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REVIEW ARTICLE

A Meta-analytic Review of Platelet-Rich Plasma in Fat Grafting: Enhancing Clinical Outcomes

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Abstract

While platelet-rich plasma (PRP) has gained popularity in plastic surgery, the supporting evidence for its use in this field has not been thoroughly evaluated. This meta-analysis investigated the efficacy and safety of PRP combined with fat grafting compared to fat grafting alone, focusing on fat survival rate outcomes. A comprehensive and systematic search of the Cochrane Library, Web of Science, EMBASE, and PubMed databases was conducted for clinical studies on platelet-reconstituted plasma and fat transfer between 2000 and 2024 for this PRISMA-guided meta-analysis. The methodological quality of the included studies was assessed using the Downs and Black measure. Fifteen trials, encompassing 1215 patients, 417 in the autologous fat graft (AFG) group, and 798 in the (PRP) group, were included and evaluated. Patients were monitored from 3 to 12 months after PRP administration, compared to the fat grafting alone group. The PRP + AFG group demonstrated a significantly higher fat survival rate (0.34 [0.33, 0.35], $p < 0.00001$) and a significantly shorter recovery period (-2.67 [$-4.95, -0.40$], $p = 0.02$). Patient satisfaction was also significantly higher in the PRP group (3.81 [2.59, 5.60], $p < 0.00001$). This research suggests that PRP-enhanced fat transplantation offers advantages over conventional fat grafting alone in terms of fat survival rate and recovery period.

Keywords Meta-analysis · Plastic surgery · Fat grafting · Platelet-rich plasma · Fat survival rate · Patient satisfaction · Recovery time · Autologous · Aesthetic surgery

Introduction

Autologous fat grafting is a breakthrough in the realm of soft tissue augmentation and repair. In plastic and reconstructive surgery, its primary goal is to fill in congenital shortfalls and soft tissue abnormalities, such as healing wounds, reconstructing the breast after breast cancer, and repairing other comparable procedures [1]. A major barrier to graft retention and subsequent filling is the unpredictable resorption of the grafted tissue [2]. Despite the many benefits of autologous fat transplantation, its practical applicability is limited by the low preservation rate of adipose tissue [3]. Graft loss during autologous fat transplantation is erratic and frequently substantial.

Following autologous fat grafting, fat necrosis results from a variety of inflammatory agents and tissue cells reacting to particular stimuli. According to current research, ischemia and hypoxia, browning of white fat, and fibrosis are all involved in the pathophysiology of fat necrosis [4, 5]. An equally significant predictor of graft survival may be the adequate development of new blood vessels, and it has been demonstrated that well-vascularized fat grafts have greater retention rates [6, 7]. Several strategies, such as platelet-rich plasma (PRP) and platelet-rich fibrin (PRF), have been investigated in combination with fat in a clinical setting to improve neovascularization and extend the life of fat grafts [8, 9].

Autologous PRF and PRP have been shown to significantly enhance the formation of blood vessels and subsequently survival of transplanted fat. When a patient's peripheral blood is *collected*, the resultant liquid platelet concentration is known as platelet-rich plasma (PRP), which is higher in cytokines and growth factors [10]. Its application has shown significant promise in several therapeutic plastic

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surgery contexts such as skin rejuvenation, hair restoration, and wound healing [11].

Countable research has been undertaken to evaluate the effect of these alternatives [12, 13], with debatable conclusions. Regarding the optimal management of fat to guarantee the highest possible transplanted fat retention rate, there is currently no agreement in the literature. Consequently, there is disagreement and debate regarding the general clinical effectiveness and safety of these modalities.

To better inform clinical practice, a meta-analysis was undertaken to evaluate the efficacy and safety of PRP for improving fat graft survival. Specifically, this study aims to answer the following question: "Does the PRP improve fat graft survival when compared to fat-only grafts in plastic surgery settings?" This study aimed to evaluate the efficacy and safety of the use of PRP in fat grafts in various plastic surgery applications.

Patient and Methods

Protocol and Registration

Following the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement, this meta-analysis was preregistered in PROSPERO (CRD42024496631) [14]. No attempts were made to get informed consent, exploit patient data, gather unpublished data, or change the procedures described in the clinical studies that are the subject of this meta-analysis. Since this evaluation used published data from the included research, the Institutional Review Board waived the need for ethical approval.

Search Strategy

The search strategy was tailored to each database and was based on the review questions for this meta-analysis study. All relevant papers published from 2000 to 2024 were located using a comprehensive literature search, which aimed to compile the most recent research on the topic while staying up to date. Regardless of language, PubMed, Embase, the Cochrane Library, and Google Scholar were accessed, and translations were applied wherever appropriate. The search strategy was based on the review questions for this meta-analysis and customized for each database.

Medical topic headings (MeSH) and EMBASE subject headings (EHS) were used to find relevant articles for this review. Along with methodological keywords like "plastic surgery," aesthetic surgery," "trial," and "randomized," this review study employed specific MeSH and Embase terms such as "platelet-rich plasma," "PRP," "platelet concentrate," "fat graft(s)," "fat transfer," "fat injection," "extraction," "preparation," "activated," "human," "autologous," "cell assisted lipotransfer," "fat graft," "fat transplantation," "autologous fat harvest," "lipofilling," "fat transfer," and "lipograft" as search keywords.

