

Fractional Carbon Dioxide Laser Resurfacing of Rhytides and Photoaged Skin – A Prospective Clinical Study on Patient Expectation and Satisfaction

Elisabeth Kohl, MD,^{1*} Julia Meierhöfer,¹ Michael Koller, PhD,² Florian Zeman, MA,² Leopold Groesser, MD,¹ Sigrid Karrer, MD PhD,¹ Ulrich Hohenleutner, MD PhD,¹ Michael Landthaler, MD PhD,¹ and Silvia Hohenleutner, MD¹

¹Department of Dermatology, University Medical Center Regensburg, 93053, Regensburg, Germany

²Center for Clinical Studies, University Hospital Regensburg, 93053, Regensburg, Germany

Background: Fractional CO₂-laser resurfacing is increasingly used for treating rhytides and photoaged skin because of its favorable benefit-risk ratio. A key outcome measure and treatment goal in aesthetic laser therapy is patient satisfaction. However, few data are available on patient-reported outcomes after fractional ablative skin-resurfacing.

Objectives: To compare patient expectations before and patient satisfaction after three fractional CO₂-laser treatments and to correlate objectively measured wrinkle reduction with patient satisfaction after treatment.

Methods: We investigated patient expectation and satisfaction using a 14-item questionnaire in 24 female patients. We assessed the skin-related quality of life and patient satisfaction with skin appearance. We profilometrically measured wrinkle size in four facial areas before and three months after treatment and investigated correlations between wrinkle reduction and patient satisfaction.

Results: The high patient expectations before treatment (ceiling effect) were actually slightly exceeded. The average score of 14 items delineating patient satisfaction with laser treatment was higher (4.64 ± 0.82 ; $n = 24$) than the respective expectations before treatment (4.43 ± 0.88 ; $n = 24$). Skin-related quality of life and patient satisfaction with skin appearance had significantly improved after the last treatment. Patients dissatisfied with their skin appearance before treatment (mean 2.1 ± 1.5 ; evaluated on a scale ranging from 0–6) were satisfied (mean 5.1 ± 1.2) ($P < 0.001$) with skin appearance at the follow-up. Patient satisfaction with skin appearance was not correlated to the profilometrically measured reduction of wrinkle size of any facial area.

Conclusions: Our results show high patient satisfaction with ablative fractional skin resurfacing, also regarding improved self-esteem and self-satisfaction despite high pre-treatment expectations. Skin-specific quality of life had significantly improved. Thus, this treatment modality can be recommended for patients with photoaged skin wishing to improve skin appearance. *Lasers Surg. Med.* 9999:1–9, 2014. © 2015 Wiley Periodicals, Inc.

Key words: ablative fractional skin resurfacing; patient benefit; patient-reported outcomes; skin aging; wrinkles

INTRODUCTION

Physical appearance largely influences how people are perceived by others[1–6]. Physical attractiveness is associated with a higher socio-economic position and self-esteem, elicits positive personality attributions and influences partner choice[6–8]. Smooth facial skin is correlated with perceived attractiveness, health, and youthfulness[3–5]. Consequently, facial rhytides and mottled skin may negatively influence perceived attractiveness, self-esteem, and body image[6,9]. Many people undergo aesthetic procedures, such as injections with botulinum toxin and fillers, surgical procedures, and laser therapy[10], to obtain a youthful and attractive appearance. Fractional CO₂-laser resurfacing is increasingly used for treating rhytides and photoaged skin because of its favorable risk-benefit ratio. Several trials have shown improvement in skin pigmentation, laxity, texture, and in rhytides[11–15]. Additionally, neocollagenesis and intense collagen remodeling was shown by histology and *in vivo* confocal microscopy[16–18].

Despite the clinical efficacy of fractional CO₂-laser resurfacing, few data are available on patient benefit and satisfaction. Because patient satisfaction is a key outcome measure and treatment goal[1], assessing

Conflict of Interest Disclosures: All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest and none were reported.

Research Funding: This study was partially funded by Alma Lasers GmbH Nuremberg, Germany. Alma Lasers GmbH was not involved in design and conduct of the study, collection, management, analysis and interpretation of data, preparation, review, approval, and decision to submit the manuscript for publication.

*Correspondence to: Elisabeth Kohl, MD, Department of Dermatology, University Hospital Regensburg, Franz-Josef-Strauss-Allee 11, 93053 Regensburg, Germany.

E-mail: Elisabeth.Kohl@ukr.de

Accepted 22 November 2014

Published online in Wiley Online Library

(wileyonlinelibrary.com).

DOI 10.1002/lsm.22326

treatment benefits from a patient’s perspective is an important approach in aesthetic laser therapy. Thus, we evaluated patient benefits after fractional CO₂-laser resurfacing by comparing treatment expectations with patient-reported outcomes by means of a questionnaire. We also investigated whether profilometrically measured wrinkle reduction was correlated with patient-reported outcomes.

MATERIALS AND METHODS

Study Design

In a prospective mono-centric one-armed study, 24 patients were compared before and after therapy regarding expectations, subjective treatment benefits, and objective treatment efficacy. The study and the study protocol were approved by the Ethics Committee of the University of Regensburg (reference number 11-101-0050). Primary outcome measures, which had been defined in the study protocol, were reduction of wrinkle size as well as patient satisfaction. The results regarding wrinkle reduction and profilometric measurements had been published previously. Written informed consent was obtained from each patient before enrolment.

Inclusion and Exclusion Criteria

Inclusion criteria were oral and written informed consent, request for fractional CO₂-laser treatment of wrinkles and photoaged skin, Caucasian woman aged ≥ 18 years and Glogau photodamage classification type II–IV. Exclusion criteria were pregnancy, cosmetic procedures six months before study treatment (for example, botulinum toxin, chemical peeling, laser therapy, or filler), Fitzpatrick skin type IV–VI and suspected lack of compliance.

