British Journal of Dermatology

Volume 142(3) March 2000 pp 413-423

Laser resurfacing of the skin for the improvement of facial acne scarring: a systematic review of the evidence [Original Articles]

JORDAN, R.; CUMMINS, C.; BURLS, A.

Department of Public Health & Epidemiology, University of Birmingham, Edgbaston, Birmingham B15 2TT, U.K.
Accepted for publication 4 November 1999
Correspondence: Rachel Jordan. E-mail: r.e.jordan@bham.ac.uk

Outline

Graphics

- Table 7

Summary

This review presents and evaluates the evidence of the effectiveness of laser resurfacing for facial acne scars. Primary studies of all types of design in any language were identified from MEDLINE, EMBASE, the Cochrane database, Science Citation Index and various internet sites. Studies were accepted if they included patients treated by any laser for atrophic or ice-pick acne scars. The quality of the studies was assessed and data extracted by two independent researchers. There were no controlled trials but 14 case series were found which reported the effects of either the carbon dioxide or erbium:YAG laser. All of the studies were of poor quality. The types and severity of scarring were poorly described and there was no standard scale used to measure scar improvement. There was no reliable or validated measure of patient satisfaction; most improvement was based on visual clinical judgement, in many cases without blinded assessment. The inaccurate use of ordinal scales meant that any improvement was impossible to quantify with any validity, although the evidence suggested that laser treatment had some efficacy (a range in individual patients of 25-90% for both the carbon dioxide laser and the erbium:YAG laser). Changes in pigmentation as a side-effect were common (in up to 44% of patients), although lasting only a few weeks. Laser resurfacing technology is increasingly used in clinical practice to treat acne scars. Despite the poor quality evidence, it is plausible that there is some improvement of acne scarring; there is insufficient information, however, for patients to make informed decisions on whether to opt for treatment and there is not enough evidence to compare the two types of laser. There is a particular lack of information about the psychological effects of acne scar improvement. Good quality randomized controlled trials are needed with standardized scarring scales and validated patient outcome measures in order to assess the effectiveness of laser resurfacing in this group of patients.

Acne scars occur as a result of damage to the skin during healing of acne lesions. Prevalence studies indicate that almost everyone has acne at some stage in their life, although severity, duration and age at onset vary widely.1-8 Scars are more likely to form in people who have had severe acne.5

Historically, acne scars have been treated individually or, for widespread scarring, by general resurfacing of the facial skin using deep chemical peels or dermabrasion. Both general resurfacing methods have problems of precision, control and adverse effects (such as toxicity or infection risks from aerosol particles 9). Recently, lasers have been introduced as a new resurfacing technique. Lasers have greater precision and control and more acceptable risks. This paper is a systematic review to address the effectiveness and safety of lasers in the resurfacing of acne scars. In practice, this involves reviewing the effectiveness of the carbon dioxide laser and the newer erbium:YAG (Er:YAG) laser, although information about other lasers was also sought.

Background

Aetiology and pathology of acne scars

Acne scars occur as a result of damage to the skin during the healing of active acne lesions. There are different types of acne scar. Most people with acne scars have either atrophic or 'ice-pick' scars.5 Atrophic scars are broad, shallow saucer-like indentations and ice-pick scars are frequently deeper with sharp, steep sides. Both result from loss of collagen. Raised scars associated with increased collagen are much rarer. These include hypertrophic and keloid scars which sometimes reach more than 1 cm in diameter.5 One or more types of scar may occur in the same skin area.

Epidemiology of acne and acne scars

The prevalence and severity of acne scarring in the population has not been well studied, although it is probably related to severity and duration of initial acne.[5] A study in the U.K. of 2133 healthy volunteers aged 18-70 years taken from the general population [2] showed 0.7% of people to have acne scars (of the ice-pick type), although only 0.1% (one in seven of acne-scarred people) were considered to have 'disfiguring scars'. Of these acne-scarred subjects, 80-90% had ice-pick and/or macular atrophic facial scars. Hypertrophic and keloid scars on the face were much rarer (6% and 2%, respectively).[5]

