



Hand Rejuvenation: A Systematic Review of Techniques, Outcomes, and Complications

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Abstract

Background Hand rejuvenation is an increasingly popular cosmetic procedure for hand atrophy and aging. The objective of this study is to systematically evaluate the techniques, outcomes, and complications of surgical hand rejuvenation.

Methods A systematic review was undertaken using a computerized search. Publication descriptors, methodological details, techniques, outcomes, and complications were extracted. Articles were assessed using the MINORS and Cochrane instruments.

Results Thirty-one studies were included. Most studies were published in the last five years (51.6 percent) and were prospective case series (35.5 percent). The mean age of patients was 56 (range 21–82), while the mean sample size was 47 (range 10–220). The most commonly examined interventions were Radiesse (32.2 percent) and fat grafting (32.2 percent). Major complications were not observed in any study, while minor complications such as edema and pain were temporary. Injection techniques varied, however, the proximal to distal fanning technique and using a cannula was associated with a lower risk of complications. Both Radiesse and fat grafting had robust long-term esthetic outcomes.

Conclusions Hand rejuvenation is a safe and efficacious surgical intervention to reduce dorsal hand atrophy. Further studies are needed to compare the long-term outcomes of common interventions.

Level of Evidence III This journal requires that authors assign a level of evidence to each article. For a full description of these Evidence-Based Medicine ratings, please refer to the Table of Contents or the online Instructions to Authors www.springer.com/00266.

Keywords Hand rejuvenation · Esthetic · Plastic surgery · Hand

Introduction

Hand rejuvenation is a collective term for a variety of esthetic interventions aimed at improving the appearance of aged hands. As the hand ages, multiple esthetic aspects are affected. Commonly, veins, tendons, and bony contours of the dorsum of the hand become more prominent secondary to subcutaneous fat loss. [1, 2] Additionally, skin quality decreases with age as the dermis thins and skin becomes more flaccid. [1, 3] Finally, the hands are particularly susceptible to UV light exposure during the lifetime, leading to alterations in cutaneous pigmentation, known as photodamage. [3]

Recent literature has suggested that the appearance of the hand is the second-most telling sign of chronological age, second only to the face. [4] Studies of non-expert volunteers very accurately identified patient age by observing photographs of the hands of various age groups, reinforcing the role of the hands as evidence for age. [5] As such, it is unsurprising that hand rejuvenation has gained popularity in esthetic medical practices over the past 15 years with an increasing number of clients requesting procedures to improve hand appearance. [1, 2]

Hand rejuvenation procedures generally fall under two broad categories including surgical and non-surgical

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options. Surgical options involve autologous reconstructive principles, predominately the use of fat grafting, wherein fat is harvested from a donor site, purified and injected into the dorsum of the hands. Non-surgical options involve subcutaneous injection of synthetic biomaterials into the dorsal hand. The most commonly utilized materials include hyaluronic acid and calcium hydroxyapatite, though many others are commonly used. [1–3]

The purpose of this systematic review is to assess and compare the evidence for methods of hand rejuvenation along with their techniques, outcomes, and complications.

Methods

Protocol and Eligibility Criteria

The Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guideline was followed in the performance and reporting of this review. [6] The population of interest in this study consisted of the adult patient population. The intervention being considered was any surgical hand rejuvenation procedure. The control was any surgical hand rejuvenation procedure. The outcomes of interest were any esthetic outcome along with potential complications. Studies investigating lasers were excluded. Comparative and single arm studies were included. In vitro studies were included in this study, while animal studies were not included.

Search Strategy and Study Selection

The following electronic databases were searched with help from a medical librarian from inception to August 31, 2020 to identify relevant prospective and clinical trials: MEDLINE, PubMed, EMBASE, and Google Scholar. The search was mapped to MeSH terms, and the following terms were used to identify potential articles: “hand rejuvenation” or “dorsal hand rejuvenation” or “aging hand” and “dermal filler” or “injectable” or “fat transfer” or “sclerotherapy” or “vein removal” or “dermabrasion” or “chemical peel” or “skin excision.” Additionally, all references of included articles were screened for potential inclusion. The search was limited to papers published in English peer-reviewed journals. Two authors screened titles (C.M. and C.B.) and abstracts to assess eligibility for inclusion for subsequent analysis using a sensitive search strategy with broad inclusion criteria. After preliminary screening, two authors (C.M. and C.B.) then reviewed the studies based on the full text paper and eligibility was determined.

