

Methods used for evaluation of volume retention rate in autologous fat grafting for breast augmentation: a systematic review

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Abstract

Background: Autologous fat grafting has gained popularity in breast augmentation. Various methods can be used to estimate the volume retention rate. This systematic review aimed to establish whether the type of method used for measuring breast volume is a factor that influences the reported volume retention rate.

Methods: Studies were identified using the electronic databases PubMed, Embase, Cochrane Central Register of Controlled Trials, and Web of Science from inception of the database up to February 2019. Articles describing autologous fat grafting for breast augmentation were selected based on pre-determined inclusion and exclusion criteria. The characteristics of the included studies were summarized, and the reported volume retention rate from the studies was compared. A quality assessment of all included articles was performed using the methodological index for non-randomized studies criteria.

Results: A total of 618 articles were identified, of which 12 studies, with a total of 1337 cases, were eligible. The retention rate of injected adipose tissue varied when the method of fat grafting and volume analysis used were both the same, as well as when the method of fat grafting was the same but the method of volumetric evaluation used was different.

Conclusions: Currently, the tools available for estimating the volume retention rate come with limitations. In order to objectively evaluate the percentage of graft retention, a standard protocol that applies to the different methods should be established in the future.

Keywords: Breast augmentation; Lipofilling; Autologous fat transplantation; Volume retention; Fat survival; 3D imaging

Introduction

Breast augmentation surgery remains the most frequently performed aesthetic surgical procedure worldwide.^[1] After Coleman^[2,3] standardized the procedure of autologous fat grafting (AFG) in 1995 and achieved significant advancements that minimized the incidence of complications, the procedure has been steadily gaining popularity for cosmetic breast augmentation. In contrast to breast augmentation with implants, AFG is considered to be a safer and more easily adjustable technique that results in natural filling of the breast.

Volume retention rate or fat survival rate is an objective index that evaluates the efficacy of AFG for breast augmentation. AFG has, however, been criticized for having widely inconsistent graft survival rates, ranging from 10% to

50%,^[4] as well as apparent surgeon-dependent outcomes.^[5] Techniques such as fat processing and transplantation are all possible reasons for the difference in percentage graft retention.^[6,7] In addition to the factors which can influence the fat grafting procedure, resulting in different fat volume retention rates, the variation in the tools available for evaluation of the retention rate may also be a potential reason for the differences observed during the follow-up period. Few systematic reviews have to date, to the best of our knowledge, focused on identifying the correlation between volumetric tools and reported fat retention rate. Therefore, in this study we aimed to systematically review the methods used for evaluating the volume retention rate following AFG for breast augmentation in order to establish whether the type of method used may be a factor influencing the final reported fat volume retention rate.

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Methods

Search strategy

This systematic review was conducted in accordance with the “Preferred Reporting Item for Systematic reviews and Meta-Analyses” guidelines^[8] and registered in PROSPERO (PROSPERO 2018: CRD42018094721). The literature review was conducted using a digital search of PubMed, Embase, Web of Science, and Cochrane Library using the keyword “fat grafting” OR “lipofilling” AND “breast augmentation” from inception to February 2019. In addition, further articles were obtained by reviewing the references of the identified articles. The detailed search process is outlined in Figure 1.

Inclusion and exclusion criteria

Selected studies should meet the following inclusion criteria: (1) any trial, case series, or case report involving patients receiving AFG for primary cosmetic breast

augmentation; (2) the study must state the method used for evaluating the change in breast volume; (3) concrete data of fat volume retention rate or survival rate should be provided; (4) articles were restricted to the English language. Exclusion criteria were as follows: (1) AFG performed for reconstructive purposes; (2) patients with a history of other breast surgery, such as breast augmentation with implants, breast implant explantation or other mammoplasties; (3) patients receiving hormone replacement therapy; (4) reviews, letters, and commentaries; (5) studies in which the data were duplicated or overlapped.