To obtain relevant and exact contents, Boolean operators such as "AND" and "OR" were employed with the keywords. The terms were paired with adjuncts such as "and "as well as" and ''or." The bibliographic lists of pertinent research were also looked through, in an effort to increase the breadth of the screening procedure for appropriate publications. The language of the articles that were searched was unrestricted.

Inclusion and Exclusion Criteria

After a preliminary screening of identified titles and abstracts, a full-text review was conducted to determine study eligibility. The studies were deemed eligible if they were randomized controlled trials, case series, cohort studies, and case-controlled studies wherein the population was human patients who had received fat grafting for any soft tissue augmentation or filling, the intervention was platelet-rich plasma–assisted fat grafting, the comparator was fat grafting only, and the (c)outcomes was fat graft survival rate, recovery time, and patient satisfaction.

Studies in which any of the outcomes of interest were not provided or could not be calculated, studies with no control group, and studies with control groups other than AFG were excluded. Case reports, conference abstracts, editorials, letters to the editor, protocols, short surveys, review papers, and clinical consensus documents without original data were excluded. Animal studies, non-plastic surgery applications, and non-fat grafting procedures were also excluded from the review.

Data Extraction

Retrieved records from the databases were screened for the titles and abstracts. Only abstracts meeting the selection criteria were selected for full-text review. Ambiguities regarding study selection were discussed with an expert in the field and resolved. Duplicates were removed after confirming the most recent version. The collected papers' reference lists were used as further sources.

To determine if retrieved full-text studies met the inclusion criteria, further evaluation was conducted. A spreadsheet data collection form was created to extract and record pertinent data from the selected full-text studies. From every study, the following information was extracted: author and year, study methodology, patient demographics, volumetric measurement techniques, follow-up period, sites of application, outcomes fat survival rate, patient satisfaction recovery time, adverse effects or complications, and level of evidence.

Quality Assessment and Risk of Bias Assessment of Included Studies

The Downs and Black measure was used to evaluate the methodological quality of the included studies [15]. This quality evaluation checklist comprises 27 items. The highest possible score for randomized trials is 28, while the lowest possible score for non-randomized studies is 25. Methodological quality and risk of bias were assessed for all included studies across the following categories: confounding bias (6 items), reporting bias (10 items), internal validity bias (7 items), external validity bias (3 items), and study power (1 item). All risk of bias domains and individual questions were scored as 0, 1, or 2, except for one item examining the distribution of confounders, which was scored as 0, 1, or 2. Each study's overall quality of evidence was determined by its final score: outstanding (26–28), good (20–25), fair (15–19), or poor (< 14). Evidence levels for all included studies were assigned according to the Oxford Centre for Evidence-Based Medicine 2011 guidelines [16]. Publication bias was investigated using a funnel plot and Egger's test [17]. If publication bias was identified, a sensitivity analysis was performed, removing any potential source of bias.

Outcomes

The assessed fat survival rate served as a measure of the intervention's long-term effectiveness. The incidence of complications, recovery time, and patient satisfaction indicated the intervention's safety and acceptability.

Common complications included cysts, calcification, fat necrosis, nodules, and fibrosis. Fat necrosis, the first sign of ischemia and hypoxia in the grafted fat particles, can progress to cysts, nodules, and calcifications [18, 19]. Repeated fat grafting surgery at the same recipient site was considered a multiple operation frequency [7]. Recovery time, measured in days, was defined as the time patients needed to recover before resuming social activities or work [20].

Patient satisfaction was included as it highlights the procedure's safety, particularly from the patient's perspective. The following were *not* considered complications: asymmetry, under- or overcorrection, redness, swelling, and subcutaneous ecchymosis immediately following surgery and local infection that resolved within 1 to 2 weeks.

Statistical Analysis

RevMan (Review Manager V5.3) and Stata 15.1 (Stata Corporation, College Station, TX) were used for this meta-analysis. The odds ratio (OR) was calculated for the binary outcome (patient satisfaction). For continuous outcomes (fat survival rate and recovery time), the mean deviation of each group from baseline or the mean values after treatment/intervention and their standard deviation (SD) for each group were recorded. The treatment effect estimate was pooled using the calculated mean differences (MD) or standardized mean differences (SMD). The 95% confidence interval (95% CI) was calculated for each metric.

Heterogeneity was assessed using the I^2 and Cochran's Q statistics. I^2 values of 25%, 50%, and 75% indicated low, moderate, and high heterogeneity, respectively. A fixed-effects model was used when I^2 was less than 50%; otherwise, a random-effects model was used. Sensitivity and subgroup analyses were performed to investigate the source of heterogeneity.

Subgroup Analysis

Subgroup analysis was performed by classifying fat graft survival rates by recipient location. A separate subgroup analysis for fat retention rate was conducted, stratified by follow-up period.

Sensitivity Analysis

A leave-one-out sensitivity analysis was performed to ensure that the study results were not unduly influenced by any single study. This involved systematically removing one study at a time and recalculating the summary statistics for the remaining studies.