The prevalence of acne in the general population has not been frequently assessed, and studies differ in terms of design, subjects examined and criteria for acne. Cross-sectional prevalence studies in which adolescents in the 16-18 year age group (the age of highest prevalence);[1,2,4,10] were examined by dermatologists indicate that the prevalence of at least minimal acne in this age group is 88-99%.[1-4] It is therefore likely that almost everyone will have at least minimal acne at some stage in their life. About 90% have only mild or minimal acne (usually classed as clinically unimportant [2]) and 1% have moderate acne. Few have severe acne.[4] In general, acne is more severe in boys than girls. Acne severity appears also to have declined markedly since 1971,[1,4,6] probably due to better treatment such as isotretinoin.

Quality of life

Active acne has deep psychological effects on some individuals,[11-13] which do not necessarily correlate with the visual deformity apparent to the physician.[13] There is some evidence to suggest that reduced academic achievement and employment opportunities are associated with people who have acne,[11] as well as general social difficulties. The psychological effects of acne scarring are not well documented, although intuitively they could cause similar problems to other facial disfigurements.

Treatment of acne scars

Treatment of acne scars has traditionally achieved limited success. Individual scars can be treated by punch biopsy followed by closure or filling with grafted dermis, fat, polysaccharide matrix or collagen.[14,15] These methods are time consuming, often temporary,[14] and imperfect: the filled areas may remain raised or depressed compared with the surrounding normal skin, and may need planing afterwards.[16] Small areas of scarring can be treated by surgical excision, creating a line scar which can be aligned with natural facial creases to improve the appearance. Patients with larger areas of scarring can be treated by resurfacing the whole face or by cosmetic unit. Resurfacing involves the removal of the epidermis and upper dermis without extending beneath the skin appendages (sebaceous glands, hair follicles and sweat ducts), thereby allowing regeneration of the skin and also promoting collagen production.[9,17] It is generally most suitable for the skin of the face which has more appendages and therefore greater capacity to regenerate than the skin of the trunk.[9] Methods of resurfacing include deep chemical peels using a strong acid such as phenol or trichloroacetic acid, dermabrasion, or laser resurfacing.[18] This latter method has the potential to be more precise and controlled compared with other resurfacing techniques; it is less operator dependent, the procedure can be better visualized and damage to the surrounding skin areas is limited.

Lasers are identified by the gain medium with which the light source is intensified; facial resurfacing has been carried out using the carbon dioxide laser and the Er:YAG laser. The carbon dioxide laser emits radiation at a wavelength of 10,600 nm in the far infrared spectrum.[18] This radiation is absorbed totally in a depth of 0.1-0.2 mm water and is therefore suitable for targeting and vaporizing cutaneous tissue because skin cells are composed of 85-90% water.[9] The laser may be controlled by the operator using a handpiece, or by a computerized scanning device which can remove skin to a specific and uniform depth.[19] Coagulation of the local blood vessels caused by the laser ensures a bloodless field and therefore good visualization.[19] The

carbon dioxide laser is available in a high-energy superpulsed form (for example, the UltraPulse laser) or a very fast continuous form (such as the SilkTouch laser). Both types of laser act faster than the thermal relaxation time of the volume of skin ablated,18,19 thereby maximizing the specific effect required but minimizing damage to the surrounding areas. The Er:YAG laser emits radiation at a shorter wavelength (2936 nm) than the carbon dioxide laser so that the laser energy is 13 times more strongly absorbed by the water within the skin cells.20 This laser is also pulsed, so both features together mean that damage to surrounding areas is kept low. However, haemostasis is not complete: pin-point bleeding occurs at the dermoepidermal junction,21 potentially restricting the use of the Er:YAG at greater depths.22 The Er:YAG laser can also be controlled either by a handpiece or a computerized scanning device. It is thought that the Er:YAG laser may be less effective than the carbon dioxide laser in ablating the skin, but might have a better side-effect profile,23 although this is not proven. There is now laser equipment available which incorporates both the carbon dioxide and Er:YAG lasers.

