

# Non-medical treatments for inflammatory acne vulgaris: a comprehensive review on laser, radiofrequency and microneedling

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*Received: 5 April 2019  
Accepted: 19 July 2019*

There are many patients with inflammatory acne vulgaris who are not compliant or eligible to consume acne medications, such as oral antibiotics or isotretinoin. PubMed and Medline databases were searched for all related articles. All findings were summarized and chronologically presented in the tables. Non-medical device-based therapies largely improve the treatment of active inflammatory acne vulgaris, especially in patients who are not compliant or eligible to consume acne medications, do not respond to these drugs over a specified period of time, or do not sustain in the remission phase.

**Keywords:** acne vulgaris, laser, radiofrequency, microneedling, photodynamic therapy (PDT)

Iran J Dermatol 2019; 22: 97-106

## INTRODUCTION

There are many patients with inflammatory acne vulgaris who are not compliant or eligible to consume acne medications, such as oral antibiotics or isotretinoin. Patients with pregnancy planning or breastfeeding, gastrointestinal problems, fatty livers with abnormal liver function tests, dyslipidemia and so forth are among such patients who either do not respond to the aforementioned drugs over a determined period of time or do not remain in the remission phase. These patients search for non-medical, easy, effective and safe methods for treating their conditions. For this purpose, we focused on non-medical therapeutic modalities for inflammatory acne vulgaris and reviewed light, light-based and photodynamic trends in the treatment of inflammatory acne; further comprehensively reviewed were such novel emerging methods as laser, radiofrequency and microneedling.

There exist myriad studies about the suitable results of light therapy, photodynamic therapy (PDT), laser, radiofrequency and microneedling concerning the treatment of acne scars<sup>1-5</sup>; however, there are fewer studies on the therapies for

inflammatory acne vulgaris, particularly regarding laser, radiofrequency and microneedling.

## METHODS

We searched PubMed and Medline data bases and included all related articles for this review. The words, laser, radiofrequency, microneedling, photodynamic therapy (PDT) and light therapy in combination with the word acne were searched and all related articles included.

## RESULTS AND DISCUSSION

### Light and PDT

There are many studies investigating the efficacy and acceptable results of using various forms of light-based therapies and PDT in inflammatory acne vulgaris, and further comparing their therapeutic findings. These studies are chronologically summarized in Table 1<sup>6-47</sup>.

