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ORIGINAL ARTICLE

Laser-assisted lipolysis for arm contouring in Teimourian grades I and II: a prospective study of 45 patients

Franck Marie Leclère · Justo M. Alcolea · Peter Vogt · Javier Moreno-Moraga · Serge Mordon · Vincent Casoli · Mario A. Trelles

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Abstract Upper arm deformities secondary to weight loss or senile elastosis have led to an increased demand for aesthetic contouring procedures. We conducted this study to objectively assess if, in Teimourian low-grade upper arm remodelling, one session of laser-assisted lypolisis (LAL) could result in full patient satisfaction. Between 2011 and 2013, 45 patients were treated for unsightly fat arm Teimourian grade I (15 patients), grade IIa (15 patients) and grade IIb (15 patients) with one session of LAL. The laser used in this study was a 1470-nm diode laser (Alma Lasers, Cesarea, Israel) with the following parameters: continuous mode, 15 W power and transmission through a 600-μm optical fibre. Previous mathematical modelling suggested that 0.1 kJ was required in order to destroy 1 ml of fat. Treatment parameters and adverse effects were recorded.The arm circumference and skin pinch measurements were assessed pre and postoperatively. Patients were asked to file a satisfaction questionnaire. Pain during the anaesthesia and discomfort after the procedure were minimal. Complications included prolonged oedema in 11 patients. The average arm circumference decreased by 4.9±0.4 cm in the right arm ($p<0.01$) and 4.7±0.5 cm in the left arm ($p<0.01$) in grade I patients, 5.5±0.6 cm in the right arm ($p<0.01$) and 5.2±0.5 cm in the left arm ($p<0.01$) in grade IIa patients and 5.4±0.5 cm in the right arm ($p<0.01$) and 5.3±0.5 cm in the left arm ($p<0.01$) in grade IIB patients. The skin tightening effect was confirmed by the reduction of the skin calliper measurements in all three groups. Overall mean opinion of treatment was high for both patients and investigators. Of the 45 patients, all but one would recommend this treatment. A single session of LAL in upper arm remodelling for Teimourian grades I to IIb is a safe and reproducible technique. The procedure allows reduction in the amount of adipose deposits while providing full skin tightening.

Keywords Arm · Arm remodelling · Brachioplasty · Laser · Laser lipolysis · LAL

F. M. Leclère · S. Mordon
French Institute of Health and Medical Research U703, University of Lille 2, Lille University Hospital, Lille, France

F. M. Leclère · V. Casoli
Department of Plastic Surgery, Transsexual Surgery, Hand Surgery, Burn Surgery, University Hospital of Bordeaux, FX Michelet Center, Place Amelie Raba Leon, 33076 Bordeaux, France

F. M. Leclère · P. Vogt
Department of Plastic Surgery, MHH, Hannover Medical School, Hannover, Germany

J. M. Alcolea · M. A. Trelles (✉)
Instituto Médico Vilafortuny, Av. Vilafortuny, 31, 43850 Cambrils, Tarragona, Spain
e-mail: imv@laser-spain.com

J. Moreno-Moraga
Instituto Médico Láser, Madrid, Spain

Introduction

Upper arm deformities secondary to weight loss or senile elastosis have led to an increased demand for aesthetic contouring procedures. In the USA, 15,457 brachioplasty surgeries were performed during 2012, a rapid increase compared with the 338 surgeries in 2000 [1]. Most of the patients underwent brachioplasty and other body contouring surgeries, such as abdominoplasty, thigh lift, breast reduction with mastopexy and belt dermolipectomy, at the same time or serially as needed.

In 1998, Teimourian and Malekzadeh published a useful classification which is summarized in Table 1 [2]. El Khatib proposed a standard treatment for each subtype of arm

Table 1 Teimourian's classification and usual recommended treatment (adapted from El Khatib and Teimourian and Malekzadeh)