Study Treatment

Each patient received three full facial treatments at intervals of one to six months. The treating physician also conducted the informed consent discussion—including a description of the laser procedure and possible risks—with every participant one to four weeks before the first treatment. Possible treatment benefits were a more even skin tone and reduced wrinkles. We photo-documented every participant before each treatment and three months after the last treatment in a standardized manner using a FotoFinder mediscope (FotoFinder Systems GmbH, Bad Birnbach, Germany). Skin topography was measured in identical areas (forehead, cheeks, perioral, and periorbital area) *in vivo* using an Antera 3DTM (Miravex, Dublin, Ireland) skin imaging device before the first treatment and at the three-month follow-up[19,20]. Aciclovir (2 × 400 mg) was given as a herpes prophylaxis two days before until five to seven days after the treatment. For pain management, we administered 1 g metamizol p.o. and 800 mg ibuprofen 30 minutes and two hours before treatment respectively. Laser treatments included the entire face except the area of the eyelids in direct proximity to the lashes. We used a

fractional CO₂-laser (Exelo₂, Alma Lasers, Germany, 10.6 μm, microbeam spot size 250 μm) with adjustable parameters for microspot density, pulse width, and energy. The mean treatment parameters are displayed in Table 1. Pain and thermal injury were minimized by a cold-air cooling device directly attached to the laser scanner (Zimmer Cryo 6, Zimmer MedizinSysteme GmbH, Neu-Ulm, Germany). More details of the laser treatment and profilometric measurements have been described previously[19].

OUTCOME ASSESSMENT

Patient-Reported Outcomes

Dermatology life quality index. The patients filled in the ‘Dermatology Life Quality Index’ (DLQI) questionnaire before the first treatment and three months after the last treatment[21]. The DLQI is the most frequently used dermatology-specific measurement instrument for quality of life. A validated German translation is available[22–27]. The DLQI consists of ten questions regarding a patient’s perception of skin disease over the seven days before treatment and questions the effects of the skin disease on feelings, daily activities, work or school, personal relationships, and side effects. Each question is to be answered according to a 4-point scale: 0 (not at all), 1 (a little), 2 (a lot) or 3 (very much). A response option ‘not relevant’ with a score of 0 is also available. The individual score values are added up to a total score ranging from 0 to 30. Higher scores indicate more severely impaired quality of life. The total scores are subdivided into five assessment categories: no impairment (0–1), slight impairment (2–5), moderate impairment (6–10), very large impairment (11–20) and extremely large impairment (21–30)[23].

Patient expectation and fulfillment. A study-specific measure was created according to a procedure described by Koller et al.[28]. In a small pilot-study, ten patients were interviewed before laser therapy. A list of 20 issues or symptoms to be improved by laser treatment was developed. Based on these issues, we created a 14-item questionnaire with 14 treatment aims in cooperation with a psychologist. Shortly before the first treatment, study participants were asked about their expectations towards laser treatment (to what extent they expected that each of the 14 treatment aims will have improved after laser therapy). Participants had to rate each of the 14 items on a 7-point scale (0 = disagree strongly, 1 = disagree, 2 = disagree somewhat, 3 = partly agree and partly

TABLE 1. Average Treatment Parameters (n = 25) (mean ± SD)

	Tx 1	Tx 2	Tx 3
Pulse duration [ms]	2.5 ± 0.4	2.5 ± 0.3	2.5 ± 0.3
Pulse energy [mJ]	38.4 ± 5.0	38.0 ± 4.1	38.6 ± 5.1
Microspots per cm ²	236 ± 62	292 ± 64	340 ± 48
Airflow setting	1.4 ± 0.7	1.3 ± 0.4	1.3 ± 0.5

disagree, 4 = agree somewhat, 5 = agree, 6 = agree strongly).

After the last treatment, we asked how much each issue or symptom had improved (to what extent expectations had been met) using the same 14-item questionnaire. Again, patients used the 7-point scale described above. We also asked the patients about their level of satisfaction with overall skin appearance (very dissatisfied, dissatisfied, somewhat dissatisfied, partly dissatisfied and partly satisfied, somewhat satisfied, satisfied, and very satisfied).

When ten dermatologists who were not involved in the study were asked to estimate patient expectations, they also rated these 14 items on a 7-point scale.

In Vivo Skin Measurements

We measured the periorbital and perioral area, the forehead and the cheeks of each patient *in vivo* before and three months after the last treatment. The follow-up evaluation was done three months after the third treatment. Because of the lack of reference points, measurements and analysis were sometimes not possible for technical reasons. For analysis, we selected the deepest wrinkle in the pre-treatment image and marked the wrinkle in both images. Wrinkle size was calculated as the average area of the wrinkle cross-sections multiplied by a constant and the mean wrinkle depth as the average of the maximum depth within the cross-sections along the wrinkle.

Clinical Evaluation

Clinical improvement of the overall appearance was assessed by two experienced dermatologists, who were not involved in the study and who made their ratings independently of each other. Follow-up pictures taken three months after the third treatment were compared to pre-treatment pictures regarding overall appearance. Ratings were made on a 5-point scale with the following response categories: 0 (no improvement), 1 (minor or mild improvement, 1–25%), 2 (moderate improvement, 26–50%), 3 (marked improvement, 51–75%), and 4 (very significant improvement, 76–100%).

Statistical Analysis

Because of the lack of experience in patient-reported outcomes in this medical field, sample size calculation was based on the assessed reduction of wrinkle depth using 3-dimensional (3D) *in-vivo* optical skin imaging as described elsewhere[19]. We assumed that treatment would result in a mean reduction of 30 μm with a standard deviation of 50 μm . Furthermore, we assumed that the correlation between score 1 (before treatment) and score 2 (after treatment) was $r = 0.50$. Setting the alpha error at 0.05 and the beta error at 0.20 (= power 80%), $n = 24$ patients were required to detect the proposed mean reduction using a paired *t*-test. To compensate for four dropouts, 28 participants were enrolled into this study. SAS 9.3 was used for sample size calculation.