Results

Study Search

A total of 432 articles were retrieved using the predefined keywords, and 25 additional articles were identified from the references of other articles. After removing 324 duplicates, 133 potentially eligible full-text articles remained. Following a full-text review, 15 publications were ultimately included in the review [21–34]. The selection process is depicted in Fig. 1.

Figure 1 presents the PRISMA flow chart [18] of the literature search. No preferred donor location was identified across the included trials. The choice of adipose tissue harvesting site was generally left to the discretion of the surgeon and patient and included the abdomen, flanks, thighs, and dorsal cervical hump.

The basic characteristics of the 15 studies are summarized in Table 1. Of the 15 studies, 8 articles [22–27, 29, 31] reported grafted fat survival rates, 4 studies [21, 23, 33, 34] recorded patient satisfaction, and 4 studies [28, 30, 32, 33] included recovery time. Thirteen studies had evidence levels of II [29, 31], and 2 had evidence levels of III. The included articles comprised four case series studies with

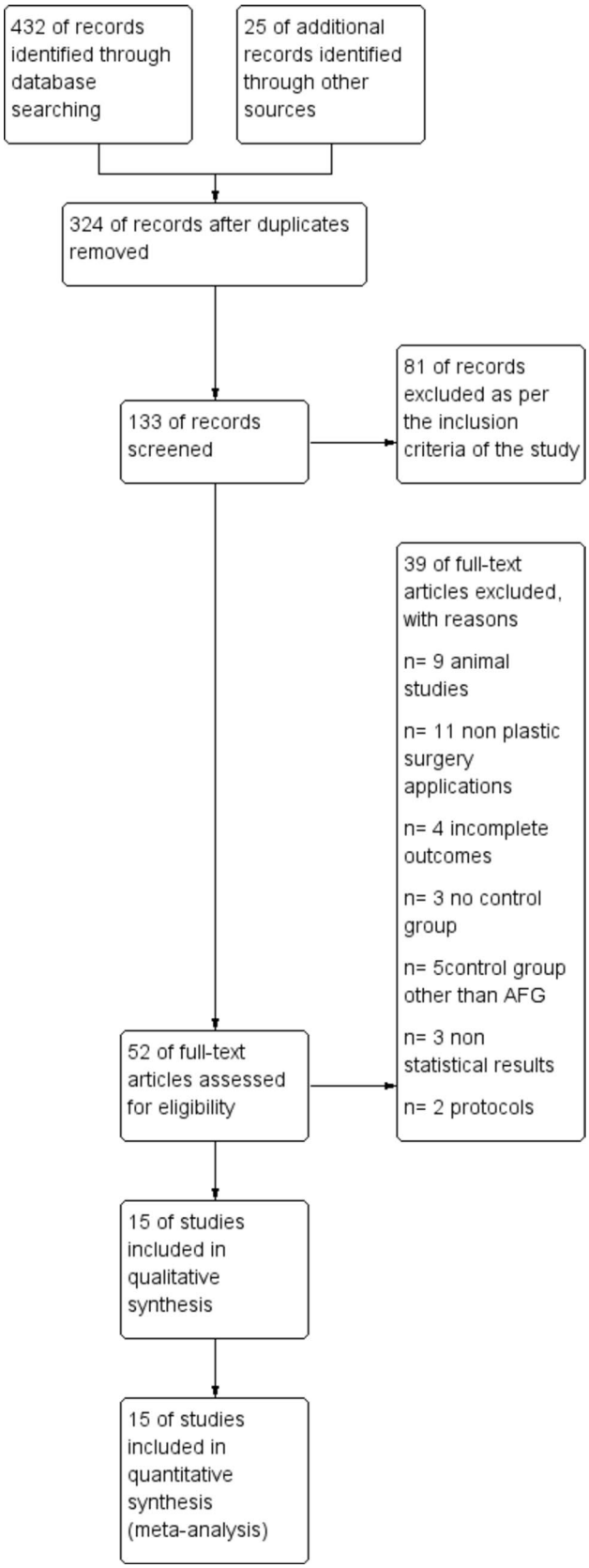

Fig. 1 PRISMA flow diagram from the study selection

accrued patient records analyzed [22, 24, 26, 27], two case-controlled studies [29, 31], four retrospective case series studies [21, 23, 25, 28], and four randomized controlled trials [30, 32–34]. The two primary recipient sites across the included studies were the face and breast. The average patient age across studies was 47.5 years.

Quality Assessment and Risk of Bias in Included Studies

The modified Downs and Black tool was used to assess the methodological quality of the included studies. Nine studies were rated "good," five "fair," and one "poor." Table 2 lists the risk of bias for each study. The risk of attrition bias was low across all studies. The 2011 Oxford Centre for Evidence-Based Medicine guidelines were used to determine the evidence level for each study.

Outcomes

Fat Survival Rate

Data on fat graft survival rates were available from eight studies (Fig. 2). Due to significant inter-study variation in this variable, a random-effects model was used to pool survival rate estimates. Meta-analysis revealed a considerably higher fat survival rate in the PRP group compared to the control group (mean difference (IV, random, 95% CI) 0.34 [0.33, 0.35]). The pooled fat survival rate demonstrated substantial heterogeneity ($Chi^2 = 140.37$, $df = 7$, $p < 0.00001$; $I^2 = 95\%$). The test for overall effect was statistically significant ($Z = 52.28$, $p < 0.00001$).