Stage	Clinical appearance	Recommended treatment
1	Minimal fat<250 mL, no ptosis	Circumferential liposuction
2a	Moderate fat, grade 1 ptosis<5 cm	Liposuction in two sessions
2b	Moderate to severe fat, grade 2 ptosis, 5–10 cm	Distal liposuction + proximal short-scar brachioplasty
3	Extreme lipodystrophy with grade 3 ptosis>10 cm	Liposuction + brachioplasty
4	Mild to moderate fat with severe grade 3 ptosis	Traditional brachioplasty

contouring [3]: The types I and IIa of this classification include patients with minimal-to-moderate fat excess and skin laxity. The proposed surgery for this subgroup of patient is single or repeated liposuction. Most patients who present for upper arm contouring in the USA are classified as stage IIb, III or IV, and the treatment protocol for these patients involves brachioplasty. However, many patients are reluctant to undergo treatment with brachioplasty, discouraged by the appearance of a long scar, and they may choose to avoid treatment. In most cases, liposuction alone may address the excess fat, but it might not aesthetically improve the unclothed appearance of the upper arm due to residual postoperative skin laxity and postoperative contour irregularities.

The search for and development of new liposuction technologies and techniques has grown steadily over the past decades in order to keep pace with patients' requirements and expectations for greater efficacy, safety and minimal scarring. In this context, recent decades have seen the introduction of internal ultrasound-assisted liposuction, power-assisted liposuction and laser assisted liposuction (LAL) [4–6]. Since 2004 and using our mathematical model [7], we have been working towards developing a safe technique for LAL [8–14].

This study focused solely on LAL in Teimourian grade I to IIb arm contouring. It addresses the question whether a single session of LAL is able to achieve reduction in the amount of adipose deposits while providing full skin tightening.

Material and methods

Patients

This clinical study protocol was reviewed and approved by our local ethics committee. Forty-five patients who were dissatisfied with the aspect of their arm and classified as grades I (15 patients), IIa (15 patients) and IIb (15 patients) according to the Teimourian and Malekzadeh classification [2] (Table 1) were recruited for this study. Exclusion criteria were the following: pregnancy, history of coagulation disorders or anticoagulants, history of allergy to the active ingredients or excipients of the anaesthetics used and history of sensitivity to laser treatment or IPL. Patients' mean age was 48.9±10.4 years (range 26–67 years). Patients' mean body mass index (BMI) was 25.8±1.2 kg/m^2 (range 23.6–27.8 kg/m^2) (Table 2).

Laser and dosimetry

The laser used in this study was a 1470-nm diode laser (Alma Lasers, Cesarea, Israel). Laser energy was transmitted through a 600-μm optical fibre and delivered in a continuous mode 15-W power. Total energy was 15–18 kJ per arm. Previous mathematical modelling suggested that 0.1 kJ was required in order to destroy 1 ml of fat. Our parameters were sufficient to achieve 42 °C when temperature was externally measured in the treatment area using an infrared thermometer (CEM DT-880B, Shenzhen Everbest Machinery Industry Co. Ltd, China). The cannula through which the laser fibre is passed has a blunt tip (Fig. 1). During LAL, laser energy is irradiated through lateral fenestrations located at the end of the cannula. This radial modality of laser irradiation differs from standard directional laser irradiation in which the fibre tip extends about 2–3 mm out of the cannula. The lower energy density deposited per area of tissue related to the time of irradiation during cannula movements drastically decreases the risk of burns to the skin.

Surgical technique

In all patients, tumescent anaesthesia was performed (Klein formula, 0.1 % lidocaine and 1:1,000,000 epinephrine) [15, 16]. Infiltration ranged from 600 to 800 ml per arm. All patients received light sedation with midazolam, controlled by the anaesthesiologist. Total energy was applied by a crossed-fanning movement of a 2-mm cannula from various points in the deep and medium-deep planes. All patients received the global energy previously calculated with our mathematical model. Subsequently, the same 2-mm diameter

Table 2 Patients' demographics

Teimourian grade	Number	Mean age	Mean BMI
I	15	46.1	25.7
IIa	15	49.3	25.8
IIb	15	51.5	25.9