Statistical analyses commenced with descriptive statistics, using counts, percentages, means, and standard deviations. Inter-rater agreement was assessed using Cohen's weighted kappa (two raters; one ordinal scale; squared weights). Clinical evaluations were made by two investigators independently of each other. The inter-rater agreement with regard to overall appearance was moderate ($\kappa = 0.64$). Before-and-after differences were calculated using paired *t*-tests and Wilcoxon tests. Correlations were analysed by a Spearman's rank correlation test. *P* values < 0.05 were considered significant. The software package SPSS for Windows, Version 21.0, was used for all statistical analyses.

RESULTS

Patient Characteristics

Of 35 women screened, 28 meeting all inclusion criteria and none of the exclusion criteria were included. Patients were recruited between April and December 2011. Two patients dropped out after the first treatment, one because of heart disease independent of laser treatment and the other for professional reasons. Because one patient had filled in the pre-treatment questionnaire incompletely, several variables could not be analyzed. One patient did not appear at follow-up. Thus, data analyses were based on $n = 24$ patients. The mean age was 56.9 ± 9.0 years (range: 41–75 years).

Treatment Results

Three months after the last treatment, profilometric analysis showed significantly reduced wrinkle size and depth in all four facial areas investigated (Table 2). As we published recently, improvements varied across treatment areas and the best improvements regarding wrinkle size and depth were observed on the cheeks (-58.3% and -51.3%). Size and depth of periocular wrinkles improved more than perioral wrinkles or wrinkles on the forehead. The distribution of melanin, measured as melanin variation, was significantly more even after treatment. Similar results were found in the periocular area (-24.0%, $P < 0.001$, $n = 22$) and on the forehead (-23.6%, $P < 0.001$, $n = 25$) and the cheeks (-21.4%, $P = 0.012$, $n = 8$)[19].

Clinical evaluations were made by two investigators independently of each other. Using a 5-point scale, the investigators considered the improvement for overall appearance moderate (26–50%). The inter-rater agreement with regard to overall appearance was moderate ($\kappa = 0.64$). The average across the two assessments was used for further statistical analyses.

Pain during treatment was assessed using a visual analogue scale (0 representing no pain and 10 worst possible pain). Patients reported a score of 5.7 for the first treatment, 6.1 for the second treatment and 6.2 for the third treatment, which may be viewed as moderate pain. Side effects after treatment were documented at visit 2 and 3 and at follow-up. All patients experienced crusting, swelling, and erythema after each treatment, which lasted longest after the first treatment. On average, crusting

TABLE 2. Wrinkle Size and Depth Before Treatment and Three Months After the Last Treatment and Mean Reduction (%) at Three-Month Follow-Up (mean \pm SD)

Area	Parameter	Before treatment	3 months after the last treatment	<i>P</i>	Mean reduction in %
Periorbital (n = 21)*	wrinkle size	34.4 \pm 16.1	22.3 \pm 9.0	<0.001	35.1
	wrinkle depth	0.10 mm \pm 0.04 mm	0.07 mm \pm 0.03 mm	0.001	31.3
Perioral (n = 24)*	wrinkle size	40.7 \pm 16.0	31.3 \pm 12.1	<0.001	23.2
	wrinkle depth	0.12 mm \pm 0.04 mm	0.10 mm \pm 0.03 mm	<0.001	19.8
Cheek (n = 7)*	wrinkle size	33.9 \pm 16.3	14.1 \pm 10.2	0.018	58.3
	wrinkle depth	0.10 mm \pm 0.04 mm	0.05 mm \pm 0.03 mm	0.018	51.3
Forehead (n = 23)*	wrinkle size	30.0 \pm 18.3	22.4 \pm 12.7	<0.001	25.3
	wrinkle depth	0.09 mm \pm 0.05 mm	0.07 mm \pm 0.04 mm	0.001	23.0

*varying sample sizes because of missing reference points and inconsistent matching of the images.

started one day and swelling two days after treatment. Duration of post-treatment crusting and erythema was on average 4 days and duration of post-treatment erythema on average 5 days. One patient developed herpes labialis after discontinuation of Aciclovir five days after laser treatment. No further side effects were observed.

Patient-Reported Outcomes and Dermatology Life Quality Index

The already high patient expectations before therapy were slightly exceeded. Table 3 shows expectations in the order of priorities. The average score of each of the 14 items evaluated after treatment ("what benefit did you experience through the laser treatment?") was higher (4.64 \pm 0.8; *n* = 24) than the respective expectations before treatment ("What do you expect from the laser treatment?") (4.43 \pm 0.9; *n* = 24). However, this difference was statistically not significant (*P* = 0.31). Patient satisfaction after laser treatment compared with corresponding expectations before laser treatment is shown in Fig. 1. Patients particularly expected a fresher look, a more even complexion, fewer wrinkles and sun spots, and to indulge oneself. After three fractional treatments, patients stated that they had indulged themselves, had a fresher look, a more even complexion, fewer sun spots, and more charisma (Table 3, Fig. 1).

The dermatologists' estimations regarding assumed patient expectations before laser treatment differed from the expectations stated by the patients themselves. The dermatologists had assumed wrinkle reduction as the most important factor for patients, whereas patients considered a fresher look most important (Table 3). Variables that do not refer to externally measurable criteria, such as more charisma, higher self-satisfaction, higher self-esteem, and better body image, were considerably more important for patients than dermatologists had assumed.