### Lasers

There are many articles and clinical trials on

**Table 1.** Light, light-based and PDT modalities in the treatment of inflammatory acne vulgaris

Authors	Findings
Light therapy <sup>6-8</sup>	
Sami NA, et al (2008)	Phototherapy is a useful therapeutic option for the treatment of moderate to severe acne.
Bitter P Jr (2016)	Three-step broadband light protocol to treat patients with moderate-severe acne, and acne scarring were found to be safe and effective therapeutic alternatives.
Ito Y, et al (2017)	Marked reductions in inflammatory acne lesions and post-acne erythema were observed following Modified 3-Step Broadband Light Treatment. The overall skin tone and texture were also improved without major side effects.
PDT <sup>9-25</sup>	
Tuchin VV, et al (2003)	PDT with Indocyanine green (ICG) dye laser is an effective and safe therapeutic option for inflammatory acne.
Genina EA, et al (2004)	Multiple sessions of low-intensity indocyanine-green (ICG) laser phototherapy in acne vulgaris is an effective and safe therapy for a short term follow-up.
Gold MH, et al (2004)	ALA-PDT with IPL activation is a well-tolerated treatment for moderate to severe inflammatory acne with no recurrence of treated lesion 3 months following the therapy.
Nouri K, et al (2004)	Adverse effects of indocyanine green-PDT (ICG-PDT) were found to be fewer than aminolevulinic. Acid-PDT Lasers are still used for acne as a relatively new therapy, and the most optimal treatment for adjuvant role.
Alexiades-Armenakas M, et al (2006)	Considering the safety and effectiveness of treatment by ALA PDT with activation by long-pulsed (LP) PDL as well as its minimal side effects, it can be used in patients with recalcitrant comedonal, inflammatory, or cystic acne of various degrees of severity. LP PDL-mediated PDT may serve as an important alternative to isotretinoin. Cosmetically well-accepted, LP PDL PDT combined with topical therapy was the first PDT modality to achieve complete clearance with long-term follow-up as compared to controls.
Gold MH, et al (2007)	Moderate to marked improvement in most acne patients was observed with new Advanced Fluorescence Technology (AFT) pulsed light source with ALA PDT as a safe and effective modality for moderate to severe inflammatory acnes.
Nestor MS (2007)	In acne vulgaris patients, therapeutic response was obtained with 30-to-60 minute contact with 5-aminolevulinic acid prior to photoactivation with blue light, red light, yellow light, broadband light, halogen, or pulsed dye laser devices. An average of three treatments can improve significant long-term efficacy.
Taub AF (2007)	In the treatment of moderate to severe acne vulgaris, ALA-PDT with activation by IPL resulted in greater, longer-lasting, and more compatible improvement compared with either RF-IPL or blue light activation.
Kim BJ, et al (2009)	Photodynamic therapy using indocyanine green (ICG) dye with a diode laser was effective on the acne treatment of Korean subjects with no superiority of multiple sessions than the single one that could otherwise be an alternative treatment modality for acne in Asian subjects.
Riddle CC, et al (2009)	Reduction in inflammatory lesions or meaningful improvement of acne was reported in all studies on PDT for acne. There are several studies that support the use of PDT as the combination of a light source with photosensitizer with superiority over light alone. A useful therapeutic option for acne patients uncooperative to standard treatments and sticking to treatments with systemic retinoids is PDT; adverse reactions included photosensitivity, pustular eruptions, and crusting.
Taylor MN, et al (2009)	Papulopustular acne is more responsive and all Fitzpatrick skin types are eligible for treatment with PDT. Patients with skin type's I-III had a reduced risk of postinflammatory hyperpigmentation. There was a good side-effect profile resulting in acne remission from at least 3 months to a year in a relatively cost-effective manner.
de Leeuw J, et al (2010)	To have a safe and effective photodynamic therapy of acne vulgaris, use can be made of 5-ALA 0.5% liposomal spray and IPL in combination with topical peeling agents even in patients with acne sticking to standard therapy.
Orringer JS, et al (2010)	Photodynamic therapy with topical aminolevulinic acid and pulsed dye laser is beneficial to inflammatory acne vulgaris.
Mei X, et al (2013)	With mild and reversible side effects, ALA-IPL-PDT is an effective treatment for moderate to severe acne vulgaris.
Zheng W, et al (2014)	PDT has a good performance, with acceptable side effects, regarding acne therapy where the optimal choice is ALA + red light.
Park KY, et al (2015)	PDT with indocyanine green (ICG) dye and IPL can be effectively and safely used in the treatment of acne.
Boen M, et al (2017)	PDT is an adjunctive treatment for mild to severe acne as well as an effective treatment for acne, especially in patients non-responsive to topical therapy and oral antibacterials, and not identified as suitable candidates for isotretinoin.

