ORIGINAL RESEARCH ARTICLE

Volumetric estimation of autologous fat for augmentation of contour defects of face

Shilpi Bhadani, Sujata Sarabahi*, Savita Arora, Vinay Kumar Tiwari, Anmol Chugh

Department of Burns, Plastic and Maxillofacial Surgery, VMMC and Safdarjung Hospital, New Delhi, India

Abstract: Autologous fat transfer for correcting contour defects of face has gained wide popularity in aesthetic surgery. However, quantification of fat requirement and its survival is still a fertile area for research to improve the predictability of volume retention of injected fat. There have been no detailed studies of the calculation for the amount of fat to be injected and percentage of fat retained. The objective of this study was to quantify the amount of fat required for correcting a facial deformity and amount retained postoperatively over a period of 6 months. Thirty patients were recruited in a prospective study where in, the fat requirement for augmenting the soft tissue defect was assessed using USG preoperatively and followed up at 1, 3 and 6 months by the same technique. It was found that USG is a simple, objective, reliable, cost-effective method of assessing the fat requirement and retention in autologous fat transfer.

Keywords: fat transfer; augmentation; volumetry

Correspondence to: Sujata Sarabahi, Department of Burns, Plastic and Maxillofacial Surgery, VMMC and Safdarjung Hospital, New Delhi 110048, India; ssarabahi@yahoo.co.in

Introduction

The current practice of fat transplantation for augmentation of contour deformities at various sites in the body is a rediscovery of the method which has been used by plastic surgeons for more than a century. The origin of the procedure may be difficult to establish but it is to Neuber that Plastic surgeons owe this minimally invasive method. Neuber's first report[1] in the 23rd congress of the German surgical society in 1893 included this procedure in the armamentarium of the plastic surgeons. Later other surgeons like Czerny[2] (1895) who used hip lipoma for mammary reconstruction, Lexer[3] (1910) who transplanted abdominal fat (12 × 13 cm) to nasolabial groove and subsequently more surgeons practised this procedure.

Due to the disappointing results of the retention of the transplanted fat the initial interest in the procedure gradually waned. Peer[4] was the first to realise and describe the importance of measuring the viability of the transplanted fat and reported a survival of 50% volume after one year. Illouz[5] in 1983 invented the technique of liposuction using a cannula and this new technique changed the concept of fat grafting. It changed from being transplanted as a fragment to being re-injected as a tissue. In 1997, Coleman[6] added another dimension to this procedure when he introduced the atraumatic handling of this fragile tissue which consisted of sampling, centrifugation and transfer. Fat processing to increase the survival of the transplanted tissue is now considered critical. The method popularised by Coleman in couple of decades has helped fat transfer re-establish its usefulness in the armamentarium of the plastic surgeons and has become the gold standard for autologous fat transfer. However, due to the various methods of harvesting, processing and injection, there is a great disparity in the reported result of fat grafting in terms of survival and outcomes[7–10]. If we are able to quantify the amount of fat required to correct a particular contour deformity and the amount of the injected fat that is expected to survive we can move in the treatment ladder from art to science.

There are a few reports in literature which have aimed to measure the long term survival of fat by different methods which include clinical observation, photography, Ultrasonography, CT & MRI[11–21]. However, no study has

been done to predict the volume required to correct the contour deformities and subsequently measure its survival in a cost-effective manner. Our study aims to achieve both these ends, using USG as a tool to measure the quantity of fat required and measure the survival.

Material and methods

This is a prospective study carried out with a sample size of 30 patients between the ages of 15–45 years who required fat graft for various facial defects *e.g.* depressed scar, Hemifacial atrophy, facial clefts, hemifacial microsomia and other contour abnormalities of the face.

Inclusion Criteria :

1. Patients with facial defects in the age group mentioned

2. Willing to be recruited in the study and undergo more than one procedure if required for the correction of the defect

3. Patients who were cosmetically concerned about their condition.

4. Willing to accept donor site fat harvest

Exclusion Criteria:

1. Patients beyond mentioned age groups

2. Not willing to undergo more than one or procedure or donor site harvest

Subjective and objective assessments were done by photography and Ultrasonography, respectively, both preoperatively and post-operatively at 1 month, 3 months and 6 months. The preoperative assessment for the volume deficit was also done by facial mould, where wax was used to fill the deficient side to match in contour with the normal side and volume displacement method was used to calculate the volume of wax used for filling the defect.