Data Extraction and Items

Data extraction was completed by two authors (C.M. and C.B.) The following data were extracted from each article and used for comparisons: author, country of origin, journal, year of publication, human or animal study, study population, age, age range, sample size, funding, type of surgical procedure, name of intervention, name of comparison group (if applicable), outcomes, follow-up period, and study results. The level of evidence of primary studies was also assessed using an established hierarchy (I-high-quality, multicenter or single center, randomized controlled trials with adequate power, or systematic review of these studies; II-lesser-quality, randomized controlled trials, prospective cohort or comparative study or systematic review of these studies; III-retrospective cohort or comparative study, case-control study or systematic review of these studies; IV-case series with pre-/post-test or only post-test results; V-expert opinion developed via consensus process, case report or clinical example or evidence-based physiology). [7] Data were extracted by the same two independent reviewers (C.M. and C.B.) using an Excel (Microsoft Corp., Redmond, Washington) data collection spreadsheet designed a priori.

Assessment of Methodological Quality

Observational non-randomized studies were assessed using the MINORS scale, which is a 12 item validated instrument devised to assess the methodological quality of non-randomized surgical studies, whether controlled or non-controlled. [8] Each item was scored out of two; thus, the total score of the scale was 24 in controlled studies and 16 in non-controlled studies. In comparative studies, a high-quality score was greater than or equal to 16; otherwise, the quality is low (< 16 points). In non-comparative studies, a high-quality score was greater than or equal to 10. [8]

Randomized studies were assessed using the Cochrane Collaboration risk of bias tool, which is a tool used to determine the internal validity of randomized controlled trials by focusing on five distinct methodologically important domains. [9] The Cochrane Collaboration risk of bias tool does not provide a summed total score for each study, it instead assesses each domain as a judgment of high, low, or unclear risk of bias. [9]

Analysis of Heterogeneity

Studies were examined to determine if significant clinical heterogeneity existed. Clinical heterogeneity can be defined as differences in the study population related to, but not limited to, participant characteristics, study setting, timing of outcomes, and intervention characteristics. If

articles contained significant heterogeneity, then this was taken into account when formulating final conclusions and when determining the possibility of conducting a meta-analysis for a given outcome.

Statistical Analysis

Summary statistics were generated for all variables. Categorical factors were assessed using frequencies and percentages. SPSS version 25 was used for all analyses (IBM SPSS Statistics, Armonk, NY, USA).

Results

Study Identification and Selection

Figure 1 details the search strategy to identify articles. The search yielded a total of 823 articles after duplicates were removed, of which 64 were potentially relevant after title review. Of the 31 included studies, all were identified from the computerized search. [10–40]

Characteristics of Included Studies

Table 1 details the characteristics of included studies. Studies were most frequently published between 2016 and 2020 (51.6 percent). The journal of publication varied, with the three most common being *Dermatologic Surgery* (22.6 percent), *Plastic & Reconstructive Surgery* (16.1

percent), and *Aesthetic Surgery Journal* (16.1 percent). The majority of publications were from the USA (58.1 percent) and were either prospective case series (35.5 percent) or technique descriptions (32.3 percent). The mean patient age was 56 years (range 21–82 years), the mean sample size was 47 (range 10–220), and the percentage of patients who were women was 96.5 percent (range 84–100). Only a single study had funding, which came from industry. [38] All studies were considered clinically homogenous.

Outcome Measures and Results

Table 2 details surgery- and outcome-related variables. The most commonly examined interventions for hand rejuvenation were Radiesse (32.2 percent), fat grafting (32.2 percent), and Restalyne (9.7 percent). Most studies assessed a single intervention with no control (66.7 percent). The mean follow-up time in months was 12 (range 0–48 months). The most commonly examined outcomes were complications (81 percent), patient satisfaction (71.4 percent), and improvement based on the Merz Hand Grading Scale (23.8 percent).

