Hassan I et al. Treatment of post-burn and post-traumatic atrophic scars with fractional CO2 laser: experience at a

tertiary care centre. Lasers Med Sci. 2018; 33(5):1039–1046. https://doi.org/10.1007/s10103-018-2469-x

Khatri KA, Mahoney DL, McCartney MJ. Laser scar revision: a review. J Cosmet Laser Ther. 2011; 13(2):54–62. https://doi.org/10.3109/14764172.2011.564625

Kontochristopoulos G, Platsidaki E. Chemical peels in active acne and acne scars. Clinics in Dermatology. 2017; 35(2):179–182. https://doi.org/10.1016/j.clindermatol.2016.10.011

Kontoes PP, Marayiannis KV, Vlachos SP. The use of intense pulsed light in the treatment of scars. Eur J Plast Surg. 2003; 5(7-8):374–377

Manstein D, Herron GS, Sink RK, Tanner H, Anderson RR. Fractional photothermolysis:a new concept for cutaneous remodeling using microscopic patterns of thermal injury. Lasers Surg Med. 2004; 34:426–438. https://doi.org/10.1002/lsm.20048

McCraw JB, McCraw JA, McMellin A, Bettancourt N. Prevention of unfavorable scars using early pulsed dye laser treatments: a preliminary report. Ann Plast Surg 1999; 42:7–14. https://doi.org/10.1097/00000637-199901000-00002

Niwa AB, Mello AP, Torezan LA, Osório N. Fractional photothermolysis for the treatment of hypertrophic scars: clinical experience of eight cases. Dermatol Surg. 2009; 35(5):773–777. https://doi.org/10.1111/j.1524-4725.2009.01127.x

Nouri K, Jimenez GP, Harrison-Balestra C, Elgart GW. 585-nm pulsed dye laser in the treatment of surgical scars starting on the suture removal day. Dermatol Surg. 2003; 29:65–73. https://doi.org/10.1046/j.1524-4725.2003.29014.x

Ogawa R, Tosa M, Dohi T, Akaishi S, Kuribayashi S. Surgical excision and postoperative radiotherapy for keloids. Scars Burn Heal. 2019; 5:2059513119891113. https://dx.doi.org/10.1177%2F2059513119891113

Rumsey N, Clarke A, White P. Exploring the psychosocial concerns of outpatients with disfiguring conditions. J Wound Care. 2003; 12(7):247–252. https://doi.org/10.12968/jowc.2003.12.7.26515

Thiboutot D, Gollnick H, Bettoli V et al. New insights into the management of acne: an update from the Global Alliance to Improve Outcomes in Acne Group. J Am Acad Dermatol. 2009; 60:S1–50. https://doi.org/10.1016/j.jaad.2009.01.019

Tidwell WJ, Owen CE, Kulp-Shorten C, Maity A, McCall M, Brown TS. Fractionated Er:YAG laser versus fully ablative Er:YAG laser for scar revision: results of a split scar, double blinded, prospective trial. Lasers Surg Med. 2016; 48(9):837–843. https://doi.org/10.1002/lsm.22562

Tierney E, Mahmoud BH, Srivastava D, Ozog D, Kouba DJ. Treatment of surgical scars with nonablative fractional laser versus pulsed dye laser: a randomized controlled trial. Dermatol Surg. 2009; 35(8):1172–1180. https://doi.org/10.1111/j.1524-4725.2009.0108

ierney EP, Eisen RF, Hanke CW. Fractionated CO2 laser skin rejuvenation. Dermatol Ther. 2011; 24(1):41–53. https://doi.org/10.1111/j.1529-8019.2010.01377.x

aibel JS, Wulkan AJ, Shumaker PR. Treatment of hypertrophi using laser and laser assisted corticosteroid delivery. Lasers S Med. 2013; 45(3):135–140. https://doi.org/10.1002/lsm.22120