Data extraction and quality assessment

Two independent reviewers screened the abstracts and full texts. Data extracted from articles included the authors, date of publication, number of patients, the techniques used for fat harvesting and processing, the injection site and volume, the volume retention rate, volume measurement methods, and follow-up time. If a study included two

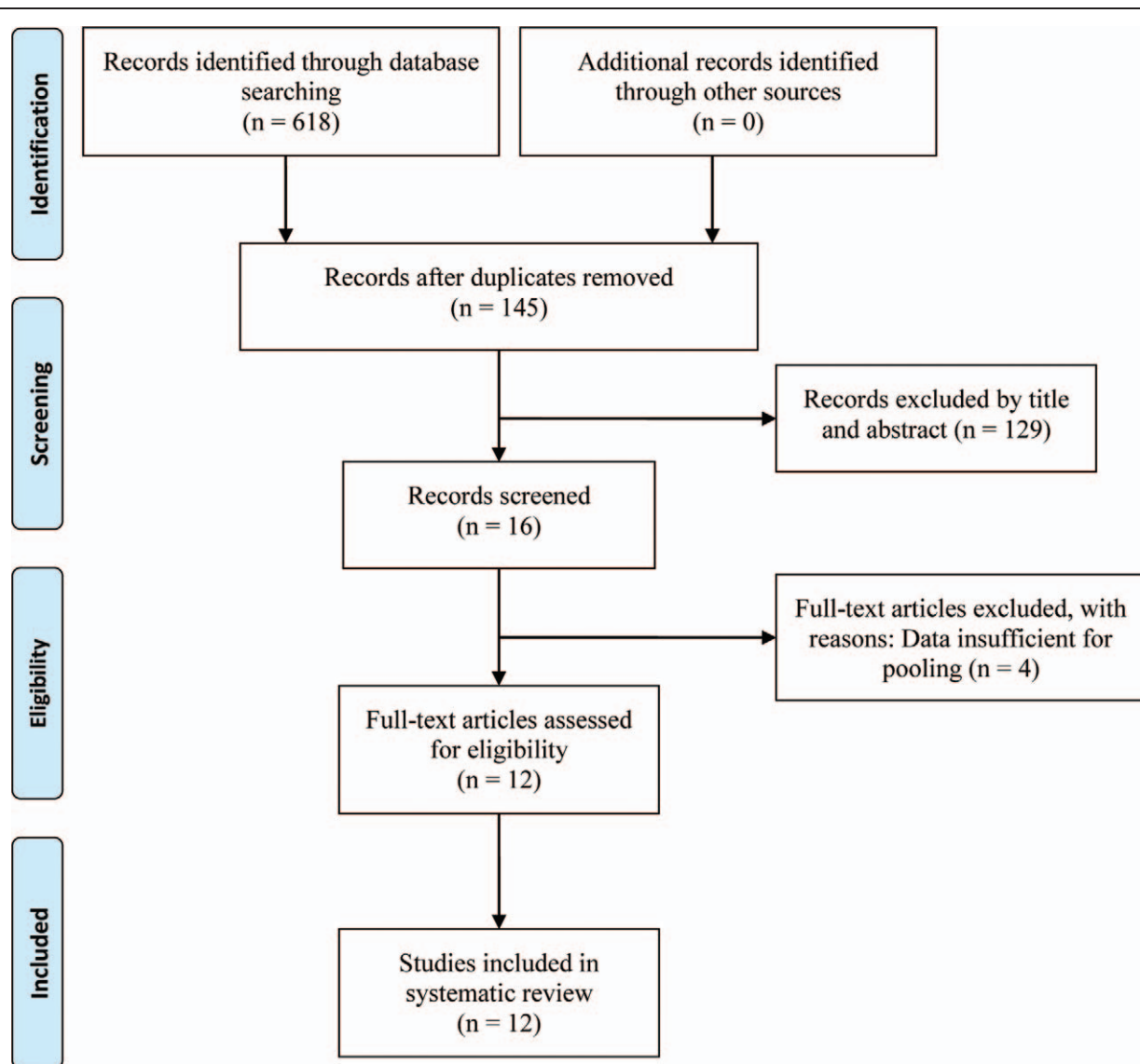


Figure 1: Search results and selection procedure.

different fat processing methods, the study was split into two independent studies. Discrepancies in data extraction were reviewed by all reviewers and discussed until consensus was accomplished. Two reviewers applied the methodological index for non-randomized studies (MINORS)^[9] criteria to assess the methodological quality of included studies. Studies were assigned 0 (not reported), 1 (reported but inadequate), or 2 (reported and adequate), with a maximum of 24 for comparative studies and 16 for non-comparative studies. In the case of a discussion in the quality assessment process, a third independent reviewer was consulted to reach consensus.

Comparison of grafted fat volume retention rate among included studies

According to previous literature,^[10] different fat harvesting techniques showed no difference in adipocyte viability, but the fat processing techniques, including centrifugation or stromal vascular fraction (SVF), did affect fat survival. Thus, in this systematic review we considered two studies to have the same method for fat grating when the studies used the same fat processing or auxiliary methods. We compared the fat retention rate when the method of fat grafting and volume analysis were kept constant, as well as when the method of fat grafting was kept constant but the tools for volume analysis were different.