Patient Satisfaction

Four studies reported patient satisfaction (Fig. 3). These studies used four- or five-category rating systems to assess satisfaction levels. For this meta-analysis, the highest score, representing the most satisfied patients, was used for pooling. Due to substantial heterogeneity among the trials ($I2 = 90.0\%$, $p = 0.001$), a random-effects model was used. Initially, the meta-analysis suggested no significant difference in patient satisfaction between the PRP fat graft (FG) and control groups.

However, a further analysis comparing patient satisfaction results revealed remarkably higher satisfaction in the PRP group compared to the control group (mean difference (IV, random, 95% CI) 3.81 [2.59, 5.60]). The pooled patient satisfaction data showed substantial heterogeneity ($Chi2 = 37.51$, $df = 3$, $p < 0.00001$; $I2 = 92\%$). The test for overall effect was statistically significant ($Z = 6.79$, $p < 0.00001$).

Table 1 Baseline characteristics of the included studies

Study	Methodology	Sites of application	No. of participants		Age	Volumetric measurement method	Follow up in months	Level of evidence	Outcomes	Adverse effects
			AFG	PRP						
Sadati et al., 2006	Retrospective cohort	Breast, face, trunk	–	448	NR	NR	6 to 12	II	PS	NC
Cervelli et al., 2009	Prospective cohort	Face and low extremity	–	35	NR	Photo	18	II	FSR	NC
Salgarello et al., 2011	Retrospective cohort	Breast	132	17	NR	NR	9	II	PS	NC
Gentile et al., 2012	Prospective cohort	Breast	6	13	19–60	MRI and ultrasound	12	II	FSR	Fat liquefaction
Cervelli et al., 2013,	Retrospective cohort	Soft tissue and lower extremity	10	40	18–75	MRI and ultrasound	12	II	FSR	NC
Gentile et al., 2013	Prospective cohort	Breast	10	50	19–60	MRI and ultrasound	12	II	FSR	NC
Gentile et al., 2014	Prospective cohort	Face	50	10	21–69	MRI and ultrasound	12	II	FSR	NC
Willemsen et al., 2014	Retrospective cohort	Face	25	18	35–65	NR	3	II	RT	Fat necrosis
Sasaki et al., 2015	Case-controlled study	Face	105	82	19–77	3D Vectra analysis	12	III	FSR	NC
Martinez-Zapata et al., 2016	RCT	Wound	33	7	45.6	Ultrasound	12	II	RT	NC
Sasaki, 2019	Case-controlled study	Face	–	10	54.4	3D Vectra analysis	12	III	FSR	NC
		Hand	–	10						
Willemsen et al., 2018	RCT	Face	13	25	51.73	NR	3	II	RT	NC
Zhang et al., 2022	RCT	Face	18	18	20–58	3D photo	3	II	FSR, PS, RT	NC
Kadry et al., 2023	RCT	Face	15	15	20–67	Photo	3	II	PS	NC

"–" not available

AFG autologous fat grafting, *MRI* magnetic resonance imaging, *PRP* platelet-rich plasma, *FSR* fat survival rate, *PS* patient satisfaction rate, *RT* recovery time, *RCT* randomized controlled trials, *NC* no complications, *NR* none reported

Table 2 Downs and Black instrument adapted a quality assessment checklist for evaluating the methodological quality of the included studies

Studies, year of publication	Sadati et al., 2006	Cervelli et al., 2009	Salgarello et al., 2011	Gentile et al., 2012	Cervelli et al., 2013	Gentile et al., 2013	Gentile et al., 2014	Willemsen et al., 2014	Sasaki et al., 2015	Martinez-Zapata et al., 2016	Sasaki, 2019	Willemsen et al., 2018	Zhang et al., 2022	Kadry et al., 2023
Reporting														
Is the hypothesis/aim/objective of the study clearly described?	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Are the main outcomes to be measured clearly described Introduction or Methods section?	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Are the characteristics of the patients included in the study clearly described?	1	0	1	1	1	1	1	1	1	1	1	1	1	1
Are the interventions of interest clearly described?	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Are the distributions of principal confounders in each group of subjects to be compared clearly described?	2	2	2	0	0	2	2	2	2	2	2	2	2	2
Are the main findings of the study clearly described?	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Does the study provide estimates of the random variability in the data for the main outcomes?	0	1	1	1	1	1	1	1	1	1	1	1	1	1

Table 2 (continued)