The disadvantages of all resurfacing techniques are that very deep scarring, particularly ice-pick scarring, may not be vastly improved,9 the procedure of resurfacing can be traumatic and painful 24 (requiring a local or general anaesthetic 19) and the skin will be red and swollen for several weeks.24-32 Aftercare is often quite restrictive.19 Potential adverse effects include bacterial and viral infection,27,31 further scarring 19,24 and hyper- or hypopigmentation can occur in some skin types.19 Resurfacing procedures are not used for hypertrophic and keloid scars as there is a high risk of recurrence of scarring.19

Current practice in the U.K.

In the U.K., both carbon dioxide and Er:YAG laser treatment for acne scarring is available in private practice. The average cost of laser resurfacing per person in private practice in the U.K. is about £3300, including three consultations and assuming only one resurfacing session is required (calculated from information supplied by Lasercare Clinics). Under the National Health Service (NHS), access is very limited. Treatment for acne scars occupies a grey area as it is often seen as cosmetic improvement only. As such, many health authorities will not fund laser resurfacing for acne scars, either within NHS hospitals or as extracontractual referrals to private clinics. Some health authorities authorize funding only to a limited number of patients, and each case is considered individually before authorization is granted. There is no clear nationwide policy (Daron Seukeran, personal communication). A survey of 27 dermatologists in the West Midlands in 1998 found that 15 of them referred patients for laser treatment, eight referred patients for dermabrasion or chemical peel and four did not refer patients for any further treatment. Together they saw at least 310 patients per year about their acne scars, and referred about 105 of them for further treatment. They estimated that should a treatment be found effective, the future annual need for treatment would exceed 175 patients per year in the West Midlands, i.e. 33 per million population, equating to about 1600 patients per annum in the whole of England.

Review question

The purpose of this review was to determine the overall effectiveness of lasers in the treatment of atrophic and ice-pick facial acne scars in achieving cosmetic and psychological improvements compared with no treatment, by a systematic review of the primary literature.

Methods

Search strategy for identification of studies

Reviews and primary studies were identified by the following methods.

(i) Search of MEDLINE (1966-April 1998) and EMBASE (1988-March 1998) electronic databases using the Medical Subject Headings 'acne vulgaris', 'cicatrix', 'lasers' and 'laser surgery' and the text words 'acne',

'cicatrix', 'scars', 'lasers', 'carbon dioxide lasers' and 'erbium:YAG lasers'.

(ii) Search of the Science Citation Index (to March 1998) using the search terms as above.

(iii) Search of the Cochrane database, York database (CRD, DARE), INAHTA, U.K. NHS HTA internet site, Bandolier, Effectiveness Matters and Effective Healthcare.

(iv) Personal contact with dermatologists and plastic surgeons.

(v) Citations from reference lists.

Criteria for including studies

Study design. Primary studies of all types were included.

Study population. Studies were accepted if they included some patients treated for atrophic or ice-pick acne scars. Treatments for hypertrophic acne scars (including acne keloid scars) or rhinophyma (a condition arising from acne rosacea) were not considered.

Types of intervention. These were carbon dioxide laser resurfacing, Er:YAG laser resurfacing and other laser resurfacing techniques.

Outcome measures. Studies were excluded if there were no details of either primary outcomes of scar improvements or side-effects.

Methods of the review

Data extraction. Data were extracted by two researchers independently and differences discussed.

Appraisal of studies: points for assessing quality. The following criteria were used in the assessment of case series. (i) Were the data collected prospectively or retrospectively and could this be assessed? (ii) How were the patients selected and how representative is the sample with regard to the population of acne-scarred patients requiring treatment? Was the selection of patients described? (iii) How well were the patients described? (iv) How was any improvement assessed? (v) Who were the observers and were the observers blinded? (vi) Were the baseline data, outcome data, follow-up and loss to follow-up reported in full? Were all patients accounted for in the analysis?

Synthesis of the data. Effectiveness estimates and details of side-effects were summarized as a range from all studies.