Table 1. Continued

Authors	Findings
Light/Laser <sup>26-33</sup>	
Elman M, et al (2004)	Laser and light-based therapies are safe and effective in the treatment of mild-moderate inflammatory acne with faster resolution, fewer side effects and higher patient satisfaction compared with oral antibiotics.
Mariwalla K, et al (2005)	In combination therapy, lasers and light-based therapies provide a safe and effective option for acne vulgaris.
Ortiz A, et al (2005)	There are many advances in laser and light sources in the treatment of acne vulgaris.
Munavalli GS, et al (2008)	There exist varying degrees of efficacy regarding the treatment of acne vulgaris through novel and promising treatments with laser/light devices, and varying degrees of efficacy devices (such as blue light, red light, pulsed dye laser, infrared lasers, light-emitting diodes, and pulsed light).
Avci P, et al (2013)	Low-level laser (light) therapy (LLLT) could be an effective and safe therapeutic option for acne.
Pei S, et al (2015)	Light and laser are safe, effective, and associated with no or minimal complications in the treatment of acne.
Momen S, et al (2015)	The alternative treatments of medical therapies for acne vulgaris were found to be laser- and light-based therapies with a high compliance and relatively low side-effect profiles.
Tong LX, et al (2017)	Laser- and light-based treatments had better compliance and safety profiles in comparison to pharmacologic therapies of acne vulgaris. These treatments were more effective when used in combination therapy. Adverse effects were minimal and generally self-limited.
Light/PDT <sup>34-36</sup>	
Gold MH (2007)	Light sources such as blue lights and intense pulsed lights (IPLs) are becoming more practical in the treatment of acne vulgaris; moreover, there are many clinical trials showing the effectiveness of 5-aminolevulinic acid and photodynamic therapy in the treatment of moderate to severe inflammatory acne.
Kim RH, et al (2011)	Blue light and photodynamic therapy can particularly be used as adjunctive therapies with promising results, targeting the factors that have roles in acne pathogenesis and may potentially complement the current conventional therapy.
Barbaric J, et al (2016)	There is paucity of high-quality evidence on the use of light therapies for acne and low certainty on the usefulness of methyl aminolevulinate (MAL) PDT (red light) or aminolevulinic acid PDT (blue light) for moderate to severe acne.
Light/PDT/Laser/ Radiofrequency <sup>37-47</sup>	
Charakida, A et al (2004)	Visible light (blue light specifically) has a marked and sufficient effect on inflammatory acne with minimal adverse effects, and blue-red light is superior to blue radiation alone. PDT has excellent therapeutic outcomes with significant adverse effects, and PDL laser is a promising treatment for active acne.
Rotunda AM, et al (2004)	Light, laser and radio frequency have faster onset of action, equal or greater efficacy, and greater convenience compared with traditional therapies of acne vulgaris; however, further studies with appropriate design and larger number of patients are necessary for more precise comments.
Bhardwaj SS, et al (2005)	Laser, light and radiofrequency devices as monotherapy or in combination are promising approaches to clearing acne in a convenient, non-invasive manner.
Borelli C, et al (2005)	Photodynamic therapy leads to promising results, but with marked side-effects such as destruction of sebaceous glands. Blue light (405-420 nm wavelengths) is an effective treatment and can be considered as a treatment alternative for inflammatory acne.
Gold MH (2007)	Medical therapy is the gold standard treatment for inflammatory acne vulgaris; recently, however, lasers and light sources have had advances in this field; moreover, 20% 5-aminolevulinic acid has become a useful option for the treatment of moderate-to-severe acne.
Haedersdal, M et al (2008)	PDT results were the most consistent outcome among those optical treatments of acne vulgaris associated with a short-term efficacy.
Degitz K (2009)	Visible light, especially of blue wavelengths, were revealed to be suitable for the treatment of mild to moderate inflammatory acne. Although treatment by photodynamic appears to be effective, it is best reserved for selected conditions due to considerable immediate side effects. Regardless of promising observations, intense pulsed light and lasers have to be investigated more in future studies.
Hamilton FL, et al (2009)	Certain forms of light therapy have short-term benefit for the treatment of acne vulgaris; despite initial discomfort, patients may find it more facile to comply with light therapy owing to their short duration. Trials comparing light with conventional therapies and assessing long term benefits of light therapy are really necessary.
Borelli C, et al (2010)	Visible light, blue light in particular, proved to be an effective option for the treatment of inflammatory acne. Photodynamic therapy is also an efficacious option, yet should not be used due to unfavorable risk-benefit ratios. Acne Treatment by UV is not logical.

**Table 1.** Continued

Authors	Findings
Piérard-Franchimont C, et al (2011)	A faster response might be induced by light/laser treatments for acne compared with the 1-3 months required for response to traditional oral and topical treatments; pulsed dye laser was revealed to be effective in, but its relative effectiveness was not supported compared with other treatments.
Rai R, et al (2013)	Acne treatment by light and laser, radiofrequency and PDT devices was found to target the underlying pathogenic factors, namely propionibacterium acnes colonization, increased sebaceous gland activity, and cutaneous inflammatory response.

the use of different lasers with various setups and designs concerning the treatment of inflammatory acne vulgaris, which findings are summarized in Table 2<sup>48-88</sup>.

Overall, laser is an effective, safe and tolerable device for the treatment of acne vulgaris with relatively long lasting results.