Before laser treatment, patients were dissatisfied with skin appearance (mean 2.1 \pm 1.5) as evaluated on a 7-point scale but satisfied at follow-up (mean 5.1 \pm 1.2, *P* < 0.001) (Fig. 2). Dermatology-specific quality of life significantly improved when the DLQI decreased from 4.3 \pm 4.6 before the first treatment to 0.1 \pm 0.4 three months after the last treatment (*P* < 0.001, *n* = 25). At follow-up, 24 out of 25

patients (96%) stated in the questionnaire that they would recommend laser treatment.

We further investigated correlations of objectively measured wrinkle reduction and satisfaction with skin appearance, patient ratings on fewer wrinkles, and DLQI. Satisfaction with skin appearance was correlated to patient ratings with regard to fewer wrinkles (correlation 0.544, *P* = 0.006, *n* = 24). We also found a correlation between improved patient satisfaction with skin appearance and the ratings of the clinical investigators on improved overall appearance (correlation 0.544, *P* = 0.006, *n* = 24). However, profilometrically measured reduction of wrinkle size (T1 vs. T4; any facial area) did neither correlate to patient satisfaction with skin appearance after treatment (correlations between -0.16 to 0.24, *P* > 0.05) nor to improved satisfaction with skin appearance (correlations between -0.39 to 0.03, *P* > 0.05). Besides, patient ratings on wrinkle reduction was not correlated to profilometrically measured wrinkle reduction (T1 vs. T4) of any facial area (correlations between -0.05 to 0.31, *P* > 0.05). The reduction in DLQI was also not correlated with patient ratings on the reduction in wrinkles (correlation 0.06, *P* > 0.05) or satisfaction with skin appearance (correlation 0.16, *P* > 0.05).

This phenomenon of a near zero correlation between objective and subjective measures can also be seen in individual patients. The 51-year old study participant shown in Figure 3 stated that all her expectations had not only been fulfilled but exceeded (Fig. 4), despite moderate clinical results. Improved overall appearance as rated by the two investigators was moderate. Objective reduction in periocular wrinkle size was 35.2%. After treatment, satisfaction with overall skin appearance was markedly improved from three (partly satisfied and partly dissatisfied) to six (very satisfied), and the DLQI was slightly decreased from five to four.

DISCUSSION

To assess patient satisfaction, this study compared patient expectations before laser therapy and the fulfillment of these expectations after the last treatment. We also investigated satisfaction with skin appearance before

TABLE 3. Patient Expectations of Laser Treatment Assumed by 10 Dermatologists (Left), Patient Expectations (Middle) and Patient Satisfaction (Right) After Treatment Displayed in Descending Order

Patient expectations assumed by 10 dermatologists (mean score \pm SD)		Patient expectations before treatment (mean score \pm SD)		Patient satisfaction after treatment (mean score \pm SD)	
Fewer wrinkles	5.50 \pm 0.5	Fresher look	5.46 \pm 0.72	To indulge oneself	5.46 \pm 0.9
Fresher look	5.40 \pm 0.7	More even complexion	5.42 \pm 0.78	Fresher look	5.38 \pm 1.6
More attractive appearance	5.40 \pm 0.7	Fewer wrinkles	5.38 \pm 0.92	More even complexion	5.25 \pm 1.0
More youthful appearance	5.10 \pm 1.1	Fewer sun spots	5.33 \pm 1.30	Fewer sun spots	5.08 \pm 1.3
More even complexion	4.90 \pm 1.0	To indulge oneself	5.13 \pm 1.30	More charisma	5.04 \pm 0.8
To indulge oneself	4.40 \pm 1.6	More youthful appearance	4.96 \pm 1.20	Higher self-satisfaction	4.96 \pm 1.1
Higher self-esteem	4.30 \pm 1.2	More attractive appearance	4.88 \pm 1.36	Higher self-esteem	4.88 \pm 0.9
More charisma	4.20 \pm 1.2	More charisma	4.79 \pm 1.21	More youthful appearance	4.83 \pm 1.2
Fewer sun spots	4.10 \pm 1.0	Higher self-satisfaction	4.75 \pm 1.51	More attractive appearance	4.83 \pm 1.1
Improved chances in finding a partner	3.90 \pm 1.3	Higher self-esteem	4.85 \pm 1.47	Better body image	4.79 \pm 0.9
Higher self-satisfaction	3.80 \pm 1.1	Better body image	4.63 \pm 1.55	Fewer wrinkles	4.67 \pm 1.2
Better body image	3.40 \pm 1.3	Feeling less ashamed about own appearance	2.71 \pm 2.24	Feeling less ashamed about own appearance	3.79 \pm 1.9
Better job opportunities	2.90 \pm 1.1	Improved chances in finding a partner	2.25 \pm 1.84	Improved chances in finding a partner	3.42 \pm 1.7
Feeling less ashamed about own appearance	2.50 \pm 1.5	Better job opportunities	1.71 \pm 1.73	Better job opportunities	2.54 \pm 1.9

*Scores are based on grading treatment expectations on a 7-point scale:

0 = disagree strongly

1 = disagree

2 = disagree somewhat

3 = partly agree and partly disagree

4 = agree somewhat

5 = agree

6 = agree strongly

and after laser treatment and correlated patient satisfaction with skin appearance and wrinkle reduction in different facial areas.

Three treatments with the fractional CO₂-laser significantly reduced wrinkle size and depth in all facial areas investigated. Average scores of expectations as evaluated by means of a 14-item questionnaire were high before the treatment (ceiling effect). Similar findings in regard to high expectations were also reported by Karsai et al.[29]. However, average scores of patient satisfaction were even slightly higher than expectations regarding fractional skin resurfacing. Expectations were exceeded with regard to two treatment aims and fulfilled in 12 and not met only with regard to wrinkle reduction. The Dermatology Life Quality Index (DLQI) dropped from 4.3 \pm 4.6 before treatment to 0.1 \pm 0.4 at the follow-up treatment ($P < 0.001$; $n = 25$). Satisfaction with skin appearance

significantly increased from 2.1 \pm 1.5 to 5.1 \pm 1.2 as evaluated on a 7-point scale ($P < 0.001$; $n = 24$).