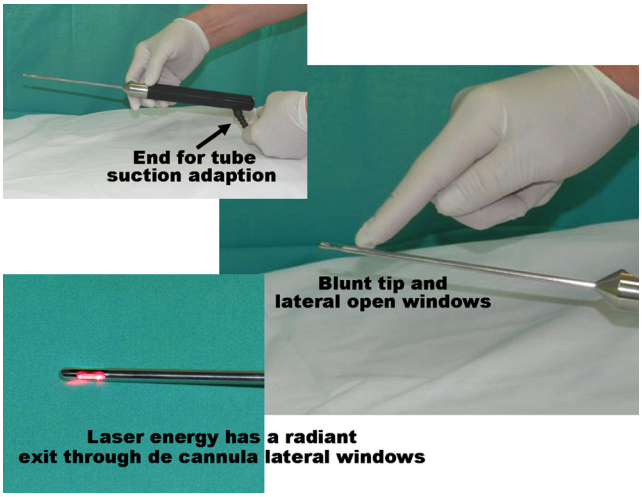

Fig. 1 Laser cannula used in this study

cannula was used for aspiration with the help of a device at 1-bar negative pressure (Lipo-MR, Ordisi SA, Barcelona). The cannula has an adaptor located close to the handle to which a tube is fitted for fat aspiration (Fig. 1). Additional treatment such as lymphatic drainage, endermology or radiofrequency was not performed. A compressive garment (VOE, S.A. Barcelona, Spain) was prescribed to be used at all times for 30 days. After this time, patients were advised to use the garment for a further 30 days only at night.

Objective assessment

For each follow-up, complications were carefully recorded and special attention was paid to burns, pain and hyperpigmentation. Fever, seromas, severe hematomas, prolonged oedema or alterations in sensitivity were also carefully evaluated. The arm circumference was measured preoperatively and at 6 months follow-up. The skin pinch was also objectively measured by a skin calliper protrusion device, which utilizes a digital approximating skin calliper at the base of the bicipital and triceps groove to set a fixed base measurement. The point of placement was standardized at 8 cm distal to the deepest anterior axillary depression.

Subjective assessment

Patients were asked to rate their level of discomfort during the anaesthesia and after the procedure on a questionnaire (from 0 to 4) (0 no pain/discomfort, 1 slight pain/discomfort, 2 moderate pain/discomfort, 3 severe pain/discomfort, 4 very severe pain/discomfort) and their inability to work (0 nil, 1 1 day, 2 2 days, 3 3 days, 4 more than 3 days) (Table 2). Patients were also asked to rate their improvement 6 months postoperatively (excellent, good, regular, poor). They were also asked to score it (from 0 to 100 %) on a visual scale (expectations met 4, 90–100 %; 3, 70–89 %; 2, 40–69 %; 1, 1–39 %). Patients were asked whether they would recommend the procedure to others. Finally, the overall opinion of both investigators and patients was recorded (Tables 3, 4, and 5).

Statistics

Statistical analysis was performed using the SPSS program (SPSS v. 22.0). Data are presented as mean±standard error of

Table 3 Questionnaire used for our study

Questionnaire		
Tolerance		
1. Did you experience pain during anaesthesia?		
No		0
Yes	Slight	1
	Moderate	2
	Severe	3
	Very severe	4
2. Did you feel discomfort after the procedure?		
No		0
Yes	Slight	1
	Moderate	2
	Severe	3
	Very severe	4
3. Has the procedure prevented you from working or interfered with your work?		
No		0
Yes	Slight	1
	Moderate	2
	Severe	3
	Very severe	4
Efficacy		
a) Has the treatment fulfilled your expectations?		
Percentage	90–100	1
	70–90	2
	40–70	3
	10–40	4
b) Would you recommend this treatment to others?		
Yes		1
No		2
Overall opinion of the investigator		
Efficacy	Very good	1
	Good	2
	Fair	3
	No change	4
Overall opinion of the patient		
Efficacy	Very good	1
	Good	2
	Fair	3
	No change	4

Table 4 Tolerance during anaesthesia, discomfort after the procedure and interference with work

Tolerance/45 patients (grade I 15 patients, grade IIa 15 patients, grade IIb 15 patients)				Pain during anaesthesia (*N*)	Discomfort after the procedure (*N*)	Interference with work (*N*)
No	0		Grade I	11	7	10
			Grade IIa	8	6	7
			Grade IIb	6	5	6
Yes	1	Slight	Grade I	4	7	4
			Grade IIa	6	7	7
			Grade IIb	7	7	7
	2	Moderate	Grade I	0	1	1
			Grade IIa	1	2	1
			Grade IIb	2	3	2
	3	Severe	0			
	4	Very severe	0			

the mean. Where applicable, Student's test (two samples) was used to calculate the p values, and $p<0.05$ was considered to be statistically significant.