**Table 2.** Lasers in the treatment of inflammatory acne vulgaris

Authors	Findings
Lasers <sup>48-88</sup>	
Seaton ED, et al (2003)	After 12 weeks of one treatment, improvement was observed, with inconsiderable adverse effects, in inflammatory facial acne with PDL therapy.
Friedman PM, et al (2004)	The safety and efficacy of laser treatment for inflammatory facial acne were shown previously. Clinical improvement was seen in all patients, even in cases of refractory to previous treatment with oral isotretinoin.
Baugh WP, et al (2005)	Treatment and management of acne vulgaris using Potassium-Titanyl-Phosphate (KTP) Laser 532 nm appeared to be safe and effective, with positive results lasting for up to 4 weeks post treatment.
Glaich AS, et al (2006)	For the treatment of inflammatory facial acne, acne scarring, and post-inflammatory erythema, 595-nm pulsed-dye laser in combination with 1,450-nm diode laser proved to be safe and effective.
Jih MH, et al (2006)	Inflammatory facial acne lesions were reduced via 1450-nm diode laser and Fitzpatrick skin phototypes IV-VI showed very few side effects. Considerable improvement was observed in acne lesion counts following the first treatment, lasting for 12 months after the third treatment, and showing significant long-term clinical remission after the laser treatment.
Maruguchi Y, et al (2006)	The 1450-nm diode laser is a new option for local treatment of acne.
Nouri K, et al (2006)	Laser treatment in combination with other therapies may best be applied to enhance its impact on acne; however, there may be concerns regarding potential pain, skin discoloration and cost of the treatment. Multiple sessions are more often than not required to obtain the desired results and future maintenance. The 532-nm potassium titanyl phosphate laser, 585- and 595-nm pulsed dye lasers, 1450-nm diode laser, and 1540-nm erbium glass laser were used with variable efficacy. Photodynamic therapy proved to be successful in combination with substances such as 5-aminolevulinic acid and indocyanine green.
Seaton ED, et al (2006)	Further inhibiting the inflammation of acne is TGF-beta upregulated by non-ablative PDL laser which provides linking stimulation and dermal remodeling of collagens and promotes photorejuvenation. However, it did not influence P. acnes or sebaceous glands.
Wang SQ, et al (2006)	The 1,450 nm diode laser is effective, well tolerated, and safe for the treatment of facial acne.
Bernstein EF (2007)	Low-energy double-pass 1,450 nm diode laser treatment effectively reduced acne counts two months post treatment, and notably decreased the pain related to treatment.
Harto A, et al (2007)	Inflammatory lesions of acne were largely improved by pulse dye laser therapy, with few adverse effects.
Jih MH, et al (2007)	Recently, the use of lasers and light devices has dramatically increased because of the overall ease of treatment, predictable clinical efficacy, and minimal adverse effects; potassium titanyl phosphate (KTP) laser, 585- and 595-nm pulsed dye lasers, 1450-nm diode laser, radiofrequency devices, intense pulsed light sources, low-intensity light treatment, and photodynamic therapy using 5-aminolevulinic acid and indocyanine green are examples of such light devices.
Konishi N, et al (2007)	Acne phototherapy with a 1450-nm diode laser is effective and well tolerated.
Orringer JS, et al (2007)	Treatment with infrared laser therapy (1320-nm Nd:YAG laser) may improve comedonal acne. It was revealed that patients had a positive view of such therapy for both acne and oily skin.
Perez-Maldonado A, et al (2007)	Clinical effectiveness of 1,450-nm diode laser may be associated with its effects on sebaceous glands, and the subsequent reduction in sebum production.
Uebelhoer NS, et al (2007)	The lower fluences of pulsed 1,450-nm diode laser reduced the discomfort and effectively improved inflammatory acne. Stacking pulses had a slightly higher efficacy compared with multiple passes. Low fluence, single-pulse, multiple-pass sessions entailed lower risks of hyperpigmentation compared with high fluence ones.