In terms of patient expectations, a fresher look and a more even complexion had higher priority than wrinkle reduction. All expectations were met or even exceeded apart from expectations towards wrinkle reduction that were not fulfilled completely. Particularly results of feeling less ashamed about one's own appearance and improved chances in finding a partner were significantly better ($P = 0.01$ and $P = 0.017$) than expectations before laser treatment. Expectations towards improved charisma, self-satisfaction, self-esteem, and body-image were only slightly lower than expectations towards skin improvement. This finding showed that patient expectations go beyond rejuvenating photoaged skin and elucidates expectations not normally communicated to but nevertheless important for treating physicians.

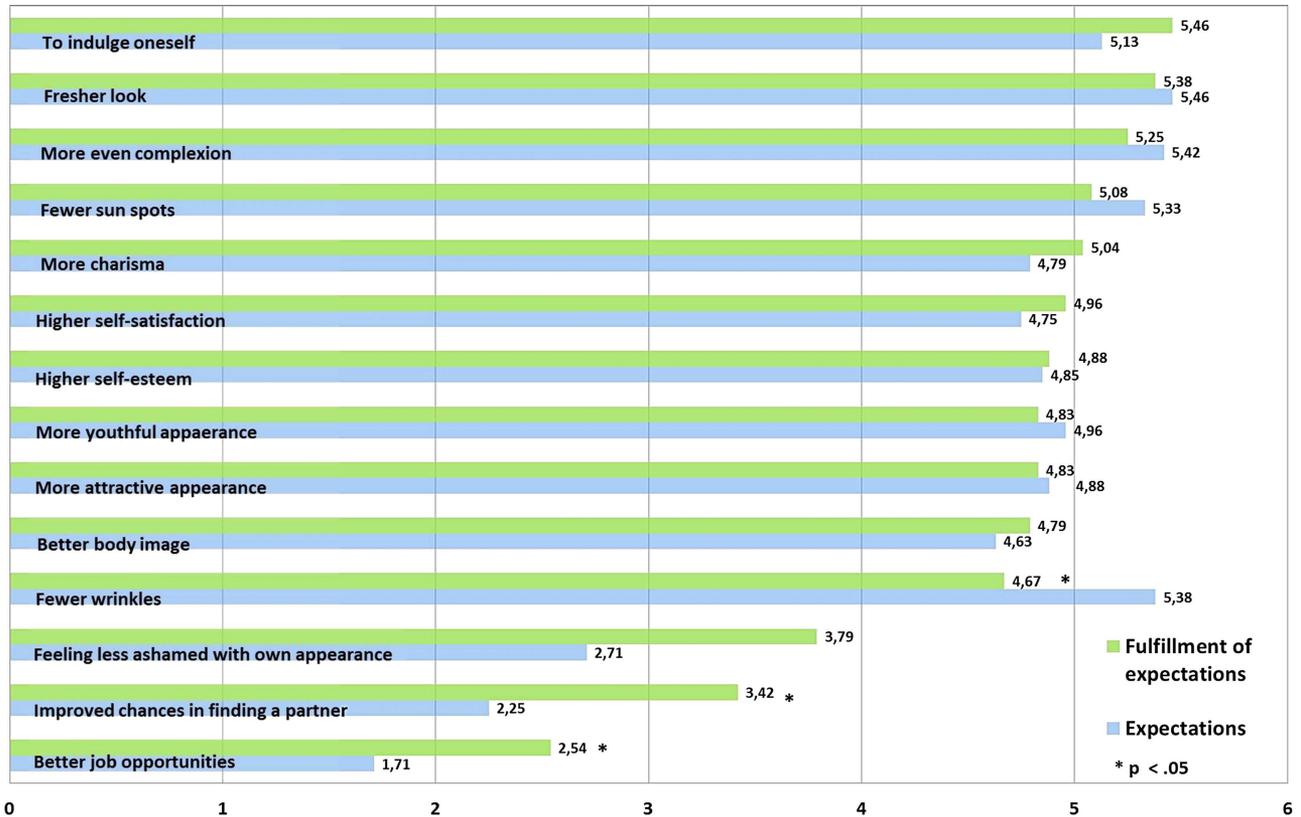


Fig. 1. Expectations before laser treatment (blue bars) and patient satisfaction (green bars) three months after the last laser treatment. Study participants had to rate each of the 14 items on a 7-point scale (0 = disagree strongly, 1 = disagree, 2 = disagree somewhat, 3 = partly agree and partly disagree, 4 = agree somewhat, 5 = agree, 6 = agree strongly).

The considerable difference between the dermatologists' estimation of patient expectation and patient ratings was striking but not surprising. The dermatologists considered the variables 'more charisma', 'higher self-satisfaction', 'higher self-esteem', and 'better body image' less important than the patients. This discrepancy underlines the necessity to assess patient satisfaction in clinical trials on aesthetic laser therapy.

No correlation could be detected between objectively reduced wrinkle size in any facial area and satisfaction with skin appearance after the treatment or with improvement of satisfaction with skin appearance. Therefore, we concluded that many patients do not primarily view wrinkle reduction as the main success of laser treatment. Moreover, objectively reduced wrinkle size in any facial area and patient ratings on wrinkle reduction did not correlate, although patients filled in the questionnaire after photo-documentation and the side-by-side comparison of photos. One possible explanation could be that patients get quickly used to improved skin appearance, forgetting about their skin condition and wrinkles before treatment. Excessive expectations towards wrinkle reduction may be another reason. However, the missing correlation shows

that objective and subjective results do not necessarily correspond, a common phenomenon in medicine[30].