Results

Search results and study quality

The database search retrieved 145 studies following removal of duplicates, of which 129 were excluded based on their title and abstract. After careful reading of the full manuscripts, 16 studies^[11-26] met the inclusion criteria. Nevertheless, four of the 16 identified studies did not report concrete data of fat retention rate.^[14,17,18,24] Therefore, the systematic review was performed on the 12 studies. A total of 1337 patients were included. The

characteristics of the included studies are shown in Table 1. Non-comparative studies had a mean MINORS score of 12.5, while comparative studies had a mean MINORS score of 21.0, indicating moderate quality of evidence [Supplementary Table 1, <http://links.lww.com/CM9/A85>].

Description of included studies

Lin *et al*^[26] performed a retrospective study included 685 Asian women (622 female patients for primary breast augmentation) underwent AFG to the breasts. Suction-assisted harvest technique was used to obtain the fat graft. Lipoaspirates were then centrifuged at 3000 r/min for 3 min. The average injection volume was 205 ± 45 mL in each breast. Vectra XT three-dimensional (3D) imaging system (Canfield Scientific, Inc, Fairfield, NJ, USA) was used to measure breast volume before the operation and at 6 months post-operatively. The mean graft retention rate was 65%.

Another prospective study included 11 patients (20 breasts) who underwent primary lipoaugmentation. Lipoaspirates were also harvested by traditional suction-assisted technique. Breasts were injected with 207 ± 29 mL of fat and the overall volume retention rate was 56%, which was measured by magnetic resonance imaging (MRI) pre-operatively and 3 months post-operatively.^[25]

Chiu *et al*^[11] compared the change in breast volume in patients who underwent SVF-concentrated fat grafting (group A) and those who underwent conventional fat grafting without SVF (group B) for breast augmentation by using a non-contact and portable 3D laser surface scanner (Konica Minolta Vivid 910 3 D, Konica Minolta Inc. Tokyo, Japan). The survival rate of the transplanted fat was 67.9% in group A and 68.7% in group B at 12 months post-surgery, which was not statistically significant.

Wang *et al*^[21] conducted a study on twelve patients who received breast augmentation using cell-assisted lipotransfer (CAL). The breast volume was digitally examined with

Table 1: Characteristics of the included studies.

| First author | Year | Patients, n | Fat harvesting | Fat preparation/auxiliary method | Injection site | Injection volume (mL) | Volume retention rate (%) | Volume measurement methods | Follow-up (months) |
|--------------|------|-------------|----------------|----------------------------------|----------------|-----------------------|---------------------------|----------------------------|--------------------|
| Lin | 2018 | 622 | SAL | Centrifugation | S/R/P | 205 | 65.0 | 3D | 6.9 |
| Guo | 2018 | 11 | SAL | Sedimentation | S/R/P | 207 | 56.6 | MRI | 3.0 |
| Chiu | 2018 | 105 | UAL | Centrifugation | NA | 310 | 67.9 | 3D | 15.8 |
| Chiu | 2018 | 101 | UAL | CAL | NA | 334 | 68.7 | 3D | 13.4 |
| Wang | 2015 | 12 | NA | CAL | S/R/P | 256 | 48.2 | MRI | 6.0 |
| Jung | 2015 | 5 | WAL | CAL | S/R/P | 221.2 | 46.8 | MRI | 12.0 |
| Spear | 2014 | 10 | SAL | Centrifugation | S/R/P | 243.0 | 37.6 | 3D | 12.0 |
| Khoury | 2014 | 294 | SAL | Centrifugation/BRAVA | NA | 367.0 | 79.8 | 3D/MRI | 9.0 |
| Peltoniemi | 2013 | 5 | WAL | CAL | S/R/P | 187.5 | 67.6 | MRI | 6.0 |
| Peltoniemi | 2013 | 4 | WAL | Sedimentation | S/R/P | 204.5 | 81.6 | MRI | 6.0 |
| Khoury | 2012 | 71 | SAL | Centrifugation/BRAVA | S/R/P | 282.0 | 82.0 | MRI | 6.0 |
| Del Vecchio | 2011 | 12 | WAL | Centrifugation/BRAVA | NA | 430 | 64.0 | MRI | 6.0 |
| Fulton | 2003 | 65 | SAL | PRP/ Ringer solution | R/P | 200–250 | 73.0 | WD | NA |
| Fulton | 1992 | 20 | SAL | Ringer solution | S/R | 289.5 | 71.0 | WD | 19.0 |