Table 2. Continued

Authors	Findings
Astner S, et al (2008)	The 1,450-nm diode laser provided moderate improvement of refractory acne vulgaris, hence considered as an adjunctive treatment for acne.
Astner S (2009)	A 1,450 nm diode laser is an adjunctive treatment for refractory acne with good results.
Bernstein EF (2009)	Two months post treatment, low-energy, double passes 1,450 nm laser treatments with a larger 12 mm-diameter spot size greatly reduced acne counts.
Cho SB, et al (2009)	The combination therapy utilizing 595-nm pulsed-dye laser and fractional photothermolysis system (FPS) can be a safe, effective and rapid treatment option for patients with both inflammatory acne vulgaris and acne scarring.
Jung JY, et al (2009)	For the treatment of inflammatory and non-inflammatory acne lesions, PDL and combined 585/1,064 nm laser proved to be effective and safe.
Laubach HJ, et al (2009)	In a split face trial, three 1,450 nm laser treatment sessions did not lead to noticeable changes in sebum excretion rate (SER), showing the unlikeliness of the major destruction mechanism of sebaceous glands in treating inflammatory acne. However, a reduced sebum production was observed on both treatment and control sides at 1 month. Therefore, its clinical efficacy should be studied to find an alternative systemic mechanism.
Leheta TM (2009)	Pulse dye laser therapy notably improves the inflammatory lesions of acne, having minimal adverse effects.
Yeung CK, et al (2009)	Multiple passes of a 1,450-nm diode laser with lower fluency and shorter dynamic cooling device remarkably reduced Post Inflammatory Hyperpigmentation (PIH) in moderate acne.
Choi YS, et al (2010)	Both PDL and IPL were revealed to effectively treat acne, with the former showing a more lasting effect. TGF-beta might play a key role in the resolution of inflammatory acne lesions.
Darné S, et al (2011)	In a split face trial, treatment with the 1450 nm laser did not reduce inflammatory lesion count or acne grade; however, after 1 year, both sides of the face improved clinically, suggesting the possible systemic effect of the laser on acne vulgaris.
Yilmaz O, et al (2011)	532-nm KTP laser treatment may be an alternative method in selected acne vulgaris patients. No significant difference was observed between once and twice weekly applications.
El-Latif AA, et al (2014)	Benzoyl peroxide 5% (BP) produced better results compared with IPL concerning the treatment of acne. Although the difference in therapeutic response was statistically significant at the midpoint of the study, no differences were observed in the end.
Sult R (2014)	Acne treatment with long-pulsed 1064 nm Nd:YAG laser is a safe, effective and well-tolerated treatment with long-term results and no side effects.
Ganceviciene R, et al (2015)	1064 nm Nd:YAG laser is effective in treating both inflammatory and non-inflammatory acne lesions, with improvements on the treated as well as control sides, suggesting a systemic effect on the skin. The treatment can be a well-tolerated, safe and effective alternative for inflammatory mild-to-moderate acne.
Paithankar DY, et al (2015)	800 nm diode laser was applied in two independent trials assessing the photothermolysis of sebaceous follicles with topically delivered light-absorbing gold microparticles. Each trial showed clinically and statistically significant improvements in inflammatory acne following three 1-2-week-apart treatments. Optical microparticles enabled a selective photothermolysis of sebaceous glands, which appears to be a well-tolerated, effective treatment for acne vulgaris.
Patidar MV, et al (2016)	IPL is an effective and safe option for inflammatory acne vulgaris with minimal reversible side effects. Subnormal fluence is as effective as normal fluence in Indian skins.
Gold MH, et al (2017)	The 650-µs 1064-nm Nd: YAG laser is a novel therapeutic option for acne.
Khan WZ, et al (2017)	IPL proved to be safe and effective regarding the treatment of mild and moderate acne vulgaris in more than half of the patients.
Mokhtari F, et al (2017)	Combination therapies such as IPL and benzoyl peroxide 5% (BP) entailed a better response compared with monotherapy (like BP alone).
Perper M, et al (2017)	The 1450 nm diode laser, 585- and 595-nm pulsed dye lasers (PDLs), near infrared diode lasers, 1320 nm Nd:YAG laser, 532 nm potassium titanyl phosphate laser, 1064 nm long-pulsed Nd:YAG laser, 1540 nm Erbium (Er):Glass Laser, and the 1550 nm Er:Glass fractional laser are among the most common lasers employed to treat acne and acne scarring.
Puttaiah M, et al (2017)	All acne patients showed a reduction in the number of lesions following 4 sessions of IPL. No significant side effects were noted, and patients observed an improvement in skin texture.
Salah El Din MM, et al (2017)	PDL and combined PDL/Nd:YAG laser treatment were found to be effective, safe and well-tolerated treatment options for inflammatory and non-inflammatory acne vulgaris.
Wiznia LE, et al (2017)	Laser therapies are increasingly becoming part of or an adjunct to the medical treatment of active acne, and are useful treatment modalities.
Bakus AD (2018)	Active acne can be successfully treated with a combination of long-pulsed (LP) and Q-switched (QS) Nd:YAG lasers, with patients remaining off acne medications throughout laser therapy and the follow-up period.
Deshpande AJ (2018)	IPL therapy with 530nm to 1,200nm filter is an effective and safe modality of treatment as monotherapy in managing grades 3 and 4 of inflammatory acne vulgaris in women of child-bearing age.