The volume of the contour defect was measured by USG where to calculate the fat volume a three dimensional measurement of the affected area and the corresponding normal area was taken assuming that fat acquires the shape of an ellipsoid in most areas of the face. The area to be assessed was divided in multiple sections (maximum 3) and length and the breadth of each section was measured with a tape and depth of all sections was assessed by ultrasound. To calculate the volume of each section the formula used for an ellipsoid was applied *i.e.* $4/3\pi$ (r1 × r2 × r3). The volume of all sections was then aggregated to get the total volume of soft tissue in the marked area. (**Figure 1**).The difference in volume of both the affected and the normal side gave us the soft tissue deficit. The plan included injecting this volume deficit + 30% extra adipose tissue into the affected area.

Fat was harvested from various sites viz. lower abdominal wall, gluteal region & thigh depending on the quantity required in different patients. Standard one hole 2 mm leur lock syringe cannula apparatus in accordance with the Coleman's method was used for the fat harvest. The harvested fat was centrifuged at 3000 rpm for 3 min and pure adipose tissue was injected with an injecting cannula (size 0.9–1.2 mm) in the deficient areas in different soft tissue planes to increase the contact area of fat

Figure 1. Diagram showing the method of calculating the volume of the defect

transferred for better vascularisation.

Post operatively USG was used again for the assessment of the fat retained at 1, 3 and 6 months by using the same calculations as mentioned above. We calculated the volume retained after deducting the initial volume of fat that was present preoperatively. At 6 months fat was reinjected in those patients in whom the result after first injection was not satisfactory. The volume for second injection was calculated based on percentage fat absorbed at the end of 6 months after first injection.

Results (Table 1)

The patients recruited in the study required fat grafting for augmenting soft tissue defect in the face due to various conditions. Ten patients were suffering from Hemifacial Microsomia (**Figures 2–5**) while fifteen patients had depressed post traumatic scars (**Figures 6 and 7**). There were 2 patients each of facial clefts & Parry Romberg's disease and 1 patient required augmentation following excision and radiotherapy for rhabdomyosarcoma (**Figures 8 and 9**). Patients for purely aesthetic consideration are not available in a government hospital set up. There were 18 males and 12 females included in the study and the mean age was 23 years. The donor area was abdomen in 17 patients, thigh in 11 patients and gluteal region in 5 patients. In three patients fat was taken from more than one site. There were no complications observed in the donor areas. In the recipient area there was one case of transient facial nerve palsy which resolved in 5 days.

The mean difference in volume calculated was 19.55 mL. The range of volume injected was 6 mL–60 mL, the average being 25.3 mL. At the end of one month the mean volume retained was observed to be 20 mL (80%). The mean volume at the end of 3 months was 16 mL (63.2%) and at the end of 6 months was 14 mL (55.3%). The maximum absorption of the transplanted fat occurred in the first three months following the procedure. Good contouring was achieved in the cases of malar deficiency and jaw line augmentation. It was observed that there was comparatively lesser absorption of fat (average 37.3%) following injection for hemifacial microsomia where the underlying tissues were healthy and vascular compared to depressed scars (52.3%) and Romberg's disease (52.7%). At the end of 6 months assessment there was significant difference ($p = 0.002$). A higher pressure was required to inject under the scarred area and the passes

