Lower rates of lipofilling sessions in latissimus dorsi flap breast reconstruction with initial higher volume transfer by preservation of subfascial fat: a 3d camera-assisted volumetric case series.

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Abstract

Breast reconstruction with latissimus dorsi flap (LDF) is a well-known technique but the achievement of a satisfying final volume restoration is a crucial goal to achieve.

Our hypothesis is that LDF reconstruction with preservation of subfascial fat can achieve a higher volume in a one-time procedure if compared to a classic LDF harvest.

The aim of the study was to quantify the volume resorption in LDF reconstructions with preservation of subfascial fat. Fifteen breasts were reconstructed with a simple LDF and the remaining 15 with a LDF with preservation of the subfascial fat between January 2016 and May 2017. Secondly, every patient underwent to a lipofilling procedure. A supplemental lipofilling was made in unsatisfying cases. A Structure-Sensor camera by Occipital® was used. Each patient received a 3D measurement in immediate postoperative and then after three and six-months follow-up.

This study shows no difference in volume retention at follow up between the two techniques. The gain of an immediate and stable fatty layer in LDF + subfascial fat technique leads to breast volume improvement in one surgical step. Breast reconstruction with latissimus dorsi flap and subfascial fat can be defined as a reliable solution which conducts to an optimal result with reduced number of surgical interventions if compared to simple latissimus dorsi flap.

Introduction

Breast reconstruction techniques are becoming more and more reliable, precise and aesthetically harmonious.

The role of adipose tissue has become essential in breast reconstruction. Since 1977 when liposuction was invented by Yves-Gérard lllouz, until the first publications of Coleman in 1995 [1], the adipose tissue grafting has improved significantly. It is nowadays widely used in breast reconstruction, as an independent technique or in association with implants or with pedicled / free flaps.

Breast reconstruction with latissimus dorsi flap leads to long-term volume loss, this due by muscle wasting. This complication must be well preconized in order to compensate by a secondary addition of adipose tissue. On the one hand, the adipose graft has limited viability with a resorption rate which rates from 30 to 80% [2]. Moreover, there is no evidence in literature evaluating the durability of fat grafting in the muscular tissue.

In plastic surgery, volume restoration is a crucial goal to achieve, particularly after reconstruction. Although the surgeon's experience is fundamental, objective measurements are increasingly considered as a major surgical criterion.

Our hypothesis is that LDF reconstruction with preservation of subfascial fat can achieve a higher volume in a one-time procedure if compared to a classic LDF harvest.

Three-dimensional imaging is an invaluable tool for obtaining precise and objective calculation of breast volume. Given its unique ability to critically analyze differences in size and shape, this tool is an essential component of preoperative planning in both reconstructive and aesthetic breast surgery, achieving breast symmetrization and satisfactory outcomes.

Materials and Methods

Study design

In this interventional study, all female patients requiring an immediate or delayed reconstruction with a latissimus dorsi flap were included in our center between January 2016 and May 2017.

The ethical principles outlined in the Declaration of Helsinki were respected by all authors. All patients signed an informed consent-form specifically designed for this study, authorizing the use of photographs. Research was approved by the local institutional review board. This study was conducted according to the STROBE and STARD guidelines.

The power of the study has been calculated before patient selection (Fig. 1).

Two different senior surgeons of the same Department performed all the interventions. Each surgeon equally performed the 2 different techniques compared in this study:

1. a latissimus dorsi flap as classically described (simple LDF);
2. a latissimus dorsi flap with preservation of fat extensions as described by Delay et al[3] (LDF + subfascial fat).

A first-step evaluation was made at first day after surgery (day 1), 3 and 6 months postoperatively. Secondly, each group underwent to lipofilling procedures in order to achieve a final volume similar to the contralateral breast according to patient's satisfaction. A self-assessment satisfaction questionnaire was developed. Six items assessed both general (4 items) and aesthetic (2 items) satisfaction:

1. I would definitively choose to have the type of breast reconstruction I had.

2. The volume of my breasts is the same.

3. The size and shape of my breasts are the same.

4. My reconstructed breast(s) feel soft to the touch.

5. Overall, I am satisfied with my reconstruction.

6. I would recommend this type of reconstructive procedure to a friend.

The questionnaire used a 5-point Leikert scale with 1 indicating high satisfaction and 5 indicating low satisfaction. Only responses of 1 or 2 for all items in each subscale were rated as "satisfied." The questionnaire was distributed 3 months postoperatively after lipofilling sessions.