## Microneedling, Fractional Radiofrequency and Radiofrequency-Microneedling

There are many studies on the acceptable therapeutic results and safety of Microneedling,

fractional radiofrequency and radiofrequency-microneedling regarding the treatment of active acne (inflammatory and non-inflammatory), summarized in Table 3<sup>89-107</sup>.

**Table 3.** Microneedling, radiofrequency and radiofrequency-microneedling in the treatment of inflammatory acne vulgaris

Authors	Findings
<b>Microneedling</b> <sup>89-92</sup>	
Cohen BE, et al (2016)	Microneedling may offer a more advantageous safety profile, particularly concerning the skin-of-color population (Fitzpatrick skin types IV-VI), compared with more conventional resurfacing modalities. Thus far, it has been shown to be effective in a number of dermatologic conditions in this population, including scarring, melasma, melanosis, skin rejuvenation, acne vulgaris, and primary hyperhidrosis.
Bonati LM, et al (2017)	Microneedling is a safe, cost-effective, and efficacious treatment option for a variety of dermatologic conditions in all skin types, particularly acne scars and cosmetic rejuvenation; however, treatment benefit has also been observed in varicella scars, burn scars, keloids, acne, alopecia, and periorbital melanosis, improvement of flap and graft survival, and enhanced transdermal delivery of topical products. Side effects were mild and self-limited, with few reports of post-inflammatory hyperpigmentation, and isolated reports of tram tracking, facial allergic granuloma, and systemic hypersensitivity
Hou A, et al (2017)	Microneedling proved to be a generally effective and safe therapeutic option for numerous dermatologic conditions such as scars, acne, melasma, photodamage, skin rejuvenation, hyperhidrosis and alopecia, and for the facilitation of transdermal drug delivery. While permanent adverse events are uncommon, transient erythema and postinflammatory hyperpigmentation are more commonly reported.
Ramaut L, et al (2018)	Microneedling was investigated in experimental settings for its effects on atrophic acne scars, skin rejuvenation, hypertrophic scars, keloids, striae distensae, androgenetic alopecia, melasma and acne vulgaris. This systematic review considered microneedling as a safe and effective therapeutic alternative for the treatment of scars and wrinkles.
<b>Radiofrequency</b> <sup>93-99</sup>	
Ruiz-Esparza J, et al (2003)	Nonablative radiofrequency proved to be a new safe and effective treatment alternative for moderate-to-severe acne vulgaris.
Prieto VG, et al (2005)	The combination of optical and RF energies may be an alternative nonablative modality for the treatment of moderate acne. Clinical improvement may partly be due to the reduction in both perifollicular inflammation and sebaceous gland areas.
Braun M, et al (2007)	Combination of a new radiofrequency device and blue light showed promising results regarding the treatment of acne vulgaris, with improvements observed in the skin tone as an added cosmetic benefit.
Lolis MS, et al (2012)	Radiofrequency is frequently used in dermatology to treat skin laxity, rhytides, acne vulgaris and scarring.
Kaminaka C, et al (2014)	Histological studies of facial acne and atrophic acne scars treated with a bipolar fractional radiofrequency (FRF) system showed that two-pass FRF treatment created deeper dermal thermal injury zones compared to one-pass treatment. Periadnexal collagen was coagulated, as well as that in the sebaceous glands, as evaluated in all cases with two-pass FRF treatment. No severe side-effects were observed after treatment. The level of dermal thermal injury is directly related to the number of passes; moreover, a noticeable benefit of this treatment is the preservation of adnexal structures.
Kaminaka C, et al (2015)	Bipolar fractional radiofrequency (FRF) system significantly improved the atrophic acne scars and acne of Japanese patients, remarkably reducing the acne lesions and sebum production levels, and ameliorating patients' quality of life with minimal side-effects.
Kaminaka C, et al (2016)	Bipolar fractional radiofrequency (FRF) system showed significant long-term effectiveness against acne and mild acne scar, with least side effects.
<b>Radiofrequency microneedling</b> <sup>100-107</sup>	
Lee SJ, et al (2012)	Fractionated microneedle RF can have a positive therapeutic effect on inflammatory acne vulgaris and the related scars. In addition, this technique does not worsen active acne lesions.
Shin JU, et al (2012)	Microneedle radiofrequency (MRF) device and CO2 fractional laser system (FS) can be used for acne vulgaris patients, with the former device more convenient than the latter owing to its short downtime.
Badawi A, et al (2013)	Although fractional radiofrequency microneedling is capable of treating acne, studies assessing the usefulness of the technique are limited. None of the studies have measured objective parameters, such as the number of the inflammatory and non-inflammatory acne lesions or the levels of sebum excretion.