In terms of complications, major complications such as finger ischemia or infection were not described by any study. The most common minor complications described were local reactions such as edema, ecchymosis, erythema, pain at the injection site, and pruritis. In all cases, these minor complications were self-limiting within the first days and rarely lasted beyond a week. One study described a patient who had a subcutaneous nodule following

Figure 1 PRISMA diagram detailing the search strategy for included articles ($N=3$)

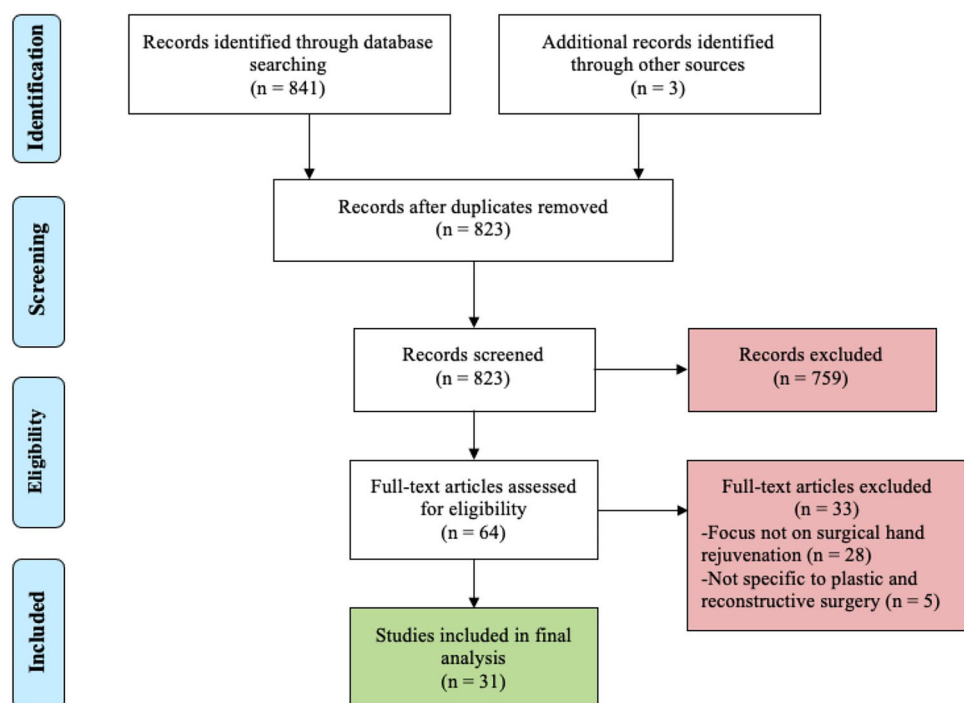


Table 1 Characteristics of included studies assessing hand rejuvenation ($N=31$)

Characteristics	Frequency (%)
<i>Year</i>	
2000–2005	1 (3.2)
2006–2010	7 (22.6)
2011–2015	7 (22.6)
2016–2020	16 (51.6)
<i>Journal</i>	
<i>Dermatologic surgery</i>	7 (22.6)
<i>Plastic and reconstructive surgery</i>	5 (16.1)
<i>Aesthetic surgery journal</i>	5 (16.1)
Other*	14 (45.2)
<i>Country</i>	
United States	18 (58.1)
Italy	4 (12.9)
Egypt	2 (6.5)
Other**	7 (22.6)
<i>Study Design</i>	
Prospective case series	11 (35.5)
Technique description	10 (32.3)
Randomized controlled trial	6 (19.4)
Retrospective review	4 (12.9)
<i>Level of Evidence</i>	
I	3 (9.7)
II	4 (12.9)
III	6 (19.4)
IV	8 (25.8)
V	10 (32.3)
<i>Age of Patients</i>	
Mean (SD)	56.1 (6.5)
Range	21–82
<i>Sample Size</i>	
Mean (SD)	47.1 (50.4)
Range	10–220
<i>Percentage Women</i>	
Mean (SD)	96.5 (5.3)
Range	84–100
<i>Funding</i>	
None	30 (96.8)
Materials funded by industry	1 (3.2)
<i>Clinical Heterogeneity (N=21)</i>	
Homogenous	21 (100)
<i>Methodological quality assessment instrument used (N=21)</i>	
MINORS	14 (66.7)
Cochrane tool	7 (33.3)
<i>MINORS Score (N=24)</i>	
High quality	13 (92.9)
Low quality	1 (7.1)