A second-step evaluation had the aim to measure volumes at zero and three months after each fat grafting session (Fig.1).

The primary endpoint of the study was to quantify the volume resorption in LDF reconstructions with preservation of subfascial fat. Volume comparison with simple LDF was performed to find any significant resorption rate of the subfascial fat.

The secondary endpoint was to determine which of the two techniques gives the most satisfactory result in less surgical reinterventions. All characteristics were registered (number of patients, age, average BMI, type of breast reconstructions, number of supplemental lipofilling sessions). Post-operative complications and their length were also recorded.

Exclusion criteria such as obesity (BMI >30), diabetes, active smokers or patients who have undergone radiotherapy were applied.

Breast cancer patients have already undergone to several medical and surgical procedures. Obtaining an optimal result with the fewest number of interventions and the shortest recovery time was our aim.

Patient preparation

Before breast reconstruction, a preoperative assessment was made during consultation: medical history, any antecedents, the state of local tissues, the condition of the contralateral breast, and any available donor sites.

Particular attention is given to the amount of tissue obtainable in the dorsal region by pinching the latero-dorsal pad to gauge the thickness of the adipose layers. It is crucial to compare the mass available with that which will be needed to achieve a suitable breast size.

The patient was also informed of the prospect of dorsal seromas and of their treatment, possibly by repeated puncture, during the postoperative phase.

Surgical Technique

The line of the cutaneous paddle was made in the posterolateral thoracic region, in a crescent shape, opening upward. The paddle length was between 22 and 25 cm. The harvest of the autologous latissimus dorsi flap was made in the lateral supine position.

The cutaneous paddle was then incised and detached on all sides by taking in all the fatty layer over the muscle's surface including its anterior border, the iliac crest and the scapula (fatty zones from 1 to 5 by Delay et al.[3]).

The fat over the muscle is vascularized by the perforators coming from the muscle itself. The thickness of fat varies according to the dorsal adiposity of the patients. The detachment of the flap proceeded downward and then upward. It is crucial to preserve the subdermal plexus blood supply of the dorsal skin (at least 1 cm thick), which becomes the main source of vascularization once the perforators of the latissimus dorsi muscle have been removed.

Secondly, the patient was put in a supine, half-sitting position in order to achieve a correct placement of the flap.

In immediate breast reconstruction, the paddle was positioned into the mastectomy scar. In case of skin-sparing mastectomy, the de-epithelialized flap was put in the subcutaneous layer in place of the breast gland, leaving only an areolar cutaneous disc corresponding to the future areola. In delayed breast reconstruction, cutaneous paddle positioning is dependent on residual thoracic tissues and can be achieved in different ways:

- inserting the cutaneous paddle above the inframammary fold of the new breast;
- reopening the mastectomy scar and positioning the cutaneous paddle in this site;
- combining the de-epithelialized flap with an abdominal advancement flap.

When a satisfactory arrangement of the tissues was achieved, the flap was fixed on itself by using a 2-0 resorbable suture. Closure was performed on two layers after a drain placement. Bandages were put in place leaving a surveillance window over the cutaneous paddle.

The two techniques used in this study differed to each other by the presence or not of the fatty zone two over the harvested muscle.

Lipofilling procedure

Fat tissue was harvested (after at least 6-months post LDF procedure) from the abdominal, flank and thighs fatty areas under general anesthesia. The fat was treated by centrifugation at 3000 rotations per minute for 30 seconds and then purified. The fat tissue was then transferred to the reconstructed breast using a two-millimeter transfer cannula injected in a three-dimensional pattern in order to bring volume to the reconstructed breast.

Post-operative measurements

The material used for our work consists of an iPad mini 2®, characterized by a 5-megapixel camera with an aperture of f/2.4 and a Structure-Sensor camera by Occipital®. Each patient received a 3D measurement in immediate postoperative and then after three and six-months follow-up. The patient was positioned in the middle of a room, without dressing and jewelry, the feet were 35 cm apart, the hands were placed on the hips. The patient had to maintain the position for the duration of the measurement without moving. A decimeter was fixed on the patient's chest, which made it possible to have an objective measurement unit for numerical calibration. The camera has to turn around the patient at a distance of 1,50 meters in order to capture all patient's details. After complete acquisition, the software generates a file in format ".obj" ready to be sent via mail or stored in the hard drive of the device.