Table 1. Details of patients

No.	Etiology	Age/sex	Diff in volume by USG	Diff in volume by Mould	Injected volume (mL)	Volume (mL) at 1 month	Volume (mL) at 3 months	Volume (mL) at 6 months	Difference in volume from desired	Re-injection of fat (double the estimated volume)	Volume retained at 6 months
1	Hemifacial Microsomia	18/F	28	25	36	30	22	20	8	13	9
2	Hemifacial Microsomia	22F	27	24	35	31	24	22	5	8	6
3	Hemifacial Microsomia	25F	15	16	20	18	15	15	0	-	-
4	Hemifacial Microsomia	29M	18	18	24	22	16	16	2	-	-
5	Hemifacial Microsomia	28M	15	15	20	16	13	13	2	-	-
6	Hemifacial Microsomia	16F	25	20	33	29	20	20	5	8	5
7	Hemifacial Microsomia	18F	9	10	12	10	6	6	3	-	-
8	Hemifacial Microsomia	20F	40	38	52	45	30	30	10	16	10
9	Hemifacial Microsomia	19M	18	20	26	22	16	16	2	-	-
10	Hemifacial Microsomia	21M	30	30	39	30	22	22	8	13	8
11	Depressed Scar	21/F	10	12	13	10	10	7	3	-	-
12	Depressed Scar	26/M	8	9	11	9	6	6	2	-	-
13	Depressed Scar	35/M	9	7	12	10	7	7	2	-	-
14	Depressed Scar	27/M	14	15	19	15	10	5	9	18	10
15	Depressed Scar	21/M	20	18	26	22	18	18	2	-	-
16	Depressed Scar	26/M	21	20	27	16	16	10	11	22	10
17	Depressed Scar	33/M	26	25	34	20	13	13	13	26	15
18	Depressed Scar	16/F	24	20	32	16	13	10	14	-	-
19	Depressed Scar	19/F	13	11	17	10	10	7	6	12	13
20	Depressed Scar	20/M	12	10	16	10	7	7	5	10	6
21	Depressed Scar	36/M	20	17	26	20	12	10	10	20	8
22	Depressed Scar	18/M	24	22	18	16	13	10	14	28	15
23	Depressed Scar	22/M	30	28	39	35	32	30	0	-	-

Table 1. Continued.

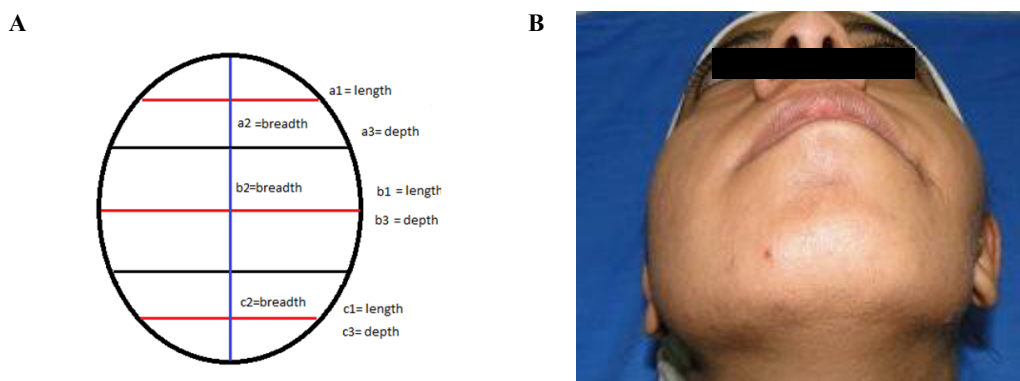| No.	Etiology	Age/sex	Diff in volume by USG	Diff in volume by Mould	Injected volume (mL)	Volume (mL) at 1 month	Volume (mL) at 3 months	Volume (mL) at 6 months	Difference in volume from desired	Re-injection of fat (double the estimated volume)	Volume retained at 6 months
24	Depressed Scar	20/F	25	23	33	26	23	14	11	22	10
25	Depressed Scar	22F	16	15	21	16	16	10	6	12	6
26	Parry Romberg's Disease	16/M	12	10	16	10	7	5	7	-	-
27	Parry Romberg's Disease	26/M	45	40	60	50	42	38	7	14	7
28	Post Radiation damage	22/F	22	22	28	25	21	14	8	16	9
29	Facial cleft	15/M	6	6	8	4	4	3.5	2.5	-	-
30	Facial cleft	26/M	4.5	4.5	6	4	3	2.7	1.2	-	-

A

B

Figure 2. Preoperative photograph of patient of hemifacial microsomia

A

B
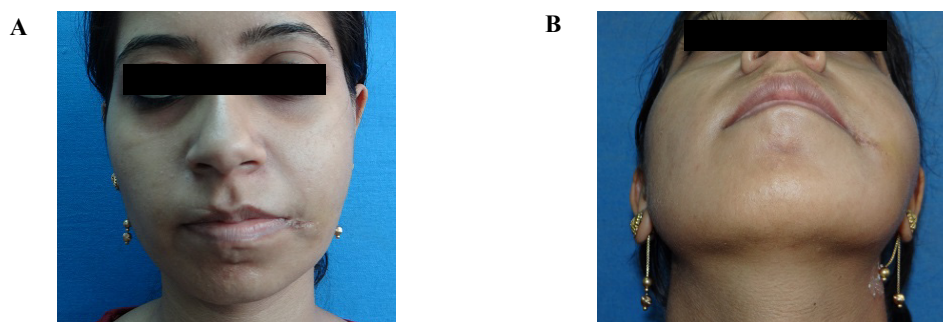
Figure 3. Same patient 1 year after injection of fat