We assessed the skin-specific quality of life using the DLQI before laser treatment and at follow-up. The total DLQI score before laser treatment (4.3 ± 4.6) indicated slightly impaired quality of life, comparable to scores reported by patients with mild to severe psoriasis or eczema[31,32]. DLQI scores significantly differed before and three months after the last treatment (DLQI T4: 0.1; $P < 0.001$). Particularly the score for question 2 ('Over the last week, how embarrassed or self-conscious have you been because of your skin?') was significantly lower at follow-up (T1: 1.04; T4: 0.04; $P < 0.001$; $n = 24$). Five study participants indicated that they were very embarrassed or self-conscious before the laser therapy, whereas only one patient reported embarrassment or self-consciousness at follow-up. The decrease in DLQI underlines the emotional concern that wrinkles and photoaged skin represent for patients and shows the impact of fractional CO₂ skin resurfacing on quality of life.

Patient ratings on wrinkle reduction or patient satisfaction with skin appearance do not correlate with objectively measured wrinkle reduction. Therefore, exact and

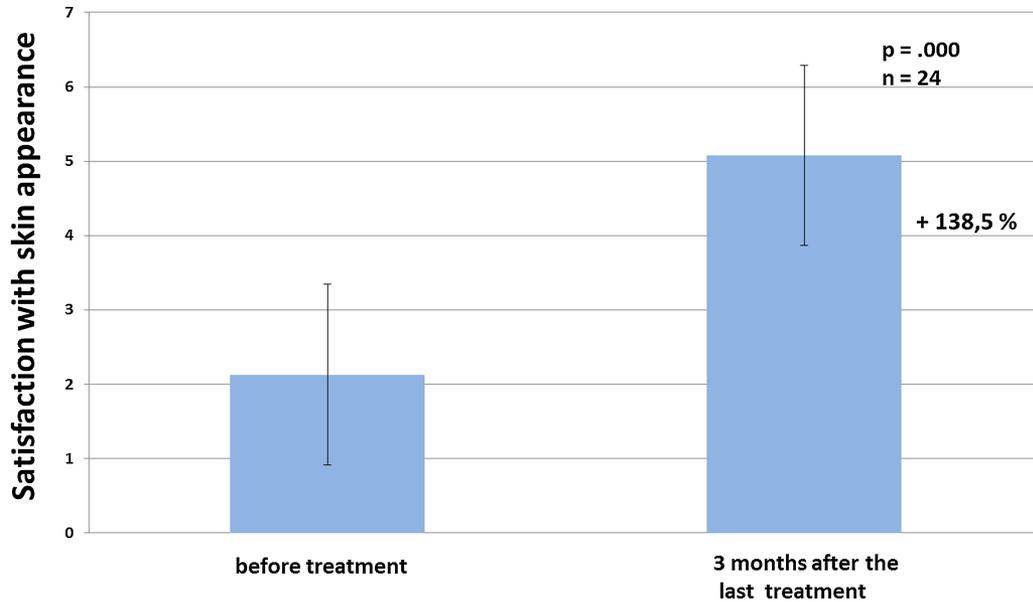


Fig. 2. Average overall satisfaction with skin appearance before the first treatment and three months after the third treatment. Overall satisfaction with skin appearance significantly increased from 2.13 (SD 1.5) to 5.08 (SD 1.2). *0 = not satisfied at all, 1 = dissatisfied, 2 = not too satisfied, 3 = partly dissatisfied and partly satisfied, 4 = rather satisfied, 5 = satisfied, 6 = very satisfied.



Fig. 3. A 51-year old Caucasian woman before (a) and three months after (b) fractional skin resurfacing. Wrinkle size had decreased by 35.2% periorbitally and by 13.8% periorally. The score of satisfaction with skin appearance was 3 (partly dissatisfied and partly satisfied) before treatment and 6 (very satisfied) at follow-up.