*Other includes: *Egyptian Journal of Plastic Reconstructive Surgery, Dermatologic Therapy, Seminars in Plastic Surgery, Practical Dermatology, Journal Cosmetic Dermatology, Journal of the Egyptian Women's Dermatologic Society, European Journal Plastic Surgery, Journal Hand Surgery American, Journal of Cutaneous and Aesthetic Surgery, Journal of Cosmetic and Laser Therapy, Clinical Cosmetic and Investigational Dermatology, Akt Dermatology, Journal of Plastic Reconstructive & Aesthetic Surgery.*

**Other includes: Switzerland, UK, Canada, Germany, Greece, Taiwan, China

Table 2 Surgery- and outcome-related variables for studies assessing hand rejuvenation procedures ($N=31$)

Characteristics	Frequency (%)
<i>Intervention Type</i>	
Radiesse	10 (32.2)
Fat grafting	10 (32.2)
Restalyne	3 (9.7)
Small gel particle hyaluronic acid	1 (3.2)
Biorevitalization cocktail	1 (3.2)
Dermicol P-25	1 (3.2)
Cristal 2	1 (3.2)
Ellanse Type M	1 (3.2)
Polylactic acid	1 (3.2)
Foam sclerotherapy	1 (3.2)
No intervention tested	1 (3.2)
<i>Comparator intervention (N=21)</i>	
No control	14 (66.7)
Multiple types of control	2 (9.5)
Standard fat grafting	1 (4.8)
Saline	1 (4.8)
Collage	1 (4.8)
Juvaderm	1 (4.8)
Radiesse	1 (4.8)
<i>Follow-up (months)</i>	
Mean (SD)	12.0 (12.2)
Range	0–48
<i>Outcomes examined (inclusive; N=21)</i>	
Complications	17 (81.0)
Patient satisfaction	15 (71.4)
Improvement based on Merz Hand Grading Scale	5 (23.8)
Hand volume loss	2 (9.5)
Surgeon satisfaction	2 (9.5)
Photoaging	1 (4.8)

Restalyne treatment that resolved at six months with no intervention. [30]

Table 3 details studies investigating Radiesse. [13, 14, 17, 20–23, 27, 34, 38] In terms of technique, Frank and colleagues found that there were more complications with needle usage versus cannula usage and the proximal to distal fanning method was the safest technique when compared to the bolus technique, tenting technique, and single-line technique. [20] Local anesthetic was either used at the site of insertion [14, 21] or combined directly with Radiesse prior to injection. [13, 17, 22, 23, 27] The site of injection varied between studies, however, injections starting at the interphalangeal joints and injecting proximal were the most commonly described method. [13, 14, 21] The amount of Radiesse injected per hand was consistently

Table 3 Summary of studies investigating Radiesse (N=10)