Results

Quality and characteristics of studies

No controlled trials of laser resurfacing to improve acne scars were found; however, 16 case series were identified which included patients with atrophic or ice-pick facial acne scars undergoing laser resurfacing. The carbon dioxide laser was used in 13 studies,[24-36] and the Er:YAG laser in the other three.[22,37,38] In one study,[38] the Er:YAG laser was used in combination with the carbon dioxide laser for the deeper scars. Two studies were excluded as they did not report any outcomes.[34,36] Tables 1 and 2 summarize the quality of each included case series for a range of assessment points (see Methods) and Tables 3-6 describe the characteristics and results of each study.

Graphic
[Help with image viewing]

Table 1. Quality checklist: acne scars treated with the carbon dioxide laser: case series

Graphic
[Help with image viewing]

Table 2. Quality checklist: acne scars treated with the erbium:YAG laser: case series

Graphic
[Help with image viewing]

Table 3. Carbon dioxide laser treatment of acne scars: summary of included case series

Graphic
[Help with image viewing]

Table 4. Carbon dioxide laser treatment of acne scars: side-effects, preoperative treatments and postoperative treatments

Graphic
[Help with image viewing]

Table 5. Erbium:YAG laser treatment of acne scars: summary of included case series

Graphic
[Help with image viewing]

Table 6. Erbium:YAG laser treatment of acne scars: side-effects, preoperative treatments and postoperative treatments

All of the studies were of poor quality and 11 of the 14 included studies included fewer than 15 relevant patients. In no case was there a clear description of the study design. Case series as a whole are subject to bias and will tend to overestimate the effects.

Only three studies described patients only being treated for acne scars;22,25,26 the remainder included patients with other types of scars or patients having the resurfacing treatment for the improvement of wrinkles, some of which gave separate details for acne-scarred patients. The types and severity of scarring prior to treatment were not well described; there were no standard or validated scales used to describe either variable. Several studies excluded patients who had taken isotretinoin as an acne treatment in the last 6 months to 2 years,25,27,28,30-32 because it is thought that this treatment alters the follicles and impairs regeneration of the skin after resurfacing, thereby increasing the risk of scarring.9,19

The interventions were clearly described, but different in all studies. Laser settings varied between studies and sometimes within studies, as did number of treatment passes. Other pre-operative and post-operative treatments varied between series.

The methods for measuring scar improvement varied between studies. Valid and reliable measures to determine an improvement in scarring might include optical profilometry of the skin before and after treatment using silicon impressions and digital analysis, and patient satisfaction and psychological status, measured by standard quality of life or psychological questionnaires before and after treatment. However, no studies measured the psychological status of the patients either before or after treatment and only one study reported the results of optical profilometry, but in a subset of patients.32 The remainder measured

improvement clinically, usually by non-blinded observers, even though it is known that results quantified by clinicians may not reflect patient perception.39 Most of these studies had taken photographs at baseline and at outcome,22,24-27,29,30,32,33,35,37 although this method of assessment is not generally held to be very accurate or reproducible. The scale for quantifying visual improvement varied widely and was usually based on subjective percentage improvement, which would depend on initial severity. No scale had had its validity or reliability investigated. Mean improvements were all calculated from ordinal scales. Medians rather than means should have been reported because the properties of ordinal scales are not known and points on the scale are not necessarily equidistant. Reported means from these studies reflect the range and number of categories available, and results cannot be compared across studies.

Frequently there was no report of the completeness of follow-up or reasons for any loss to follow-up. It is likely that in most cases the follow-up (which ranged from 2 weeks to 23 months) would be too short to examine the eventual effects of resurfacing. Although the erythema subsides on average after 2 months, there is often a slight residual swelling, which may last longer and which may artificially enhance the appearance of the skin. Any improvement recorded before the residual swelling subsides might overestimate the final effect.

Effectiveness of carbon dioxide laser resurfacing

The largest and best quality study 25 was a series of 50 patients with acne scars. The improvement in scarring (although using photographs) was assessed blindly. Patients had moderate-severe scarring (no definitions given) and a mean overall improvement (based on an ordinal scale) of 81.4% (range 70-90). Thirty-six per cent of patients had transient hyperpigmentation, although this resolved in 3 months. Fourteen per cent of patients developed milia, but there were no bacterial or viral infections.