Results

Complications

A total of 45 patients were treated for unsightly arm fat Teimourian grades I to IIb with a single session of LAL (Figs. 2, 3, 4, and 5). Prolonged oedema was found in 11 patients.

Table 5 Patients and investigator overall opinion about efficacy of the procedure

Overall opinion/45 patients (grade I 15 patients, grade IIa 15 patients, grade IIb 15 patients)				Patients (*N*)	Investigator (*N*)
Efficacy	1	Very good	Grade I	11	12
			Grade IIa	8	10
			Grade IIb	7	9
	2	Good	Grade I	4	3
			Grade IIa	7	5
			Grade IIb	7	6
	3	Fair	Grade I	0	0
			Grade IIa	0	0
			Grade IIb	1	0
	4	No change	Grade I	0	0
			Grade IIb	0	0
			Grade IIb	0	0

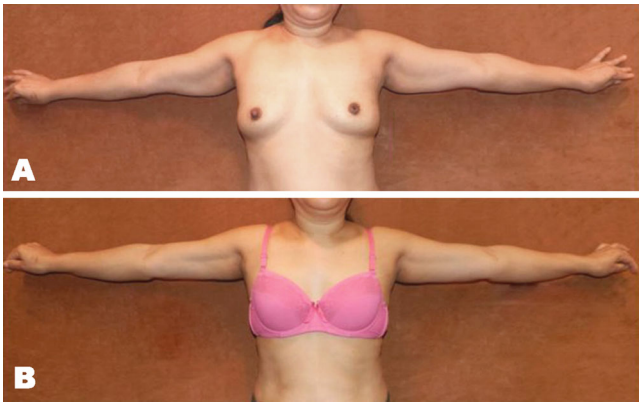

Fig. 2 Anterior view of a 38-year-old patient (patient no. 2, Table 2) before (**a**) and after (**b**) LAL for arm remodelling

Subjective assessment

Mean pain during anaesthesia was 0.27±0.46, 0.53±0.64 and 0.73±0.70 in Teimourian groups I, IIa and IIb, respectively (TI/TIIa/TIIb) (Table 3). Mean discomfort after the procedure was 0.60±0.63, 0.73±0.70 and 0.87±0.74 for TI/TIIa/TIIb. Mean down time was 0.33±0.49, 0.60±0.63 and 0.73±0.70 for TI/TIIa/TIIb. Of the 45 patients, all but one (98 %) would recommend this treatment. Overall mean opinion of treatment was very high for both patients and investigators, 1.27±0.46 and 1.20±0.41 for TI, 1.47±0.42/1.33±0.49 for TIIa and 1.60 ±0.63/1.40±0.51 for TIIb.

Objective assessment

The average arm circumference decreased by 4.9±0.4 cm in the right arm ($p<0.01$) and 4.7±0.5 cm in the left arm ($p<0.01$) in grade I patients, 5.5±0.6 cm in the right arm ($p<0.01$) and 5.2±0.5 cm in the left arm ($p<0.01$) in grade

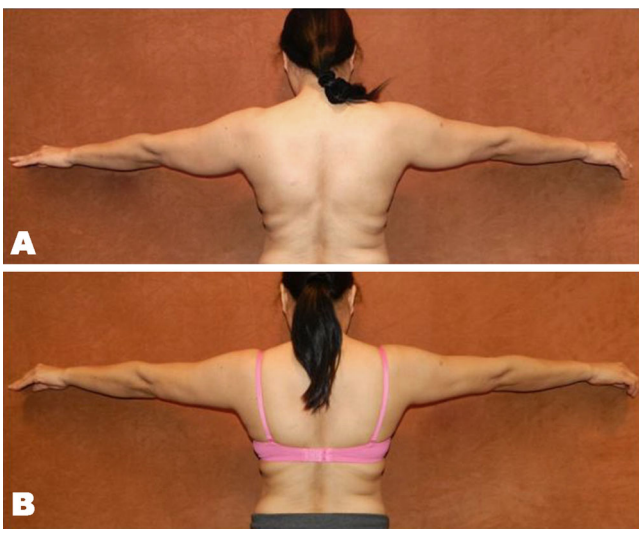

Fig. 3 Posterior view of a 38 year old patient (patient no. 2, Table 2) before (**a**) and after (**b**) LAL for arm remodelling