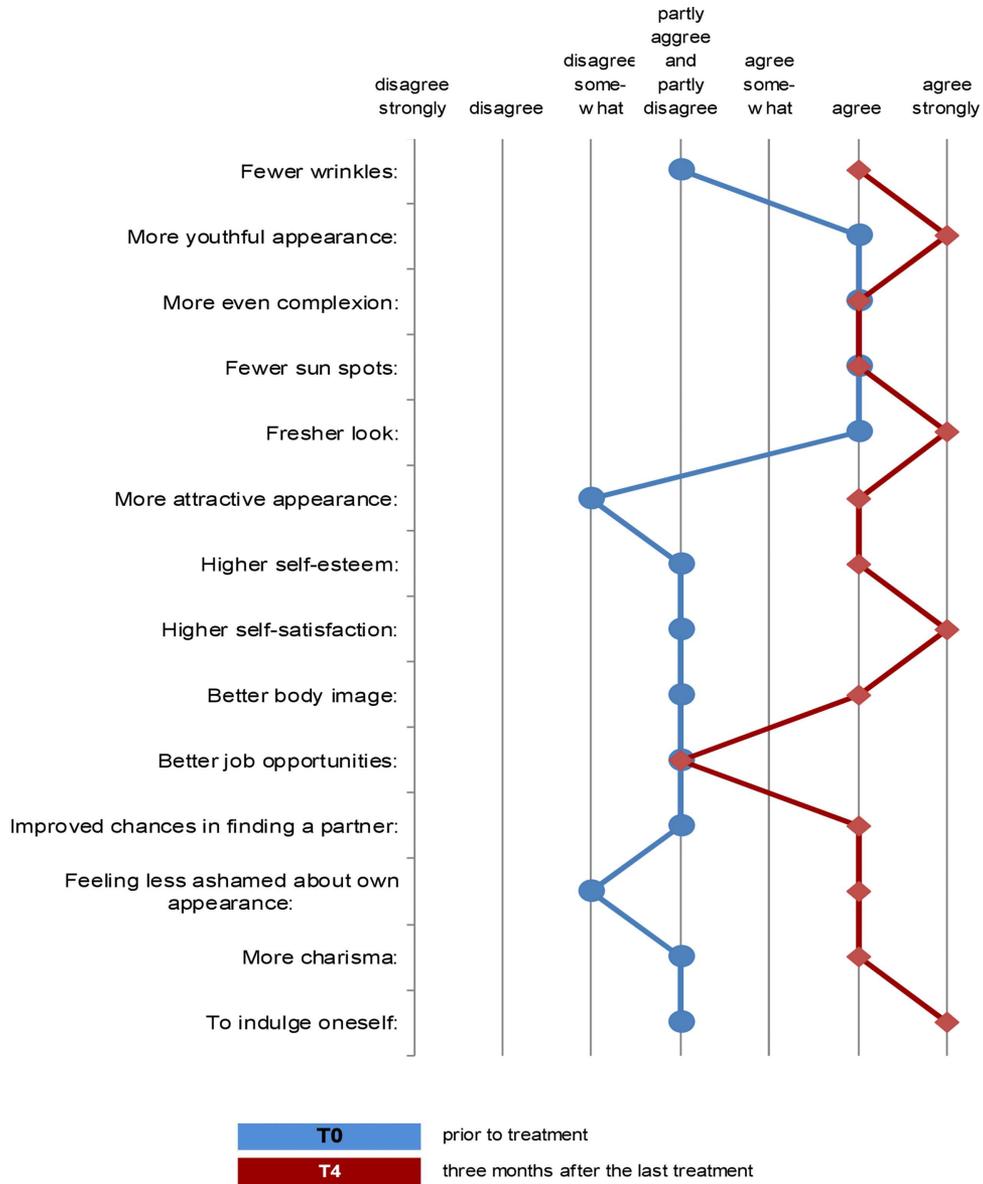


Fig. 4. Expectations before laser treatment (blue line) and satisfaction (red line) three months after the last laser treatment of the 51-year old Caucasian woman shown in Fig. 3. The expectations towards laser treatment were either exceeded or at least fulfilled, in particular expectations towards wrinkle reduction, more attractive appearance, higher self-esteem and self-satisfaction, better body image, feeling less ashamed, more charisma, and to indulge oneself. However, improvement of overall appearance was rated as moderate by two investigators. Objective reduction of periorcular wrinkle size was 35.2%. The Dermatology Life Quality Index slightly decreased from 5 before treatment to 4 after laser treatment.

meaningful photo-documentation is crucial. Treating physicians need to know that patients expect more charisma, higher self-satisfaction, self-esteem, and a better body image from fractional skin resurfacing. Although all expectations but one were met, lowering excessive expectations seems to be reasonable, especially with regard to wrinkle reduction and psychological variables. The results of this clinical trial underline the

necessity of a tool in aesthetic laser therapy for assessing patient satisfaction and patient expectations. This clinical study has several limitations. Expectations towards skin resurfacing evaluated in this trial may have been influenced by the informed consent discussion. Thus, the results of this trial depend to some degree on the informed consent discussion, which underlines the necessity and importance to ascertain patient expectations and

fulfillment of these expectations after treatment. The 14-item questionnaire used to evaluate patient satisfaction is not validated. Because of the lack of suitable instruments for investigating patient expectations and benefits in aesthetic laser therapy, we decided to develop a new questionnaire[29]. The questionnaire was well received by the patients and, because of its high face validity, easy to interpret. Nevertheless, the questionnaire would profit from further validation studies. Another limitation of this trial is the non-randomized design without controls.

CONCLUSION

Three treatments with the fractional CO₂-laser substantially improved patient satisfaction with overall skin appearance. Our results show high patient satisfaction with fractional laser therapy despite the high expectations before treatment, particularly with regard to self-esteem and self-satisfaction. Since skin-specific quality of life significantly improved after laser treatment, this therapy can be recommended for patients with photoaged skin wishing to improve skin appearance.

ACKNOWLEDGMENT

We thank Ms Monika Schoell for the linguistic revision of our manuscript.