Overall results from all the studies showed a mean clinical scar improvement in individuals ranging from 25%30 to 90%25 where quantified (see Table 3). One study indicated that the prognosis for mild scarring was better than for severe scarring; 26 no other study quantified the effects by severity of scarring. Improvement was not graded by scar type. The implausibly high values of improvement seen in several studies 25 reflect the bias of case series in general which tend to overestimate effects.27,29 The smallest improvements were seen in a group of Asian patients 30 with darker skins.

Re-epithelialization was complete after 7-10 days where reported, and erythema lasted about 2 months on average. Most studies detailed the presence or absence of other side-effects: hyperpigmentation was quite common (in up to 45% of patients), as was hypopigmentation, although both were usually transient (lasting for a few weeks only). Details of skin type in these patients were frequently absent. Bacterial, viral and fungal infections were rare and disappeared on treatment, as were cases of scarring resulting from resurfacing. One case of toxic shock syndrome following staphylococcal infection and necessitating intensive care unit admission was reported.

Effectiveness of resurfacing using the erbium:YAG laser

Evidence of the effectiveness of the Er:YAG laser in the treatment of acne scarring is sparse and poor. The largest case series 22 (only 21 patients) suggests that the median visual improvement might be about 50%. Over the three studies, individual patients ranged from <= 25%22 to 90%38 scar improvement (based on ordinal scales). Re-epithelialization occurred in about 10 days, and although based on minimal evidence, erythema lasted for 1-3 months, occasional transient hyperpigmentation was observed, but infection was rare. Table 7 summarizes the range of values for scar improvement and side-effects observed in the included case series, for both the carbon dioxide and the Er:YAG laser.

Graphic

[Help with image viewing] Table 7. Summary of effectiveness information

Discussion

Despite the paucity of good quality information, it is important that a systematic search for the evidence that is available is carried out and the results presented in order to inform patients, clinicians and healthcare purchasers. Although there may be some benefit from laser resurfacing, the case series available are poorly designed so that the benefits have not been quantified adequately and, due to bias inherent in case series, are almost certainly overestimates of the true treatment effect. The data are more sparse for the Er:YAG laser than the carbon dioxide laser, and the evidence is inadequate to compare the two lasers.

A summary of the overall effects (see Table 7) suggests that following laser resurfacing treatment with the carbon dioxide laser, patients will experience: re-epithelialization after 7-14 days; erythema for 1.5-4 months; a high chance of temporary side-effects (pigmentary changes in up to 44%, recurrence of acne/milia in up to 84% and other side-effects including scarring, hypersensitivity and infection in up to 9% of patients); a possibility of life-threatening outcomes including hospitalization due to systemic infection (although rare); scar improvement in the range 25-90%.

Data on the Er:YAG laser are very sparse, and there is no good evidence at present to suggest that the time to re-epithelialization, the length of erythema or the improvement of scars is any different from with the carbon dioxide laser. The chance and duration of pigmentary change may be less than with the carbon dioxide laser because the depth of resurfacing is probably less, although information on side-effects is too scanty to quantify.

There is also no evidence on the impact of treatment with either laser on psychological status or quality of life. Patients should be made aware that no randomized controlled trials have been carried out and that any results presented will be inflated by bias and subject to clinicians' perceptions.

While individual patients are free to purchase aesthetic surgery treatment, evidence of effectiveness should be available to consumers. In this case, there is no clear scientific evidence. Facial disfigurement can have an important impact on a patient's social and psychological functioning 11 and it is this feature of the evidence which is most lacking. It can be argued that there is a presently under-recognized need for treatment in the U.K. and that proven effective treatment should be available under the NHS. Costs of laser treatment at about £3300 per person would be relatively cheap should there be proven clinical and psychological benefit, as the effect on the quality of patients' lives would be long-term, often in excess of 40 years. However, lack of convincing evaluation of laser technology means that without randomized controlled trials, laser resurfacing cannot be recommended, despite an identifiable patient need and demand for treatment.

Acknowledgments

This study was funded by the U.K. West Midlands National Health Service Regional Public Health Levy. Thanks to Hywel Williams and Daron Seukaran for their valuable comments.