SAL: Suction-assisted liposuction, UAL: Ultrasound-assisted liposuction, NA: Not available, WAL: Water-jet assisted liposuction, CAL: Cell-assisted lipotransfer, PRP: Platelet-rich plasma, S: Sub-cutaneous, R: Retromammary space, P: Pectoralis muscle, 3D: Three-dimensional, MRI: Magnetic resonance imaging, WD: Water displacement.

MRI. The ultimate resorption of grafted fat 6 months post-operatively was 51.84% (fat retention rate 48.2%).

A study conducted by Jung *et al*^[13] enrolled five patients (ten breasts) who underwent primary augmentation of both breasts with CAL. The mean grafted fat volume was 221.2 mL and the mean survival rate shown with MRI at the 1-year follow-up was 46.8%.

Spear *et al*^[20] harvested autologous fat using standard low-pressure machine liposuction. After centrifugation, the fat was infiltrated into multiple planes (sub-cutaneous, sub-glandular, and intra-muscular) of the breasts. The average amount of fat injected was 236 mL in the right breast and 250 mL in the left. The mean volume change based on VECTRA 3D imaging (Canfield Scientific, Inc) was 85.1 mL (retention rate 36%) for the right breast and 98.1 mL (retention rate 39.2%) for the left at the 1-year follow-up.

Another study included 294 patients who received AFG with pre-expansion. All patients were asked to wear the Brava device for 10 h/day for 4 weeks. The breast volume was determined using MRI for 62% of the patients and 3D imaging (the device brand was not reported) for the remaining 100 patients. The average MRI follow-up was at 9 months post-operatively. For each patient, the mean fat grafting volume was 367 mL per breast and the graft retention rate was 79.8%. Notably, the authors did not discuss the difference in the methods used for measuring the breast volume.^[16]

The study of Peltoniemi *et al*^[19] included patients who underwent breast augmentation with water-assisted lipotransfer (WAL). In ten of these cases, transferred lipoaspirate was concentrated with SVF while the rest were not. MRI was done pre-operatively and at 6 months after the procedure to measure breast volume change. After excluding the patients who did not satisfy our inclusion criteria, the recalculated retention rate for the SVF group and WAL only group was 67.6% and 81.6%, respectively.

Khoury *et al*^[15] conducted a prospective multi-center study which include patients who underwent autologous fat injection with pre-expansion. The patients were asked to wear the Brava external breast tissue expander for 10 h/day for 4 weeks. MRI was performed at baseline and at final at least 6 months post-operation. The graft survival rate measured using MRI was 82%.

Del Vecchio *et al*^[12] used expansion before breast augmentation with fat grafting. There were 12 patients who had both their pre-operative and 6-month post-operative breast MRIs. The average retention rate was 64%.

Fulton *et al*^[22] added platelet-rich plasma to the adipose tissue and transferred the fat to the breast. The water displacement method was used to measure the volumetric changes, showing an average retention of 73%.

An earlier study also conducted by Fulton *et al*^[23] using the normal autologous fat transfer for breast augmentation found that the volumetric retention rate was 71%, again

measured using water displacement. The average follow-up time was 19 months.

Retention rate of injected adipose tissue varied despite use of the same method for both fat grafting and volume analysis

Three studies used the CAL fat grafting method and MRI for breast volume analysis. The reported long-term fat retention rate was 48.2%,^[21] 46.8%,^[13] and 67.6%.^[19] Three studies used centrifugation for fat processing and 3D imaging for breast volume measurement. The fat retention rate also varied between studies: 65.0%,^[26] 67.9%,^[11] and 37.6%.^[20] Both the studies of Khoury *et al*^[15] and Del Vecchio *et al*^[12] used centrifugation for fat processing and pre-operative expansion, and the measured fat retention rates using MRI were 82.0% and 64.0%, respectively. Additionally, the fat retention rates were 56.6%^[25] and 81.6%^[19] despite both sedimentation used for fat processing and MRI for breast volume measurement in another two studies.