Figure 4. Patient of hemifacial microsomia pre-operatively

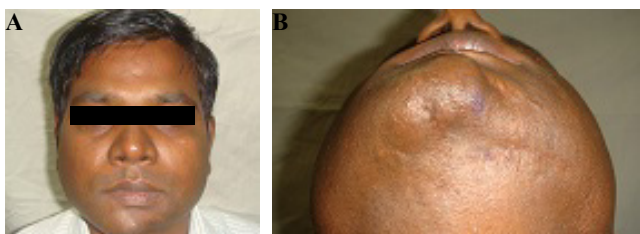**Figure 5.** Patient 1 year after 2 sittings of fat injection

Figure 6. Post traumatic scar on chin pre-operatively

Figure 7. 1 year after 2 sittings of fat injection

Figure 8. Soft tissue defect due to radiation damage

Figure 9. 1 year after 2 sittings of fat injection

of the injecting cannula also led to subcision of the scars. However, subsequent injections under the same scarred areas were comparatively easier and the first procedure led to decrease in the adherence of the scar, hence more passes were possible in the second sitting.

Discussion

Adipose tissue has been lauded by the plastic surgeons as an ideal filler; it is safe, effective, reproducible, devoid of any reactions, non-teratogenic, non-infectious and potentially removable. Due to the high degree of patient satisfaction it has gained wide spread popularity among both the doctor and the patient. The procedure is minimally invasive and because of no donor site morbidity has high acceptance in the patient population. However, even after existence for more than a century among the treating surgeons, it has eluded us of its predictability. The treating surgeon right from the time he starts attending a potential patient often finds asking himself, how much is actually enough? How many touch ups will be required? Finally, it is the method of trial and error that the surgeon often practices when it comes to fat transfer. It is due to unreliable survival of the transplanted fat that literature on autologous fat transplantation is still experiment rich and evidence poor. Kaufman *et al*.[22] have outlined that quantitative evidence of the survival is lacking and optimisation of results needs to be supported by large scale clinical assessment that can quantify the volume of fat surviving after the transfer. Most of the present day studies quote anything between 20–80% of the survival of fat[13,16,21–23]. Majority of these studies rely

on subjective assessment of photographs and patient's and surgeon's subjective opinion to predict the percentage of fat surviving[13–21]. Radiological assessment has also been used by some to quantify the fat volume which includes assessment by MRI and CT scan[19–21]. There has however been no detailed study which calculates the requirement of fat for augmentation in a particular area and the survival of that transplanted fat. MRI, although a reliable method is not cost-effective in repeated assessments and there is risk of exposure to radiation when employing CT scan repeatedly. Ultrasound on the other hand is safe, reliable, cost-effective method which can be repeated to assess volume of retained fat at intervals. Our study aims at predicting the volume required to augment a given area to make it comparable to the normal side. The predictability of absorption would help in assessing the amount of extra fat needed to be injected over and above the required volume (which in aesthetic indications would be judged clinically by the surgeon) in order to take care of the volume that is expected to be absorbed after a procedure). With our follow up we have been able to predict the added percentage of fat required in the initial sitting of lipofilling so that the future touch ups are either obviated altogether or reduced to a minimum.

Ultrasound is an easily available, cost effective and safe method and with its ready availability it becomes a handy tool in assessment which can be carried out by the surgeon himself. Though mould technique was also used by us to calculate the volume deficit, it was found to be too cumbersome and not very reliable for small defects. The method used for fat harvest was standard Coleman's method to exclude any confounding factor due to the technique involved. Since there is a wide range of absorption seen when it came to technique of harvesting of the fat we use gentle manual suction for fat harvest. Controversy also surrounds the processing of the fat before transfer to the recipient site. However, studies support the centrifugation and it has been found that centrifugation helps eliminate the unwanted debris and increases the concentration of fat transferred in a particular volume. Histological difference in the fat centrifuged at 3000 rpm and 4200 rpm was not significant in a study by Yoshimura *et al.*[25]. The injection was done in multiplanar manner to increase the surface area of contact between the fat and the native tissue to help increase the vascularisation of the graft. We do not believe in washing the fat before injection to maintain a closed system of processing and transfer to maintain the sterility. The aim was also to expose the fat as little as possible to procedures that may be a confounding factor in assessing the reasons for absorption and we followed Coleman's method for the same.