Post-production analysis

Three dimensional acquisitions were analyzed using Geomagic Studio® 12 software (Geomagic Solutions, Morrisville, NC, USA). Two different engineers made the 3D analysis. The principle was based on the superposition of volumes. The subtraction of the different volumes analyzed for the same patient made it possible to obtain the volume variation between the two acquisitions. For each patient, the immediate postoperative image was compared with images at three and 6 months after.

During post-production, all artifacts were eliminated from the original acquisition and the 3D mold was "cleaned" cutting-off elements not useful to the analysis (Fig.2).

Once all modeling has finished, scan accuracy was checked by using the "Deviation Analysis tool". The result is a color map on the mesh object showing the surface difference between the two models superimposed (Fig.3). A blind evaluation of the outcomes (3D analysis and volume rate) was performed by two engineers during the whole study.

Statistics

Data were analyzed in order to show any significant differences between the findings collected. GraphPad Prism® (version 7.0 GraphPad Software, San Diego California USA) was used for the statistical analysis. A p-value < 0.05 was considered significant. T-student test was used for volume resorption comparison and Kruskal-Wallis non-parametric test was used to compare BMI modifications during follow-up.

Results

The prospective study included 30 reconstructed breasts (29 patients). The repartition of the procedures, and additional lipofilling sessions are resumed in figure 1.

There were nine cases of delayed breast reconstruction and six cases of immediate reconstruction. There was only a case of bilateral breast reconstruction, so 29 patients were included in the study. The average age was 56 years (ranging from 36 to 65 years) and the BMI had an average of 23,3 kg/m^2 in LDF sec. Delay[3] group and 22,8 kg/m^2 in simple LDF group (Tab.1).

The volumetric study focused on each reconstructed breast after LDF and, secondly, after fat grafting.

The average LDF "with subfascial fat" volume at "time zero" (immediate postoperative) was 526 cc (from 350 to 746). After a three-months follow-up an average resorption rate of 9,1% was found (mean volume of 479 cc, SD of differences 16,2). Immediate postoperative "simple" LDF mean volume was 547 cc (range 340 to 732). Analysis after three months revealed an average intramuscular resorption rate of 8,5% (SD of differences 16,2) (Tab.2).

Moreover, the LDF+subfascial fat group at postoperative six months was 466 cc with a resorption rate of 2,9% (SD of differences 9,7). The average "simple" LDF volume at postoperative six months was 491 cc demonstrating a supplemental resorption rate of 2,1% (SD of differences 7,8). (Tab.3).

Comparison at three and six months revealed no significant difference between the two groups (P value of 0,8 and 0,4 respectively).

Six months after LDF reconstruction, all patients in both groups underwent a fat grafting procedure. The fat tissue harvested for the second part of the study had an average of 420 cc (from 280 to 560) and the fat volume obtained after centrifugation was 194 cc (from 90 to 300) (Tab.4).

A satisfactory result was achieved if volumetric 3D assessment of the reconstructed breast was comparable to the contralateral one and confirmed by patient's expectations at post-operative six months and after every lipofilling session.

After a three-months follow-up, twelve patients (LDF+subfascial fat group) had a satisfying result (80%) (SD of differences 14,8) compared to six patients (40%) belonging to the simple LDF group (SD of differences 16). Volume resorption rate was of 19,3% in both groups with no statistical differences between each group (P value of 0,72) (Tab.5).

A supplemental lipofilling was needed in those breasts with an unsatisfactory volume (three patients in LDF+subfascial fat group and nine in simple LDF group). At this point, volume resorption slightly increased up to 23,5% demonstrating any statistical difference between the two groups (P value of 0,4 and SD of differences 14). (Tab.6).

Discussion

Limitations of the study can be attributed to fat harvesting technique used and variations in fat quality. If the harvested fat is very oily (after centrifugation) the resorption can be more important, rising up to 50%[10,11]. Each surgeon slightly varies in fat harvest and preparation but accordingly to many authors there is no significant difference on the adipocyte survival[12,13]even if integrated with platelet-rich plasma[14].

In order to obtain a scientifically-precise result we had to tackle with several problems encountered during acquisition and post-production analysis.

Limitations in the acquisition phase are the difficulty of scanning large ptotic breasts hiding the inframammary fold and light conditions. For this reason, is crucial the need of performing the digitalization through different heights by inclining the device by multiple angles in a large and bright room in order to reduce the number of "pixel-holes".

Moreover, volume variations are correlated with breathing according to Liu et al.[4]. We applied a position protocol requiring the patient to hold her breath at the end of normal exhalation during 5 seconds. The acquisition was then paused until another inhalation and exhalation was done.