Although some studies used the same method for fat grafting, their methods of measuring the retention rate varied resulting in different outcomes

Of four studies^[11,13,19,21] those used CAL for breast augmentation, three^[13,19,21] used MRI as the tool for measuring breast volume change, while the study of Chiu *et al*^[11] measured the breast volume using 3D imaging. Interestingly, the long-term follow-up of the volume retention rate varied between studies. Additionally, in the study of Spear *et al*,^[20] both 3D imaging and MRI were used to determine the volume of fat retention 1 year after the procedure. The mean volume change based on 3D imaging was 85.1 mL for the right breast and 98.1 mL for the left. The mean volume change based on MRI measurements was 30.0 mL on the right and 29.3 mL on the left.

Discussion

AFG has gained great recognition in aesthetic and reconstructive breast surgery, particularly in recent years. The fat volume retention rate is a key parameter used to evaluate the efficacy of this procedure. The unpredictable long-term fat volume retention rate; however, remains a major clinical issue. Previous studies mainly focused on the effect of fat harvesting, preparation or other auxiliary methods like stem cell concentrated fat or pre-expansion, on the survival of lipoaspirates.^[7,27] Various methods for breast volume analysis have been used to calculate the fat retention rate. Unfortunately, few studies have studied whether the difference in the methods used could have an effect on the final reported retention rate. Herold *et al*^[4] conducted a systematic review which summarized the characteristics of various volumetric tools used for estimation of the volume survival and concluded that 3D imaging was a good tool for frequent follow-up. They, however, did not offer information about the techniques used in AFG nor compared the volume retention rate reported with different methods.

In this systematic review we found that when the methods used for fat grafting and breast volumetric evaluation were kept constant, the fat retention rate still varied between studies. One possible reason for this observation may be that different researchers adopt the same tool but use different standards to measure the breast volume. Glovinski *et al*^[28] reported there were systematic errors when using MRI to measure breast volume changes as the contour of the breast changes after the fat grafting procedure. They advised surgeons to use fixed osseous markers as the breast boundary in order to serve as the reference for all future volumetric measurements and to minimize that systematic error. Additionally, the breast shape can be easily affected by many factors like posture and respiration state, which may also contribute to the variation in the breast volume, thus showing different retention rates even when the same measuring tool is adopted.^[29] Liu *et al*^[30] found that differences in the respiratory state can influence the result of breast volume when a 3D scanning technique is used and concluded that keeping patients in the same respiration state is crucial for accurate measurement of breast volumetric change. Our previous studies also showed that respiration and menstrual cycle are potential factors that influence breast volume measurement.^[31,32] Furthermore, the breast border may vary from patient to patient due to variation in breast shape, as well as differences in the posterior wall due to movement of the thoracic cage. In order to minimize the error created by the use of different protocols for the same method, criteria including patients' respiratory state, posture, menstrual cycle, and breast border should be established in the future.

Another finding of this systematic review was that the reported retention rate was different when studies used the same method for fat grafting but different tools for estimating the retention volume. Currently, success of autologous fat transfer is based on the percentage of graft retention which is equal to final volume augmented divided by initial volume grafted.^[33] In order to get an objective graft retention rate accurate data of pre- and post-operative breast volume must be acquired. However, the tools included in this study, such as MRI, 3D imaging and water displacement all come with limitations. Specifically, due to the restriction of the fixed shape and size of the MRI scanner coils breast volume can be affected, especially for larger breasts.^[29] In 3D imaging, it is not possible to measure the actual breast volume due to the inability of a 3D scanner to scan the posterior border of the breast^[34,35]; The water displacement method is currently regarded as the volumetric gold standard,^[36] but patient compliance varies and reproducibility, precision, and exactness are low. From our perspective, when the same method is used for fat grafting but different tools used for measuring breast volume, the reported retention rates are not always believable. Data from different institutions or surgeons can become better comparable if researchers adopt the same tool for breast volume measurement.

Our study did, however, have some limitations. Factors such as fat processing and techniques of fat injection may all influence fat survival. In this systematic review, we tried to keep other factors consistent in order to study the effect

of the methods used for measuring the breast volume. It is possible, however, that some factors influencing the fat retention rate were not taken into consideration. Furthermore, the studies included in this systematic review are mainly descriptive studies and high quality randomized controlled studies are needed to further verify the results of this systematic review.

Overall, we concluded that another possible reason for the different retention rates in autologous fat transplantation for breast augmentation is the use of different methods of estimating volume change. Surgeons must be informed of the limitations of common methods. In order to make the data from different institutions or surgeons more comparable, the same method should be adopted and a standard protocol for this method should be established.

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Conflicts of interest

None.

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