Reference	Study design*	Intervention	Technique	Results
Busso [13]	Technique	Radiesse, no comparison	Local anesthetic added to syringe of Radiesse (0.1mL plain 2% lidocaine), mix from syringe to syringe, inject interphalangeal fold access sites, skin tenting to separate skin from structures, injected into subcutaneous plane, filler introduced as bolus then massaged, 1.4mL per hand	N/A
Busso [14]	RCT	Radiesse, comparison with control hand	Local anesthetic bleb, inject interphalangeal fold access sites, skin tenting to separate skin from structures, injected into subcutaneous plane, filler introduced as bolus then massaged, 27-gauge 0.75-inch needle used, 1.5mL per hand	Global improve score 89% and 75% of hands were rated as being at least “improved” on the score at 3 and 6 months from treatment; 66% and 56% of hands showed at least a 1-point improvement on standardized scale; 76% of patients reported being satisfied or extremely satisfied; at 3 and 6 months, a majority of patients (66% at both time points) reported that they were likely or extremely likely to return for future treatments
Edelson [17]	Technique	Radiesse, no comparison	Radiesse combined with 0.5mL of 2% plain lidocaine, line of injection midway between dorsal crease of wrist and metacarpophalangeal joints and laterally between second and fifth metacarpal, fill between superficial fascia and subcutaneous fat, tent the skin, use 27-gauge 0.5 inch needle, inject between two and four boluses, 0.2-0.5mL boluses, massage as necessary	N/A
Frank [20]	Retro review	Radiesse, multiple comparison	Needle versus fanning, bolus versus tenting versus proximal-distal fanning versus distal to proximal single-line technique	Higher rate complications events with needle (pain, erythema, discoloration, OR: 7.57, 95% CI: 3.76 to 15.24, $p < 0.001$); proximal to distal fanning technique safest as others risk of complications higher (bolus technique OR: 26.9; 95 percent CI: 6.87 to 105.2, $p < 0.001$; tenting technique OR: 24.73; 95% CI, 7.48 to 81.76, $p < 0.001$; single-line technique OR: 26.68; 95% CI, 7.45 to 95.48, $p < 0.001$); amount injected does not influence complications
Gatgasz [21]	Technique	Radiesse, no comparison	Flex fingers, injected lidocaine where enter needle, injection above fascia below subcutaneous tissue, limit to two injection sites, bolus 0.5–1.3mL per injection, manipulate through hand while patient making fist, pinching/tenting dorsal skin helps	N/A
Goldman [22]	RCT	Radiesse, comparison with control hand	Mix 1.5mL Radiesse with 0.26mL 2% lidocaine, 27-gauge needle, skin tented, needle between subcutaneous tissue and superficial fascia, number of injection sites varies, max 3mL per hand with small boluses of 0.1-0.5mL	Increase in Merz Hand Grading Scale at 3 months higher in Radiesse group compared to control ($p < 0.001$, 75.3% and 3.4%) and this stayed for 12-months (72%); subjective improved high at 3 months (97.6%) 6 months (93.4%) and 12 months (86.4%) in Radiesse group; complications mostly swelling, pain, redness in bruising and nearly all in first 2 weeks (96.4%), higher bruising in people who received > 2.6 mL injected ($p = 0.03$); no change in hand function at 3 and 12 months

Table 3 continued

Reference	Study design*	Intervention	Technique	Results
Graivier [23]	Technique	Radiesse, no comparison	Single proximal injection site in subdermal plane, use blunt cannula, use local, dilute the Radiesse (1:1 with 1% lidocaine with 1:100,000 epi), average patient needs 0.5-1cc per hand diluted 1:1 or 2:1 with 1% lidocaine	N/A
Kuhne [27]	Technique	Radiesse, no comparison	One-part lidocaine to four parts Radiesse, 28-gauge quarter inch thin-walled needle, single bolus of Radiesse, patients sit on hands for 10 min, flattens out the boluses with pressure and warmth, massage hands afterward	N/A
Sattler [34]	RCT	Radiesse, comparison with Juvaderm	No local anesthetic, injected using 27-gauge cannula, injected at 45-degree angle with small boluses of 0.2mL interdigitally, massage after injection, no heavy lifting for 5 days and elevate hand, 0.8mL per hand	No difference in results at 12 months ($p>0.05$); no serious complications, minor complications of edema and pain in 13 patients; no difference in pain ($p>0.05$)
Wu [38]	RCT	Radiesse with triamcinolone, comparison with Radiesse with saline	Radiesse was with 2mg/mL triamcinolone or just saline, triamcinolone delivered immediately after Radiesse injection to total volume of 5mL (10mg absolute dose), all injections done using 5mL syringe and 30-gauge needle at multiple injection sites, massage post inject	No difference in treatment efficacy between groups ($p>0.05$); swelling reduced between days 6 and 19 in Radiesse and triamcinolone group