Studies, year of publication	Sadati et al., 2006	Cervelli et al., 2009	Salgarello et al., 2011	Gentile et al., 2012	Cervelli et al., 2013	Gentile et al., 2013	Gentile et al., 2014	Willemsen et al., 2014	Sasaki et al., 2015	Martinez-Zapata et al., 2016	Sasaki, 2019	Willemsen et al., 2018	Zhang et al., 2022	Kadry et al., 2023
Have all important adverse events that may be a consequence of the intervention been reported?	0	1	0	1	0	0	0	0	0	1	0	1	0	1
Have the characteristics of patients lost to follow-up been described?	0	1	0	1	0	1	1	0	0	0	1	0	1	1
Have actual probability values been reported for the main outcomes except where the probability value is less than 0.001?	1	1	1	1	1	1	1	1	1	1	1	1	1	1
External validity														
Were the subjects asked to participate in the study representative of the entire population from which they were recruited?	1	0	1	0	0	1	1	1	0	1	1	1	1	1
Were those subjects who were prepared to participate representative of the entire population from which they were recruited?	0	0	1	0	0	1	1	1	0	1	1	1	1	1

Table 2 (continued)

Studies, year of publication	Sadati et al., 2006	Cervelli et al., 2009	Salgarello et al., 2011	Gentile et al., 2012	Cervelli et al., 2013	Gentile et al., 2013	Gentile et al., 2014	Willemsen et al., 2014	Sasaki et al., 2015	Martinez-Zapata et al., 2016	Sasaki, 2019	Willemsen et al., 2018	Zhang et al., 2022	Kadry et al., 2023
Were the stay, places, and facilities where the patients were treated, representative of the treatment the majority of patients receive?	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Internal validity—bias														
Was an attempt made to blind study subjects to the intervention they have received?	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Was an attempt made to blind those measuring the main outcomes of the intervention?	0	0	0	0	0	0	0	0	0	0	0	0	0	0
If any of the results of the study were based on "data dredging", was this made clear?	1	1	1	1	1	1	1	1	0	1	0	1	1	1

Table 2 (continued)

Studies, year of publication	Sadati et al., 2006	Cervelli et al., 2009	Salgarello et al., 2011	Gentile et al., 2012	Cervelli et al., 2013	Gentile et al., 2013	Gentile et al., 2014	Willemsen et al., 2014	Sasaki et al., 2015	Martinez-Zapata et al., 2016	Sasaki, 2019	Willemsen et al., 2018	Zhang et al., 2022	Kadry et al., 2023
In trials and cohort studies, do the analyses adjust for different lengths of follow-up of patients, or in case–control studies, is the time period between the intervention and outcome the same for cases and controls?	1	1	1	1	1	1	1	1	0	1	1	1	1	1
Were the statistical tests used to assess the main outcomes appropriate?	1	1	1	1	1	1	1	1	0	1	1	1	1	1
Was compliance with the intervention/s reliable?	1	1	0	1	1	1	1	1	1	1	1	1	1	1
Were the main outcome measures used accurate (valid and reliable)?	1	1	1	1	1	1	1	1	0	1	1	1	1	1
Internal validity—confounding (selection bias)														
Were the patients in different intervention groups (trials and cohort studies) or were the cases and controls (case–control studies) recruited from the same population?	1	1	1	1	1	1	1	1	0	1	1	1	1	1

Table 2 (continued)

Studies, year of publication	Sadati et al., 2006	Cervelli et al., 2009	Salgarello et al., 2011	Gentile et al., 2012	Cervelli et al., 2013	Gentile et al., 2013	Gentile et al., 2014	Willemsen et al., 2014	Sasaki et al., 2015	Martinez-Zapata et al., 2016	Sasaki, 2019	Willemsen et al., 2018	Zhang et al., 2022	Kadry et al., 2023
Were study subjects in different intervention groups (trials and cohort studies) or were the cases and controls (case–control studies) recruited over the same period of time?	1	1	1	1	1	1	1	1	0	1	1	1	1	1
Were study subjects randomized to intervention groups?	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Was the randomized intervention assignment concealed from both patients and healthcare staff until recruitment was complete and irrevocable?	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Was there adequate adjustment for confounding in the analyses from which the main findings were drawn?	0	1	1	1	1	1	1	1	0	1	1	0	1	1
Were losses of patients to follow-up taken into account?	0	1	1	1	0	1	1	1	1	1	1	0	1	1
Power														

Table 2 (continued)

Studies, year of publication	Sadati et al., 2006	Cervelli et al., 2009	Salgarello et al., 2011	Gentile et al., 2012	Cervelli et al., 2013	Gentile et al., 2013	Gentile et al., 2014	Willemsen et al., 2014	Sasaki et al., 2015	Martinez-Zapata et al., 2016	Sasaki, 2019	Willemsen et al., 2018	Zhang et al., 2022	Kadry et al., 2023
Did the study have sufficient power to detect a clinically important effect where the probability value for a difference being due to chance is less than 5%?	1	0	0	0	0	1	0	1	0	0	0	0	0	0
Final score	18	20	20	19	16	23	22	22	12	22	20	23	23	19

Recovery Time

Four of the fifteen included studies reported postoperative recovery time (Fig. 4). Meta-analysis showed moderately shorter recovery times in the PRP group compared to the control group (mean difference (IV, random, 95% CI) −2.67 [−4.95, −0.40]). The pooled recovery time data exhibited substantial heterogeneity ($Chi^2 = 27.70$, df = 3, $p < 0.00001$; $I^2 = 89\%$). The test for overall effect was statistically significant ($Z = 2.30$, $p = 0.02$).