REFERENCES

- Charles Finn, Cox J, Earl SE. Social implications of hyperfunctional facial lines. *Dermatol Surg* 2003;29(5):450–455.
- Sarwer DB, Pertschuk MJ, Wadden TA, Whitaker LA. Psychological investigations in cosmetic surgery: A look back and a look ahead. *Plast Reconstr Surg* 1998;101(4):1136–1142.
- Samson N, Fink B, Matts PJ, Dawes NC, Weitz S. Visible changes of female facial skin surface topography in relation to age and attractiveness perception. *J Cosmet Dermatol* 2010;9(2):79–88.
- Matts PJ, Fink B. Chronic sun damage and the perception of age, health and attractiveness. *Photochem Photobiol Sci* 2010;9(4):421–431.
- Matts PJ, Fink B, Grammer K, Burquest M. Color homogeneity and visual perception of age, health, and attractiveness of female facial skin. *J Am Acad Dermatol* 2007;57(6):977–984.
- Kwart DG, Foulsham T, Kingstone A. Age and beauty are in the eye of the beholder. *Perception* 2012;41(8):925–938.
- Mathes EW, Kahn A. Physical attractiveness, happiness, neuroticism, and self-esteem. *J Psychol* 1975; 90(1st Half): 27–30.
- Langlois JH, Kalakanis L, Rubenstein AJ, Larson A, Hallam M, Smoot M. Maxims or myths of beauty? A meta-analytic and theoretical review. *Psychol Bull* 2000;126(3):390–423.
- Pruzinsky T. Psychological factors in cosmetic plastic surgery: Recent developments in patient care. *Plast Surg Nurs* 1993;13(2):64–69.
- Sadick NS. The impact of cosmetic interventions on quality of life. *Dermatol Online J* 2008;14(8):2.
- Rahman Z, MacFalls H, Jiang K, Chan KF, Kelly K, Tournas J, Stumpp OF, Bedi V, Zachary C. Fractional deep dermal ablation induces tissue tightening. *Lasers Surg Med* 2009;41(2):78–86.
- Karsai S, Czarnecka A, Junger M, Raulin C. Ablative fractional lasers (CO₂) and Er:YAG): A randomized controlled double-blind split-face trial of the treatment of peri-orbital rhytides. *Lasers Surg Med* 2010;42(2):160–167.
- Alexiades-Armenaka M, Sarnoff D, Gotkin R, Sadick N. Multi-center clinical study and review of fractional ablative CO₂ laser resurfacing for the treatment of rhytides, photoaging, scars and striae. *J Drugs Dermatol* 2011;10(4):352–362.
- Chan NP, Ho SG, Yeung CK, Shek SY, Chan HH. Fractional ablative carbon dioxide laser resurfacing for skin rejuvenation and acne scars in Asians. *Lasers Surg Med* 2010;42(9):615–623.
- Ortiz AE, Tremaine AM, Zachary CB. Long-term efficacy of a fractional resurfacing device. *Lasers Surg Med* 2010;42(2):168–170.
- Longo C, Galimberti M, De Pace B, Pellacani G, Bencini PL. Laser skin rejuvenation: Epidermal changes and collagen remodeling evaluated by in vivo confocal microscopy. *Lasers Med Sci* 2013;28(3):769–776.
- Hantash BM, Bedi VP, Kapadia B, Rahman Z, Jiang K, Tanner H, Chan KF, Zachary CB. In vivo histological evaluation of a novel ablative fractional resurfacing device. *Lasers Surg Med* 2007;39(2):96–107.
- Berlin AL, Hussain M, Phelps R, Goldberg DJ. A prospective study of fractional scanned nonsequential carbon dioxide laser resurfacing: A clinical and histopathologic evaluation. *Dermatol Surg* 2009;35(2):222–228.
- Kohl E, Meierhofer J, Koller M, Zeman F, Klein A, Hohenleutner U, Landthaler M, Hohenleutner S. Fractional carbon dioxide laser resurfacing of rhytides and photoaging: A prospective study using profilometric analysis. *Br J Dermatol* 2014;170(4):858–865.
- Clementoni MT, Lavagno R, Catenacci M, Kantor R, Mariotto G, Shvets I. 3D in vivo optical skin imaging for intense pulsed light and fractional ablative resurfacing of photodamaged skin. *Facial Plast Surg Clin North Am* 2011;19(4).
- Finlay AY, Khan GK. Dermatology Life Quality Index (DLQI)—a simple practical measure for routine clinical use. *Clin Exp Dermatol* 1994;19(3):210–216.
- Basra MK, Fenech R, Gatt RM, Salek MS, Finlay AY. The dermatology life quality index 1994–2007: a comprehensive review of validation data and clinical results. *Br J Dermatol* 2008;159(5):997–1035.
- Strand V, Fiorentino D, Hu C, Day RM, Stevens RM, Papp KA. Improvements in patient-reported outcomes with apremilast, an oral phosphodiesterase 4 inhibitor, in the treatment of moderate to severe psoriasis: Results from a phase IIb randomized, controlled study. *Health Qual Life Outcomes* 2013;11:82.
- Silverberg JI, Silverberg NB. Association between vitiligo extent and distribution and quality-of-life impairment. *JAMA Dermatol* 2013;149(2):159–164.
- Bostoen J, Bracke S, De Keyser S, Lambert J. An educational programme for patients with psoriasis and atopic dermatitis: a prospective randomized controlled trial. *Br J Dermatol* 2012;167(5):1025–1031.
- Finlay AY, Basra MK, Piguet V, Salek MS. Dermatology life quality index (DLQI): A paradigm shift to patient-centered outcomes. *J Invest Dermatol* 2012;132(10):2464–2465.
- Steinbauer J, Koller M, Kohl E, Karrer S, Landthaler M, Szeimies RM. Quality of life in health care of non-melanoma skin cancer - results of a pilot study. *J Dtsch Dermatol Ges* 2011;9(2):129–135.
- Koller M, Lorenz W, Wagner K, Keil A, Trott D, Engenhart-Cabillic R, Nies C. Expectations and quality of life of cancer patients undergoing radiotherapy. *J R Soc Med* 2000;93(12):621–628.
- Karsai S, Raulin C. Comparison of clinical outcome parameters, the Patient Benefit Index (PBI-k) and patient satisfaction after ablative fractional laser treatment of peri-orbital rhytides. *Lasers Surg Med* 2010;42(3):215–223.
- Koller M, Kussman J, Lorenz W, Jenkins M, Voss M, Arens E, Richter E, Rothmund M. Symptom reporting in cancer patients: The role of negative affect and experienced social stigma. *Cancer* 1996;77(5):983–995.
- Norlin JM, Steen Carlsson, Persson K, Schmitt-Egenolf U. Analysis of three outcome measures in moderate to severe psoriasis: A registry-based study of 2450 patients. *Br J Dermatol* 2012;166(4):797–802.
- Badia X, Mascaro JM, Lozano R. Measuring health-related quality of life in patients with mild to moderate eczema and psoriasis: Clinical validity, reliability and sensitivity to change of the DLQI. The Cavide Research Group. *Br J Dermatol* 1999;141(4):698–702.