*Retro = retrospective, Pros = prospective, RCT = randomized controlled trials

around 1.5mL. Massage was used by the majority of studies to distribute the product. Busso and colleagues [14] along with Goldman and colleagues [22] found that when compared to control hands, patient satisfaction was significantly higher in treated hands up to the 12-month mark post procedure. When comparing Radiesse with Juvaderm, there was no significant difference in esthetic result or complications at 12-months post procedure. [34] Wu and colleagues found that Radiesse combined with triamcinolone was of little benefit compared to Radiesse alone in terms of swelling. [38] Rates of patient satisfaction were generally high (greater than 80 percent) at all timepoints using Radiesse.

Table 4 details studies investigating fat grafting. [10, 11, 15, 18, 19, 24, 35, 36, 39, 40] Sites of liposuction were from the abdomen, flanks, or medial thighs and generally used a superwet technique. There was no consensus on centrifugation prior to injection, as in a number of studies the fat was centrifuged prior to injection [10, 18, 24, 35, 39, 40], while for others, it was not. [11, 15, 19, 36] There was no clear benefit in terms of patient satisfaction or esthetic outcomes when comparing centrifuged and non-centrifuged fat. Fat was most commonly injected using a cannula [15, 18, 19, 24, 36, 39] as opposed to a needle. [10, 11] The injection method varied

between studies. The amount injected per hand varied between 10mL and 30mL, with an average of 15mL per hand. Patient satisfaction rates were generally greater than 80% and Merz Hand Grading Scale improved, regardless of technique and amount injected.

Table 5 details studies investigating Restalyne. [26, 30, 31] One study used local anesthesia [26], while two studies did not. [30, 31] The method of injection varied between the three studies. The amount injected was on average 2mL per hand. Man and colleagues found that Restalyne was superior to collagen in terms of patient satisfaction at six months. [30] Moradi and colleagues found that when compared to a control hand, Restalyne was superior until their final follow-up at six months. [31].

Table 6 details studies investigating a variety of methods for hand rejuvenation. [12, 16, 25, 28, 29, 32, 33, 37] These studies were all descriptive in nature and did not compare interventions to controls. Dermicol P-35, [25] Ellanse Type M, [29] and polyactic acid [32] were beneficial for hand rejuvenation. Only a single study examined sclerotherapy, which showed that treatment with Sotradecol was found to have a significantly positive effect on patient satisfaction. [37]

No study compared the common treatment modalities of injectable fillers and fat grafting. When comparing patient

Table 4 Summary of studies investigating fat grafting (N=10)