Other Complications Only 2 studies reported fat necrosis as a complication, and one study reported fat liquefaction. All the other studies reported no complications or requirements for repeated procedures.

Subgroup Analysis

A subgroup analysis of fat retention rate was performed, stratified by recipient site (Table 3). This analysis revealed a significant difference in fat retention rates between the PRP and control groups across various recipient sites, including the hand, face, breast, and soft tissues.

The difference in fat survival rates between the two groups appeared to increase with longer follow-up periods. Therefore, a stratified analysis based on follow-up duration was conducted to investigate follow-up as a potential source of heterogeneity. The follow-up period was stratified for subgroup analysis of fat retention rate. Reported assessments at two, three, six, eight, twelve, and eighteen months were considered. Pooled results were evaluated for the combined follow-up intervals from 2 to 18 months.

Subgroup analysis by follow-up period showed that the pooled odds ratio (OR) for fat survival rate was statistically significantly higher in the PRP group compared to autologous fat grafting alone at most time points, with the exceptions of 2, 6, and 8 months. The pooled OR for the other follow-up time points was 0.24 [0.21, 0.27]. The highest pooled OR was observed at the 18-month follow-up [22].

Publication Bias

The funnel plot in Fig. 5 indicated a high risk of publication bias for the fat survival rate.

The observed asymmetry in the funnel plot suggests potential publication bias. This may indicate that the true effect of PRP-enriched grafts on fat graft outcomes is underestimated due to the underrepresentation of studies with non-significant findings. The funnel plot also suggests substantial