References

1 Burton JL, Cunliffe WJ, Stafford I, Shuster S. The prevalence of acne vulgaris in adolescence. Br J Dermatol 1971; 85: 119-26. Bibliographic Links [Context Link]

2 Cunliffe WJ, Gould DJ. Prevalence of facial acne vulgaris in late adolescence and in adults. Br Med J 1979; i: 1109-10. [Context Link]

3 Lello J, Pearl A, Arroll B et al. Prevalence of acne vulgaris in Auckland senior high school students. NZ Med J 1995; 108: 287-9. Bibliographic Links [Context Link]

4 Rademaker M, Garioch JJ, Simpson NB. Acne in schoolchildren: no longer a concern for dermatologists. Br Med J 1989; 298: 1217-19. Bibliographic Links [Context Link]

5 Layton AM, Henderson CA, Cunliffe WJ. A clinical evaluation of acne scarring and its incidence. Clin Exp Dermatol 1994; 19: 303-8. Bibliographic Links [Context Link]

6 Fellowes HM, Billewicz WZ, Thomson AM. Is acne a sign of normal puberty? A longitudinal study. J Biosoc Sci 1981; 13: 401-7. Bibliographic Links [Context Link]

7 Stern RS. The prevalence of acne on the basis of physical examination. J Am Acad Dermatol 1992; 26: 931-5. Bibliographic Links [Context Link]

8 Healy E, Simpson N. Acne vulgaris, Br Med J 1994; 308: 831-3. [Context Link]

9 Weinstein C, Roberts TL. Aesthetic skin resurfacing with the high-energy ultrapulsed CO_2 laser. [Review.] [157 refs.] Clin Plast Surg 1997; 24: 379-405. Bibliographic Links [Context Link]

10 Kilkenny M, Stathakis V, Hibbert ME et al. Acne in Victorian adolescents: associations with age, gender, puberty and psychiatric symptoms. J Paediatr Child Health 1997; 33: 430-3. Ovid Full Text Bibliographic Links [Context Link]

11 Cunliffe WJ. Acne and unemployment. (Letter.) Br J Dermatol 1986; 115: 386. [Context Link]

12 Finlay AY, Khan GK. Dermatology Life Quality Index (DLQI)-a simple practical measure for routine clinical use. Clin Exp Dermatol 1994; 19: 210-16. Bibliographic Links [Context Link]

13 Jowett S, Ryan T. Skin disease and handicap: an analysis of the impact of skin conditions. Soc Sci Med 1985; 20: 425-9. Bibliographic Links [Context Link]

14 Kaplan EN. Falces E, Tolleth H. Clinical utilization of injectable collagen. Ann Plast Surg 1983; 10: 437-51. Bibliographic Links [Context Link]

15 Moritz D. Surgical corrections of acne scars. Dermatol Nurs 1992; 4: 291-9. Bibliographic Links [Context Link]

16 Stegman SJ, Tromovitch TA. Cosmetic dermatologic surgery. Arch Dermatol 1982; 118: 1013-16. Bibliographic Links [Context Link]

17 Weinstein C. Carbon dioxide laser resurfacing. Long-term follow-up in 2123 patients. (Review.) Clin Plast Surg 1998; 25: 109-30. [Context Link]

18 Ries WR, Speyer MT. Cutaneous applications of lasers. Otolaryngol Clin North Am 1996; 29: 915-29. Bibliographic Links [Context Link]

19 West TB. Laser resurfacing of atrophic scars. (Review.) Dermatol Clin 1997; 15: 449-57. [Context Link]

20 Kaufmann R, Hartmann A, Hibst R. Cutting and skin-ablative properties of pulsed mid-infrared laser surgery. J Dermatol Surg Oncol 1994; 20: 112-18. Bibliographic Links [Context Link]

21 Hohenleutner U, Hohenleutner S, Baumler W, Landthaler M. Fast and effective skin ablation with an

Er:YAG laser: determination of ablation rates and thermal damage zones. Lasers Surg Med 1997; 20: 242-7. Bibliographic Links [Context Link]

22 Kye YC. Resurfacing of pitted facial scars with a pulsed Er:YAG laser. Dermatol Surg 1997; 23: 880-3. Bibliographic Links [Context Link]