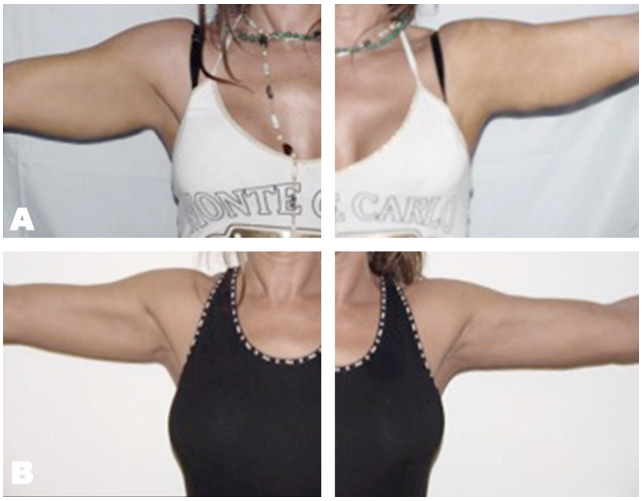

Fig. 4 Anterior view of a 41-year-old patient (patient no. 1, Table 2) before (**a**) and after (**b**) LAL for arm remodelling

IIa patients and 5.4±0.5 cm in the right arm ($p<0.01$) and 5.3 ±0.5 cm in the left arm ($p<0.01$) in grade IIB patients. The skin tightening effect was confirmed by the reduction of the skin calliper measurements in all three groups (Figs. 6 and 7): The average skin pinch decreased by 0.7±0.1 cm in the right arm ($p<0.01$) and 0.7±0.1 cm in the left arm ($p<0.01$) for grade I patients, 2.1±0.3 cm in the right arm ($p<0.01$) and 2.1 ±0.3 cm in the left arm ($p<0.01$) for grade IIa patients and 2.9 ±0.2 cm in the right arm ($p<0.01$) and 2.9±0.2 cm in the left arm ($p<0.01$) for grade IIB patients.

Discussion

In this study, 45 patients who underwent LAL for arm remodelling in Teimourian grades I to IIb were prospectively assessed. There were no burns in the entire series.

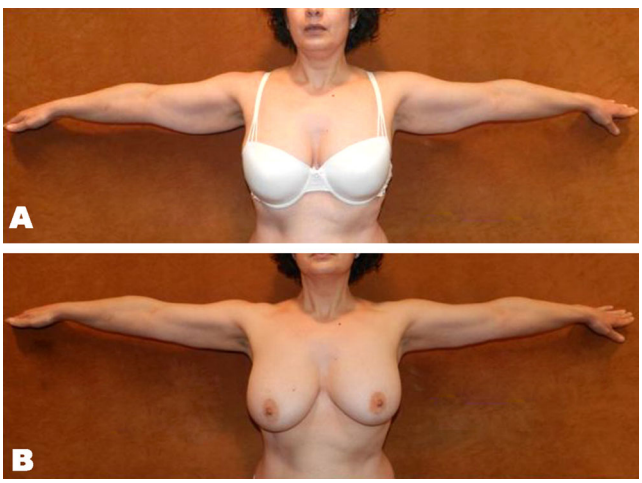

Fig. 5 Anterior view of a 55-year-old patient (patient no. 12, Table 4) before (**a**) and after (**b**) LAL for arm remodelling

Complications included prolonged oedema in 11 patients. Pain during anaesthesia and discomfort after the procedure were minimal. The reduction in the amount of adipose deposits and skin tightening effect were confirmed by the measures of the arm circumference and the reduction of the skin calliper measurements in all three groups. Overall mean opinion of treatment was high for both patients and investigators. Of the 45 patients, all but one would recommend this treatment.

The search for and development of new liposuction technologies and techniques has grown steadily over the past decades in order to keep pace with patients' requirements and expectations for greater efficacy, safety and minimal scarring. Indeed, after great experience with the conventional procedures and knowledge of the decision tree proposed by El Khatib [3], we conducted this study to objectively assess if a single session of LAL could lead to full skin tightening and patient satisfaction in Teimourian low grades.