The need to standardize breast surface measurements represented an important objective. Acquisitions were performed several months after each other and patient's morphology could vary. In terms of surface, breast area had to correspond at every superimposition in order to give the exact discrepancy of volume.

Tepper et al.[5] established fixed planes and points to perform objective breast measurements thus called "mammometrics".

The standardized landmarks helped us to clearly identify the breast region over a two-dimensional plane but the posterior chest-wall hidden below the breast cannot be acquired by the camera.

Many techniques have been proposed in order to overcome this problem[6]. We preferred to modify the traditional method introduced by Kovacs et al.[7]. First, the anatomic border of the breast is delineated. A mark is made from 10 cm below the sternal notch along the middle of the sternum to the offshoot of the medial breast fold and caudal to the inframammary fold (IMF) up to the lateral offshoot of the breast fold. The posterior side of the frontal axillary fold and the postero-lateral offshoot of the pectoral muscle up to 5 cm below the clavicle forms the lateral delimitation. The cranial demarcation is placed 10 cm caudal and parallel to the clavicle. The simulated chest wall template is constructed via ‘‘curvature-based filling’’ function after the breast region inside the anatomic border is removed. Breast volume is then computed by Boolean operation of superimposition of the scan containing the breast with the chest wall created (Fig.2).

Data interpretation let us better understand volume variations depending on the reconstructive technique chosen.

Resorption volume percentage in simple LGD after three (8,5%) and six months (2,2%) is comparable to LGD and subfascial fat (9% and 2,9%) without any statistically significant difference. The advantage is to immediately obtain more volume by including the fatty layer in one surgical step. As the percentage of volume variation is similar in both groups we assume that the volume loss is mainly due to muscular atrophy.

Fat graft resorption is a difficult aspect to evaluate in an objective way. Several clinical evaluations reporting important volume variations (up to 80%) have been published in literature[8]. EL Fadl et al.[9] showed a volume variation rate ranging from 40 to 60% after fat grafting. Contrastingly, Delay et al. demonstrated through a CT study an average resorption rate of 21,5%[8]. A possible evolution to the average 30% volume loss can be taken into account, this due to the edema remission.

The resorption rate of latissimus dorsi flap fat grafting is comparable to those found in Delay et al. study[8]. This confirms that the muscle is an optimal receiving tissue for autologous breast reconstruction. BMI measurements were considered in order to avoid an important bias given to weight variations. These data remain sufficiently stable without significant differences (Tab.7).

A detailed analysis of postoperative complications, especially for lymphocele drainages, demonstrates that there is not a significant difference in number of punctures between the two groups this, defining a similar risk in both techniques.

The real gain is given by the reduced number of fat graft interventions (Tab.1). The achievement of a supplemental immediate volume during LDF reconstruction avoids additional interventions, contributing to the patient's physical and psychological well-being.

Conclusions

This study shows no difference in volume retention at follow up between the two techniques. The gain of an immediate and stable fatty layer in LDF + subfascial fat technique leads to breast volume improvement in one surgical step.

Breast reconstruction with LDF and subfascial fat is a reliable solution which conducts to an optimal result with a reduced number of surgical reinterventions (lipofilling sessions) and follow-up.

This study provides a valuable achievement for breast surgery giving us the capability to evaluate the future resorption in order to obtain a satisfying breast result.

Figure legends

Fig. 1 Power calculation of the study

Fig. 2 Study design algorithm

Fig. 3 Volumetric extraction technique in post-production analysis

Fig. 4 Deviation analysis showing no volume modifications (green) and volume reduction (blue) between two 3D models

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Funding: None

Conflicts of interest: None declared

Ethical approval: Not required

Acknlowledgements

We would like to show our gratitude to Stephanie Weber who provided technical equipment and support to our research.

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$$k = \frac{n_2}{n_1} = 1$$

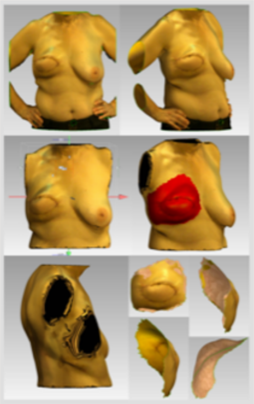
$$n_1 = \frac{(\sigma_1^2 + \sigma_2^2/K)(z_{1-\alpha/2} + z_{1-\beta})^2}{\Delta^2}$$