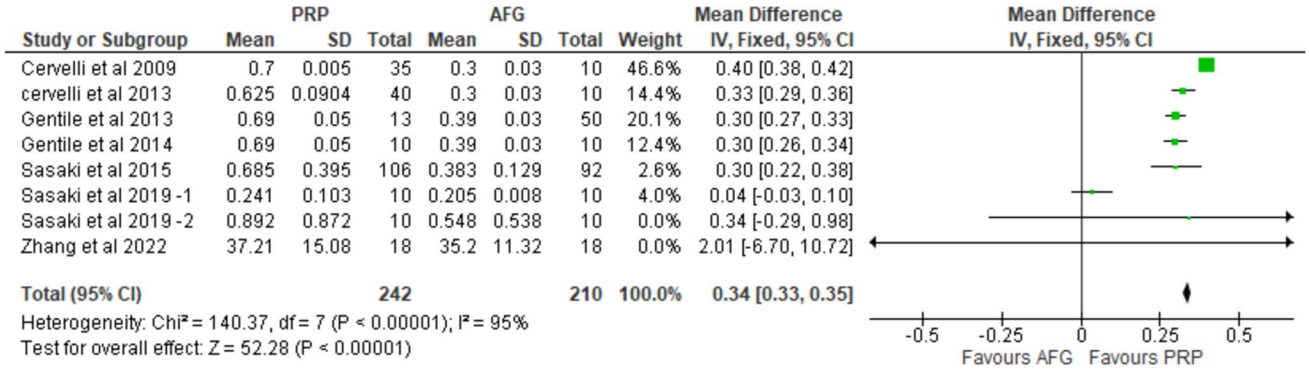

Fig. 2 Forrest plot of pooled fat graft survival rate from the included studies

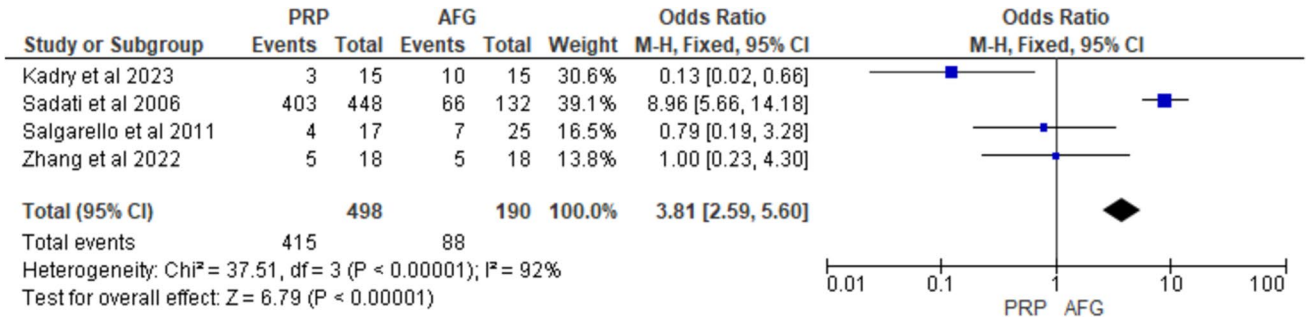

Fig. 3 Forrest plot of pooled patient satisfaction from the included studies

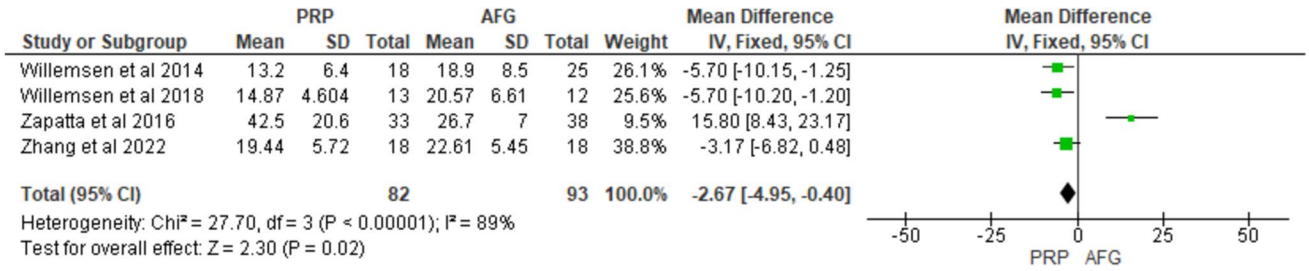

Fig. 4 Forrest plot of the recovery time from the included studies

Table 3 Subgroup analysis for the fat survival rate from the included studies

Subgroup	Number	95% CI	I^2	*p*-value for heterogeneity
Face	8	0.30 [0.29 to 0.32]	95%	$p < 0.001$
Breast	4	0.26 [0.23 to 0.30]	95%	$p < 0.001$
Soft tissue	2	0.33 [0.27 to 0.36]	95%	$p < 0.001$
Hand	1	0.21 [0.17 to 0.28]	95%	$p < 0.001$

heterogeneity among the included studies, potentially due to variations in study design, patient populations, and PRP preparation methods.

Sensitivity Analysis

Although publication bias was identified in the analysis of fat survival rates, the pooled analysis, even after excluding a small study [34], still showed a significant improvement in fat survival, with a pooled effect size of 0.29 (95% CI 0.27–0.30). However, the substantial heterogeneity ($I^2 = 91\%$) underscores the need for further research to identify factors influencing treatment effectiveness and optimize patient selection.

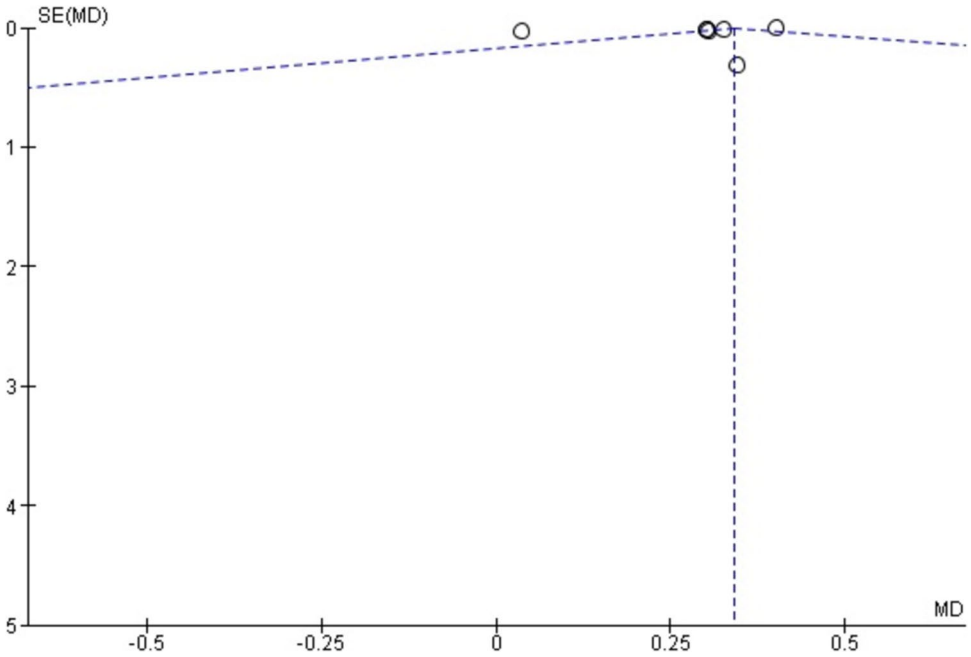

Fig. 5 Funnel plot of the studies comparing fat survival rate

Discussion

While autologous fat and platelet co-transplantation has emerged as a promising method for soft tissue repair in plastic surgery, its safety and clinical efficacy remain debated. This study aimed to systematically evaluate the clinical effectiveness, safety, and patient acceptability of autologous fat grafting with PRP compared to traditional fat grafting in plastic surgery. This meta-analysis, comprising 15 publications, demonstrated a significantly higher fat graft survival rate with PRP-enhanced fat grafting compared to traditional fat grafting alone. Patients in the PRP group also experienced faster recovery times and reported notably higher satisfaction with the procedure.

The potential benefits of platelet-rich plasma (PRP) in fat grafting have been demonstrated in both human and animal studies [35–38]; however, the methodologies used in these studies vary considerably. This methodological discrepancy is important, especially given the growing body of research indicating that procedural factors play a crucial role in determining PRP quality and fat graft outcomes. Further data from high-quality trials are needed to address these methodological variations in fat grafting.

The results of this meta-analysis are consistent with a recent study [39] that focused on animal research and demonstrated that combining platelet-rich fibrin (PRF) and fat grafting can improve microvessel density and survival rate in transplanted tissue.