23 Teikemeier G, Goldberg DJ. Skin resurfacing with the erbium:YAG laser. Dermatol Surg 1997; 23: 685-7. Bibliographic Links [Context Link]

24 Bernstein LJ, Kauvar AN, Grossman MC, Geronemus RG. The short- and long-term side effects of carbon dioxide laser resurfacing. Dermatol Surg 1997; 23: 519-25. Bibliographic Links [Context Link]

25 Alster TS, West TB. Resurfacing of atrophic facial acne scars with a high-energy, pulsed carbon dioxide laser. Dermatol Surg 1996; 22: 151-4. Bibliographic Links [Context Link]

26 Apfelberg DB. Ultrapulse carbon dioxide laser with CPG scanner for full-face resurfacing for rhytids, photoaging, and acne scars. Plast Reconstr Surg 1997; 99: 1817-25. Ovid Full Text Bibliographic Links [Context Link]

27 Apfelberg DB. A critical appraisal of high-energy pulsed carbon dioxide laser facial resurfacing for acne scars. Ann Plast Surg 1997; 38: 95-100. Bibliographic Links [Context Link]

28 Apfelberg DB. The Ultrapulse carbon dioxide laser with computer pattern generator automatic scanner for facial cosmetic surgery and resurfacing. Ann Plast Surg 1996; 36: 522-9. Bibliographic Links [Context Link]

29 Bernstein LJ, Kauvar AN, Grossman MC, Geronemus RG. Scar resurfacing with high-energy, short-pulsed and flashscanning carbon dioxide lasers. Dermatol Surg 1998; 24: 101-7. Bibliographic Links [Context Link]

30 Ho C, Nguyen Q, Lowe NJ et al. Laser resurfacing in pigmented skin. Dermatol Surg 1995; 21: 1035-7. Bibliographic Links [Context Link]

31 Rubach BW, Schoenrock LD, Histological and clinical evaluation of facial resurfacing using a carbon dioxide laser with the computer pattern generator. Arch Otolaryngol Head Neck Surg 1997; 123: 929-34. Ovid Full Text Bibliographic Links [Context Link]

32 Shim E, West TB, Velazquez E et al. Short-pulse carbon dioxide laser resurfacing in the treatment of rhytides and scars: a clinical and histopathological study. Dermatol Surg 1998; 24: 113-17. [Context Link]

33 David LM, Sarne AJ, Unger WP. Rapid laser scanning for facial resurfacing. Dermatol Surg 1995; 21: 1031-3. [Context Link]

34 Garrett AB, Dufresne RGJ, Ratz JL, Berlin AJ. Carbon dioxide laser treatment of pitted acne scarring. J Dermatol Surg Oncol 1990; 16: 737-40. Bibliographic Links [Context Link]

35 Ruiz-Esparza J, Barba GJ, Gomez de la Torre OL et al. UltraPulse laser skin resurfacing in Hispanic patients. A prospective study of 36 individuals. Dermatol Surg 1998; 24: 59-62. Bibliographic Links [Context Link]

36 Ting JC. Carbon dioxide laser treatment of facial scars. In: ISCLS Abstracts. American Society for Dermatologic Surgery, Inc. 1998, 118 (Abstr.). [Context Link]

37 Drnovsek-Olup B, Vedlin B. Use of Er:YAG laser for benign skin disorders. Lasers Surg Med 1997; 21: 13-19. Bibliographic Links [Context Link]

38 Weinstein C. Computerized scanning erbium:YAG laser for skin resurfacing. Dermatol Surg 1998; 24: 83-9. Bibliographic Links [Context Link]

39 Fitzpatrick TB. Ultraviolet-induced pigmentary changes: benefits and hazards. Curr Probl Dermatol 1986; 15: 25-38. Bibliographic Links [Context Link]

40 Krowchuk DP, Stancin T, Keskinen R et al. The psychosocial effects of acne on adolescents. Pediatr Dermatol 1991; 8: 332-8.

Key words: acne; carbon dioxide laser; erbium:YAG laser; laser treatment; scarring; systematic review

---

Accession Number: 00002300-200003000-00004