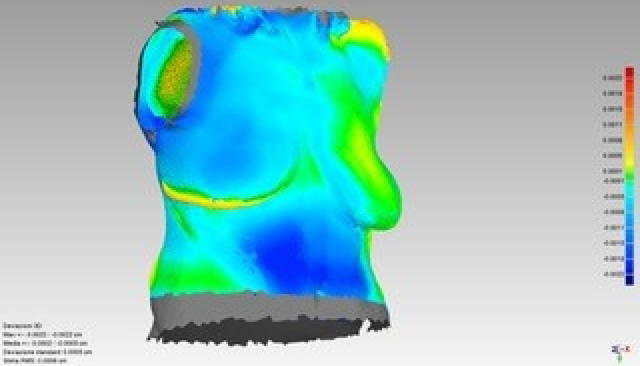
$$n_1 = \frac{(1.5^2 + 1.5^2/1)(1.96 + 1.64)^2}{2^2}$$

$$n_1 = 15$$

$$n_2 = K * n_1 = 15$$

$\Delta = |\mu_2 - \mu_1|$ = absolute difference between two means
σ_1, σ_2 = variance of mean #1 and #2
n_1 = sample size for group #1
n_2 = sample size for group #2
α = probability of type I error (usually 0.05)
β = probability of type II error (usually 0.2)
z = critical Z value for a given α or β
k = ratio of sample size for group #2 to group #1





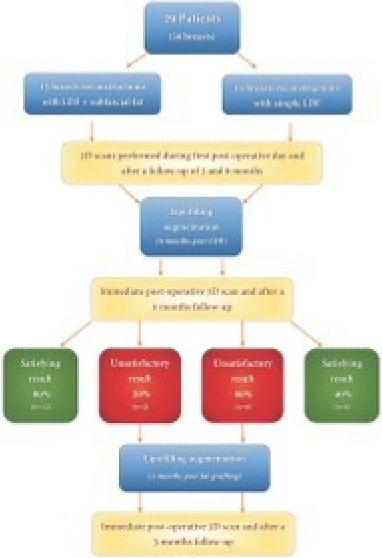

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Table 1. Comparison between the two techniques

	LDF sec. Delay (*15 breasts*)	**Simple LDF** (15 breasts)	**Significance level** (*P*)
Age			
Range (years)	36-65		-
Type of reconstruction			
Immediate	6	4	-
Delayed	9	11	-
BMI (Kg/m²)			
Average	23,3	22,8	0,77
Range	19-30	18-32	
Complications			
Cutaneous necrosis	1 (6,6%)	0	-
Scar disunion	3 (20%)	2 (13,3%)	-
Lymphocele	15 (100%)	14 (93,3%)	-
N° of lymphocele drainages			
Mean weeks	7	6	0,07
Range	5-9 weeks	4-7 weeks	-
Follow-up duration (months)			
Mean	13,2	14,8	0,13
Range	12-18	6-48	-
N° of lipofilling sessions			
mean	1,2	1,6	0,02*

*Statistically significant for $P<0,005$

Tab. 2 Comparative volumes in LDF reconstruction at 3-months post-op

	LGD + subfascial fat volume (cc)		Volume resorption	
PPN	**Time zero**	**3-months postoperative**	**cc**	**%**
1	370	320	50	13,5
2	447	412	35	7,8
3	369	324	45	12,2
4	554	520	34	6
5	417	350	67	16
6	588	532	56	9,5
7	675	642	33	4,9
8	350	329	21	6
9	746	673	73	9,8
10	639	574	65	10
11	544	498	46	8,4
12	413	379	34	8,2
13	473	448	25	5,3
14	623	562	61	9,8
15	689	629	60	8,7
Mean	526,4	479,4	47	9
	Simple LGD volume (cc)		**Volume resorption**	
PPN	**Time zero**	**3-months postoperative**	**cc**	**%**
1	383	340	43	11,2
2	409	375	34	8,3
3	632	567	65	10,2
4	699	629	70	10
5	425	379	46	10,8
6	433	368	65	15
7	637	591	46	7,2
8	637	605	32	5
9	498	459	39	7,8
10	592	541	51	8,6
11	560	493	67	11,9
12	505	473	32	6,3
13	732	711	21	2,8
14	340	320	20	5,8
15	730	680	50	6,8
Mean	547,4	502	45,4	8,5
P value (*P*<0,005) = 0,8				