Table 3. Continued

Authors	Findings
Lee KR, et al (2013)	The study demonstrated the sebosuppressive effect of a single fractional radiofrequency microneedle (FRM) treatment.
Kim ST, et al (2014)	The number of both inflammatory and non-inflammatory acne lesions was significantly reduced. The sebum excretion and subject satisfaction scores were statistically favorable. The inflammatory acne lesions were more improved compared with the non-inflammatory lesions. Further observed were certain minor and transient adverse effects such as pinpoint bleeding, pain and erythema.
Lee SJ, et al (2014)	Fractional radiofrequency micro-needle (FRM) devices have been used to treat acne vulgaris. A study of FRM system on 20 patients with moderate inflammatory acne revealed clinical improvement as evidenced by a reduction in lesion count and sebum secretion. Side effects included temporary erythema, tingling, and burning sensation after treatment, resolved two days after the treatment. FRM treatment conducted to reducing inflammatory acne lesions and sebum secretion with the proposed parameters.
Min S, et al (2015)	Comparison of fractional microneedling radiofrequency (FMR) and bipolar radiofrequency (BR) on acne and acne scar revealed that FMR was more effective on acne scars, especially in icepick and boxcar scar. Both inflammatory and non-inflammatory acne lesions were reduced by 80 and 65 % in the FMR-treated side on the final visit of 12 weeks, respectively. FMR treatment resulted in a significant reduction in sebum excretion. Neither treatment showed severe adverse effects, except for erythema. The FMR showed superior efficacy regarding acne and acne scar compared with BR. Increased expression of TGF $\beta$ and collagen I and decreased expression of NF- $\kappa$ B, IL-8 are suggested to be involved in the improvement of acne scar and acne lesion by FMR.
Pai GS, et al (2015)	The temporary aggravation of acne vulgaris or folliculitis was spontaneously resolved within three weeks and no other remarkable side effects were observed with bipolar microneedle radiofrequency (BRF) employed on acne and acne scars. Therefore, this modality can be effectively and safely used to treat acne vulgaris and acne scars in patients with Fitzpatrick skin type IV-V.

## CONCLUSION

Non-medical device-based therapies are largely improving the treatment of active inflammatory acne vulgaris, especially in patients who are not compliant or eligible to consume acne. These patients search for non-medical effective and safe methods such as light, light-based and photodynamic trends or newly emerging methods, namely laser, radiofrequency and microneedling. Overall, this review revealed that these methods are effective, safe and tolerable with relatively long lasting results in treating patients with active inflammatory acne vulgaris.

## Acknowledgement

The author would like to thank Rasoul Akram Clinical Research Development Center (RCRDC) for its technical and editorial support.

**Conflict of Interest:** None declared.

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