Assuming that PRP supplementation enhances volume, beyond the volume-related benefits of fat grafting alone, this study provides Level III clinical evidence highlighting the need for further investigation with randomized controlled trials. The comparative effectiveness of traditional fat grafting versus fat grafting supplemented with PRP remains undetermined without Level I clinical evidence. Until such evidence is available, these findings support the clinical hypothesis that plastic surgeons may expect a 10% prolongation of autologous fat volume replacement by combining it with PRP fibrin glue [40].

Sex differences affect hormone levels and sex, which can have a variety of consequences. While many researchers assume that body mass index (BMI), hormonal status, dietary habits, stress, and lifestyle affect PRP quantity and quality, data supporting or refuting this assumption remain limited. This meta-analysis did not include comparative studies based on sex, age, BMI, health condition, number of treatments, smoking, or alcohol consumption.

Several factors beyond PRP influence fat graft survival. Recipient site pre-expansion (e.g., with BRAVA) improves the blood supply and creates space [41]. Hyperbaric oxygen therapy enhances oxygen availability. Graft enrichment with growth factors, stem cells (adipose-derived stem cells, adipose-derived stem cells (ADSCs)), or other bioactive substances and accelerated revascularization (e.g., with stromal vascular fraction (SVF) or vascular endothelial growth factor (VEGF)) promote integration [6, 6, 42–44]. Other promising techniques include promoting preadipocyte differentiation (e.g., with salvianolic acid-B), and polymer therapy is also being explored [45, 46]. Postoperative care, including compression, hydration, activity restrictions, and specific positioning, is crucial for minimizing pressure on the graft [47].

Strengths and Limitations

Due to the limited number of high-quality clinical trials currently available on enhanced fat grafting techniques, only a small number of articles could be included in this analysis. These studies not only assessed fat graft duration (using MRI, ultrasound, or 3D Vectra analysis) but also employed a variety of PRP extraction, activation, and concentration methods. Some included studies used Coleman fat grafting, while others used adipose-derived stem cells (ADSCs) and pure stromal vascular fraction (SVF). This methodological variability was not accounted for in the meta-analysis due to insufficient data.

In order to distribute growth factors and encourage angiogenesis for better graft survival, PRP and AFG are combined by first activating PRP (for example, with calcium chloride) and then gently combining or stacking it with prepared fat tissue. A thorough description of the precise approach employed in any study is essential because differences in mixing techniques (activation, ratios, method, and timing) can have a major impact on the PRP-AFG product and its biological effects. This is a crucial methodological aspect in PRP-AFG research since it guarantees repeatability, permits appropriate interpretation of results by recognizing the technique's possible influence on outcomes, aids in locating sources of variability, and informs the generalizability of findings.

Ultimately, the caliber of a meta-analysis cannot outweigh the caliber of the papers it incorporates, as prior meta-analyses have shown. Due to the fact that four of the included research were case–control studies and only four were randomized controlled trials, the included studies had an inherent bias, such as selection bias. Despite these drawbacks, the research adhered to PRISMA guidelines, used the Cochrane risk of bias tool to evaluate the quality of the included studies, and presented a summary of the clinical evidence gathered over a 23-year period regarding the safety and effectiveness of PRP-enhanced fat grafting in terms of patient satisfaction, recovery time after surgery, and fat graft survival.

Conclusion

While numerous strategies have been proposed to improve the clinical outcomes of autologous fat grafting, the optimal approach remains debated. In conclusion, our study suggests that platelet-rich plasma (PRP)-enhanced fat grafting is superior to traditional fat grafting, demonstrating reduced recovery time and increased fat graft survival rates. Future well-designed, randomized controlled trials are needed to confirm these findings and to determine the platelet-rich plasma (PRP concentration and combination ratio, safety profile, and long-term therapeutic efficacy).

The results of this study can inform the design of future research. Recovery time, for example, could serve as a valuable endpoint. A prolonged recovery period significantly impacts a patient's daily life compared to a shorter one. Given this impact, recovery time is a relevant objective in therapeutic trials aimed at optimizing the patient experience. Therefore, recovery time may be a reliable endpoint for future systematic reviews and meta-analyses in fat grafting. Patient satisfaction also warrants further investigation. Combining platelet-rich plasma (PRP) with other fat grafting techniques may result in a more viable and natural-looking graft with higher—or at least comparable—patient satisfaction. This possibility is worth exploring, as improved satisfaction rates could influence patients' willingness to invest in the procedure.

Author Contribution The sole author contributed to all aspects of this study like concept and design, acquisition, analysis, or interpretation of data, drafting of the manuscript, critical review of the manuscript for important intellectual content, and statistical analysis and took responsibility for the integrity of the data and the accuracy of the data analysis.

Data Availability As this meta-analysis review did not generate any new data, the data analyzed in this review were extracted from published studies identified through our systematic search. All data sources are documented in the reference list of this article (including references and DOIs).

Declarations

Ethics Approval and Consent to Participate Ethical review and approval were waived for this study as it was a systematic review that did not involve primary data collection or direct patient involvement.

Conflict of Interest The author declares no competing interests.

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