Tab. 3 Comparative volumes in LDF reconstruction at 6-months post-op

	LGD + subfascial fat volume (cc)		Volume resorption	
PPN	**3-months postoperative**	**6-months postoperative**	**cc**	**%**
1	320	295	25	7,8
2	412	402	10	2,4
3	324	296	28	8,6
4	520	513	7	1,3
5	350	350	0	0
6	532	517	15	2,8
7	642	633	9	1,4
8	329	325	4	1,2
9	673	654	19	2,8
10	574	544	30	5,2
11	498	498	0	0
12	379	358	21	5,5
13	448	437	11	2,4
14	562	553	9	1,6
15	629	624	5	0,8
Mean	479,4	466,6	12,8	2,9
	Simple LGD volume (cc)		**Volume resorption**	
PPN	**3-months postoperative**	**6-months postoperative**	**cc**	**%**
1	340	332	8	2,3
2	375	371	4	1
3	567	555	12	2,1
4	629	618	11	1,7
5	379	351	25	6,6
6	368	359	9	2,4
7	591	573	18	3
8	605	598	7	1
9	459	438	21	4,5
10	541	541	0	0
11	493	476	17	3,4
12	473	473	0	0
13	711	705	6	0,8
14	320	312	8	2,5
15	680	675	5	0,7
Mean	502	491,8	10	2,2
P value (*P*<0,005) = 0,4				

Tab. 4 Volume of fat graft injected

PPN	LGD + subfascial fat	Simple LGD
	First fat graft infiltration (cc)	
1	120	260
2	150	250
3	240	210
4	210	120
5	260	190
6	180	170
7	110	200
8	280	110
9	100	270
10	120	165
11	210	240
12	300	290
13	290	90
14	130	255
15	100	95
Mean	***186,6***	***194,3***
	Second fat graft infiltration (cc)	
1	72	80
2	55	135
3	80	72
4	-	120
5	-	72
6	-	64
Mean	***69***	***90,5***

Tab. 5 Comparative volumes in first fat grafting at 3-months post-op

	LGD + subfascial fat volume (cc)		Volume resorption	
PPN	Post FIRST Lipofilling (immediate)	3-months post lipofilling	cc	% compared to volume injected
1	415	392	23	19
2	552	527	25	16,6
3	536	488	48	20
4	723	682	41	19,5
5	610	558	52	20
6	697	661	36	20
7	743	723	20	18
8	605	555	50	17,8
9	754	736	18	18
10	664	643	21	17
11	708	652	56	26,6
12	658	606	52	17,3
13	727	672	55	18,9
14	683	656	27	20,7
15	724	705	19	19
Mean	653	617	36,2	19,3%

	Simple LGD volume (cc)		Volume resorption	
PPN	Post FIRST Lipofilling (immediate)	3-months post lipofilling	cc	% compared to volume injected
1	592	534	58	22,3
2	621	572	49	19,6
3	765	725	40	19
4	738	708	30	25
5	541	507	34	17,9
6	529	509	20	11,7
7	773	733	40	20
8	708	690	18	16,3
9	708	651	57	21
10	706	675	31	18,8
11	716	672	44	18,3
12	763	703	60	20,7
13	795	780	15	16,6
14	567	508	59	23
15	770	752	18	18,9
Mean	686	648	38,2	19,3

P value (P<0,005) = 0,7

Tab. 6 Comparative volumes in second fat grafting at 3 months post-op

	LGD + subfascial fat volume (cc)		Volume resorption	
PPN	**Post SECOND Lipofilling (immediate)**	**3-months post lipofilling**	**cc**	**% compared to volume injected**
1	464	418	16	22,2%
2	582	567	15	27,2%
3	568	551	17	21,2%
Mean	538	512	16	23,6
	Simple LGD volume (cc)		**Volume resorption**	
PPN	**Post SECOND Lipofilling (immediate)**	**3-months post lipofilling**	**cc**	**% compared to volume injected**
1	614	595	19	24%
2	707	679	28	21%
3	797	783	14	19%
4	828	807	21	18%
5	579	556	23	32%
6	573	562	11	17%
7	693	674	19	45%
8	697	679	18	72%
9	659	639	20	13%
Mean	686	667	19	29
P value (*P*<0,005) = 0,3				

Table 7. BMI analysis

			LGD + subfascial fat			
	Time zero	***6-months postoperative***	***3-months post first lipofilling***	***3-months post second lipofilling***	***P<0,05***	***Kruskal-Wallis***
Mean BMI	23,3	23,4	23,2	23,4	*0,9*	*0,7*
			Simple LGD			
Mean BMI	22,8	22,2	22,3	22,5	*0,9*	*0,4*