Our results thus far confirm the following advantages of the LAL technique: (1) The lipolysis effect improves and facilitates the removal of adipose tissue. (2) The disruption and coagulation of collagen may lead to the creation of a new, thicker and more-organized reticular dermis with the end clinical results being tightened skin and reduced laxity. (3) Due to the small cannula size, mechanical destruction is kept to a minimum, resulting in faster recovery times and a lower incidence of ecchymoses. (4) Coagulation of small vessels reduces procedural trauma. (5) The easy penetration of the cannula with the laser fibre into the fibrous tissue makes it easier to reach all of the areas with the help of the external hand, contributing to high patient satisfaction. In grades I to IIa of the Teimourian and Malekzadeh classification [2], many patients are reluctant to undergo treatment because in most cases, liposuction alone may address the excess fat, but it might not improve the unclothed appearance of the upper arm due to residual postoperative skin laxity and postoperative contour irregularities; in other words, one cure of conventional liposuction will rarely ensure full satisfaction and a second session will be usually mandatory (Table 1). In grade IIb of the Teimourian and Malekzadeh classification [2], according to El Khatib [3], a brachioplasty is mandatory. Many patients, however, are reluctant to undergo treatment with brachioplasty, discouraged by the appearance of a long scar, and they may choose to avoid the surgery. Despite the good results obtained in this study, it remains difficult to compare our parameters to those usually reported in the literature, because in most other studies, the cumulative energy used to treat a given volume is usually not reported. Kotlus et al. [17] used a Nd:YAG laser at 15 W, 30 Hz and a pulse width of 100 μs. Energy was delivered via a 1.5-mm cannula housing a 500-μm fibre until subcutaneous temperature of 41 °C was reached. The mean total energy delivered per subject was 13,634 J (range 8524–21,242 J). The mean change in mid arm circumference 3 months after treatment was 0±1.8 cm (range 1.5–2 cm). No observable improvement was

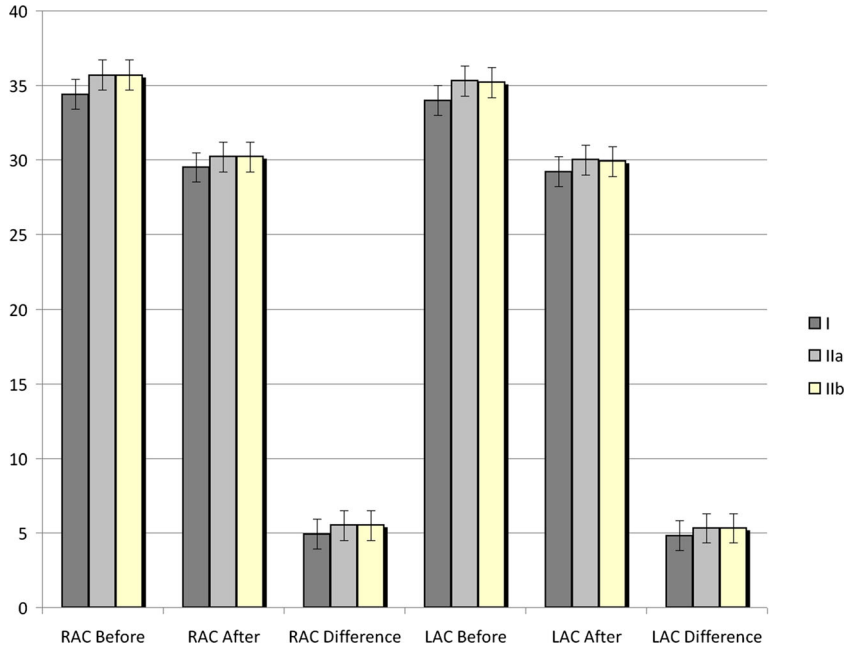

Fig. 6 Patients' arm circumference before and 6 months after LAL (*RAC* right arm circumference, *LAC* left arm circumference)