In our findings, we noted that the soft tissue edema post injection took about 10–12 days to settle. The maximum amount of absorption occurred in the first 3 months which is consistent with the results of previous studies. After the 3 months the absorption increases in a gentle curve to 6 months with about 45% getting absorbed at the end of 6 months. All patients maintained a stable weight in the six months period. In cases where there was no scarring in the recipient areas *e.g.* hemifacial microsomia, there

was less percentage of absorption (37.3%). In areas which were scarred it was more to the tune of 52.3%. This can be explained by the fewer number of blood vessels in the scarred areas because of fibrosis of tissues and resultant less vascularisation of graft. The subcision was done in the scarred cases by the injecting cannula itself. In some cases it was even difficult to inject the amount of fat calculated by USG. The methods defined a criteria of injection calculated volume plus extra volume, so to maintain the homogeneity in the study these were excluded. Although they can be a part of a separate study in the same series. In Parry Romberg's disease the absorption was also high (52.5%) and it could be explained by the fact that the underlying tissues are atrophic which doesn't allow injection in many planes. We have carried out reinjection in 16 patients and in the second sitting area was assessed for volume deficit and injected double the deficit in the scarred areas and 60% extra in case of hemifacial microsomia to compensate for predicted absorption (Table 1). Ten patients have completed 1 year follow up and seem to be satisfied with the result and do not require more touch-ups at present. The volume has stabilised around the required amount. In the rest 14 patients repeat ultrasound after 6 months showed no change in the volume of injected fat which was seen at 6 months. Since the initial assessment was with USG, we prefered to keep the method of assessment of the fat by the same method although MRI may be added to validate the same. This shows that the volume of transplanted fat gets stabilized after 6 months. The donor sites varied in cases depending on fat availability and patient preference. Literature gives evidence that the fat from different areas has no significant difference in absorption thus fat was harvested from abdomen, thigh or gluteal regions[26,27].

Conclusion

Autologous fat transplantation has gained popularity among the plastic surgeons and its use has been expanding for augmentation of different body parts. However, if we are able to predict and assess its absorption we can help reduce the number of sittings to deliver what the patient is actually looking for. With ultrasound being readily available, it can be a tool in this assessment and guide the surgeon in the first and subsequent sittings of the treatment.

Conflict of interest

The authors declare no potential conflict of interest with respect to the research, authorship, and/or publication of this article.

References

1. Neuber G. u¨ber dieWiederanheilung vollsta¨ndig vom Ko¨rper getrennter, die ganze Fettschicht enthaltender Hautstu¨cke [in German]. About the re-healing completely separated from the body, the whole fat layer containing skin pieces. Zbl f Chirurgie 1893; 30: 16.
2. Czerny V. Plastischer Ersatz der Brustdru¨ se durch ein Lipom [in German]. Plastic replacement of breast dysfunction by a lipoma. Arch f klin Chirurgie 1895; 50: 544–550.
3. Lexer E. Die freien Transplantationen. Stuttgart: Enke, 1919–

1924: 264–547.

4. Peer LA. Transplantation of tissues. Baltimore: Williams & Wilkins, 1955: 396Y–398.

5. Illouz YG. The fat cell ''graft'': A new technique to fill depressions. Plast Reconstr Surg 1986; 78: 122–123.

6. Coleman SR. Facial recontouring with lipostructure. Clin Plast Surg 1997; 24: 347–367.

7. Har-Shai Y, Lindenbaum ES, Gamliel-Lazarovich A, Beach D, Hirshowitz B. An integrated approach for increasing the survival of autologous fat grafts in the treatment of contour defects. Plast Reconstr Surg 1999; 104(4): 945–954. doi: 10.1097/00006534-199909040-00008.

8. Eremia S, Newman N. Long-term follow-up after autologous fat grafting: Analysis of results from 116 patients followed at least 12 months after receiving the last of a minimum of two treatments. Dermatol Surg 2000; 26: 1150–1158. doi: 10.1046/j.1524-4725.2000.00277.x.