noted in the treated arms in comparison photos at 3 months by independent observer evaluation. However, according to our experience, the results must be appreciated after a minimum of 6 months. Moreover, the patients were not strictly divided into groups according to the Teimourian and Malekzadeh classification [2]. In another study, Dudelzak et al. [18] reported a reduction in arm circumference in a series of 20 subjects of whom 10 underwent 1064-nm laser lipolysis without suction. These patients received 7080–12,026 J of energy during treatment. They also reported skin retraction and tightening in 16 subjects, but they did not describe how this was measured. Reynaud et al. [19] used a 980-nm diode laser at 6 W. The mean total energy delivered per subject was 12,800 J (range 4700–17,000 J). However, once again, the authors have not described how this was measured. In the present study, similar energy levels were delivered, and the skin tightening effect could be measured effectively using both the arm circumference and calliper measurements. These observations support the fact that (i) selection of the right candidate for LAL is essential. Cases of advanced upper arm deformities due to excess weight loss of fat surplus or a senile elastosis with massive skin flaccidity might not be rectified by LAL alone. (ii) The laser parameters must be clearly identified before and during the procedure in order to provide reproducible results.

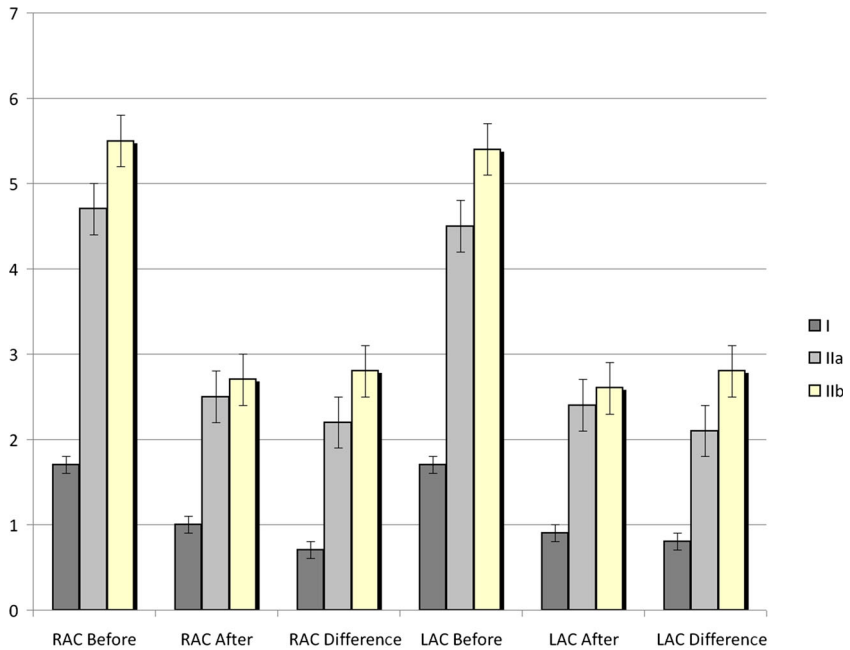

Fig. 7 Skin pinch before and 6 months after LAL (*RACSL* right arm calliper skin laxity, *LACSL* left arm calliper skin laxity)

Finally, these procedures must be performed by expert surgeons who are trained in the use of laser in plastic surgery. Less-experienced operators may benefit from adjusted dosimetry: Cynosure has developed the SmartSense™ delivery system [20]. This system contains an accelerometer inserted into the intelligent handpiece. The laser power is automatically adjusted by taking into account the setting (high, medium or low) and the motion of the cannula. Similarly, Osyris has developed the LipoControl™ system. This system integrates a magnetic tracking system to determine the position of magnetic sensors in the cannula. The tracking system allows an automatic adjustment of laser power to compensate for cannula movement. Consequently, the laser power varies in step with the speed of the cannula, continually delivering the optimal energy.

Despite the large cohort of patients and the long follow-up period covered in this study, the protocol was limited by its nature as a non-controlled analysis. However, our team has been working with LAL since 2004 and has identified and reported in many studies the numerous advantages of this procedure over conventional liposuction [8–14]. In our opinion, a control group including liposuction alone might have been ethically difficult to justify. Moreover, the procedures were performed by expert surgeons in LAL. In this context, it is important to underline that a young surgeon must be aware of factors such as Teimourian grade and general weight loss, and patient behaviour before and after the operation in order to obtain similar long-term outcomes. The compressive garment must be worn for at least the first 4 weeks. In case of possible non-compliance, the patient must be made ineligible for this operation.

Conclusion

A single session of LAL in upper arm remodelling for Teimourian grades I to IIb is a safe and reproducible technique. The procedure allows reduction in the amount of adipose deposits while providing full skin tightening.

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