9. Rubin A, Hoefflin SM. Fat purification: Survival of the fittest. Plast Reconstr Surg 2002; 109(4): 1463–1464. doi: 10.1097/00006534-200204010-00049.

10. Ersek RA. Transplantation of purified autologous fat: A 3-year follow-up is disappointing. Plast Reconstr Surg 1991; 87(2): 219–227.

11. Niechajev I, Sevcuk O. Long-term results of fat transplantation: clinical and histologic studies. Plast Reconstr Surg 1994; 94(3): 496–506.

12. Nicareta B, Pereira LH, Sterodimas A, Illouz YG. Autologous gluteal lipograft. Aesthetic Plast Surg 2011; 35(2): 216–224. doi: 10.1007/s00266-010-9590-y.

13. Coleman SR. Long-term survival of fat transplants: Controlled demonstrations. Aesthetic Plast Surg 1995; 19(5): 421–425. doi: 10.1007/BF00453875.

14. Pereira LH, Radwanski HN. Fat grafting of the buttocks and lower limbs. Aesthetic Plast Surg 1996; 20(5): 409–416. doi: 10.1007/s002669900056.

15. Scarborough DA, Schuen W, Bisaccia E. Fat transfer for aging skin: technique for rhytids. J Dermatol Surg Oncol 1990; 16(7): 651–655. doi: 10.1111/j.1524-4725.1990.tb00095.x.

16. Gormley DE, Eremia S. Quantitative assessment of augmentation therapy. J Dermatol Surg Oncol 1990; 16(12): 1147–1151. doi: 10.1111/j.1524-4725.1990.tb00027.x.

17. Slack GC, Tabit CJ, Allam KA, Kawamoto HK, Bradley JP. Parry-romberg reconstruction: Beneficial results despite poorer fat take. Ann Plast Surg 2013; EPUB [ahead of print]

18. Choi M, Small K, Levovitz C, Lee C, Fadl A, et al. The volumetric analysis of fat graft survival in breast reconstruction. Plast Reconstr Surg 2013; 131(2): 185–191. doi: 10.1097/PRS.0b013e31829fe2c0.

19. Fontdevila J, Serra-Renom JM, Raigosa M, Berenguer J, Guisantes E, et al. Assessing the long-term viability of facial fat grafts: An objective measure using computed tomography. Aesthet Surg J 2008; 28(4): 380–386. doi: 10.1016/j.asj.2008.05.002.

20. Pierrefeu-Lagrange AC, Delay E, Guerin N, Chekaroua K, Delaporte T. Radiological evaluation of breasts reconstructed with lipomodeling. Ann Chir Plast Esthet 2006; 51(1): 18–28. doi: 10.1016/j.anplas.2005.10.001.

21. Hörl HW, Feller AM, Biemer E. Technique for liposuction fat reimplantation and long-term volume evaluation by magnetic resonance imaging. Ann Plast Surg 1991; 26(3): 248–258.

22. Kaufman MR, Miller TA, Huang C, Roostaeian J, Wasson KL, et al. Autologous fat transfer for facial recontouring: Is there science behind the art? Plast Reconstr Surg 2007; 119(7): 2287–2296. doi: 10.1097/01.prs.0000260712.44089.e7.

23. Peer L. Loss of weight and volume in human fat grafts with postulation of a cell survival theory. Plast Reconstr Surg 1950; 5(3): 217–230.

24. Chajchir A. Fat injection: Long-term follow-up. Aesthetic Plast Surg 1996; 20(4): 291–296. doi: 10.1007/BF00228458.

25. Kurita M, Matsumoto D, Shigeura T, Sato K, Gonda K, et al. Influences of centrifugation on cells and tissues in liposuction aspirates: Optimized centrifugation for lipotransfer and cell isolation. Plast Reconstr Surg 2008; 121(3): 1033–1041. doi: 10.1097/01.prs.0000299384.53131.87.

26. Rohrich RJ, Sorokin ES, Brown SA. In search of improved fat transfer viability: A quantitative analysis of the role of centrifugation and harvest site. Plast Reconstr Surg 2004; 113(1): 391–395. doi: 10.1097/01.PRS.0000097293.56504.00.

27. Ullmann Y, Shoshani O, Fodor A, Ramon Y, Carmi N, et al. Searching for the favorable donor site for fat injection: In vivo study using the nude mice model. Dermatol Surg 2005; 31: 1304–1307. doi: 10.1111/j.1524-4725.2005.31207.