Reference	Study design*	Intervention	Technique	Results
Agostini [10]	Retro review	Fat grafting, no comparison	Conscious sedation, local anesthetic, harvest fat from abdomen, centrifuge fat 3600 RPM for three minutes, inject at interphalangeal fold access sites, 16-gauge needle, inject superficial, tunneling with retrograde injection, 15mL per hand	No major complications, 14% had distal sensory disturbance that resolved after two weeks; 81% of patients very satisfied and 13.6% satisfied, blinded surgeons found 81.8% very much improved esthetically
Azzam [11]	Pros case series	Fat grafting, no comparison	Liposuction from different body sites, refined by decantation, fat grafted to hand in small volumes, use 16-gauge blunt needle, 18.5mL per hand	No complications, 20% noted swelling beyond two-week mark; hand rating scale significantly improved ($p<0.05$); 60% of patients very satisfied and 30% satisfied
Conlon [15]	Technique	Fat grafting, no comparison	Harvest from flanks or peri-umbilical or medial thighs, proximal incision distal to extensor retinaculum and in webspaces, inject in subcutaneous plane, use 14 or 17-gauge cannula, 15-30mL per hand	N/A
ElKahky [18]	RCT	Stem cell enhanced fat grafting, comparison of standard fat grafting	Harvest from abdomen, lipoaspirate was divided into two portions, the first portion (used to extract adipose tissue-derived stem cells) was washed and then it treated with 0.075% collagenase for 30 min, collagenase was then inactivated with an equal volume of fetal bovine serum, and the infranatant was centrifuged at 1500 RPM for five minutes. Remaining cellular pellet (stromal vascular fraction) was then resuspended and filtered. Stromal vascular fraction cells (containing adipose tissue-derived stem cells) obtained from the previous process were gently mixed with half of the second portion of lipoaspirate for 15 min to optimize cell adherence. The other half of the second portion of the lipoaspirate was centrifuged at 3000 RPM for three minutes. Both types of fat grafts (adipose tissue-derived stem cell-supplemented and conventional fat graft) were loaded in separate 10 ml syringes and were ready for reinjection. After sterilization of both hands with povidone iodine 10%, ring anesthesia was used, and then a 5 mm incision was made into the dorsal wrist crease creating an entry point, through which the injection Coleman cannula was passed distally into the dorsal web spaces and fat was injected in a retrograde manner, dispersing small aliquots (0.3–0.5 ml per pass) as the cannula was withdrawn and filling the dorsal metacarpal spaces and sides of the hands adequately, 10mL per hand	Merz Hand Grading Scale for all patients was either 3 or 4 before procedure and became 0 for all after the procedure (disappearance of visible veins, protruding tendons, and grooving of metacarpal spaces); there was an overall patient satisfaction with the results of both hands after 1 and 3 months with no statistically significant difference between enhanced and unenhanced fat grafted hands
Fantozzi [19]	Retro review	Fat grafting, no comparison	Fat from flanks/peri-umbilical/thigh/knee, no centrifuge, decanted for 10 minutes, injected from wrist above dorsal deep fascia, 10–30cm squared injected, 1.4mm cannula	56 patients satisfied (84%), 7 somewhat satisfied and needed one more procedure to complete satisfaction, 2 patients dissatisfied

Table 4 continued

Reference	Study design*	Intervention	Technique	Results
Hoang [24]	Technique	Fat grafting, no comparison	Harvest fat from abdomen/flank/thigh/medial knee, use tumescent 15 min before fat harvest, harvest fat with 10mL tulip syringe and 2-3mm cannula, harvest 15–40mL of fat per hand, let fat separate and pour off extra fluid, 10mL syringes centrifuged 3000 RPM for 3 minutes, put local in hand, put fat in using 1–3mL syringe with 1mL blunt cannula through stab incision, fat injected retrograde with 0.3mL or smaller aliquots, many small tunnels to increase vascularization, 10–30mL per hand	N/A
Sterodimas [35]	Pros case series	Fat grafting, no comparison	Stromal vascular fraction mixed with aspirated fat from abdomen using pre-determined technique (takes 45 minutes, see paper), first through fourth interosseous subcutaneous spaces with multiple passes of 0.25mL through five or six tiny incision on hand, massage fat in compartments	80% of patients felt appearance was very good to excellent; no major complications
Teimouri-an [36]	Technique	Fat grafting and TCA peel, no comparison	Fat from abdomen, flank or thigh, harvest 15–20mL, fat is allowed to separate and fluid layer is expelled, mesh strainer used to further drain liquid and fat left unwashed, lidocaine to anesthetize hand, 14-gauge angiocath inserted between metacarpals, advanced 6-7cm to wrist, fat injected while pulling back on angiocath, 15–20mL per hand, massaged vigorously; after fat injection 30–35% TCA applied to dorsum of hand, patient massages hands for a week once daily, antibiotic ointment applied to treated areas for a week	N/A
YunNan [39]	Pros case series	Fat grafting, no comparison	Tumescent to donor site of thigh and wait 15 minutes, fat harvested using blunt tip suction cannula, centrifuged at 1200 RPM for three minutes, purified fat loaded to injection gun, 16-gauge cannula used to put fat into three layers (dorsal deep lamina layer, dorsal intermediate lamina layer, and dorsal superficial lamina layer) in small aliquots, 14mL fat per hand, no massaging, oral antibiotics for three days, no strenuous exercise for one month, lymphatic drainage massage at seven days postoperatively to reduce edema	58.8% of patients very satisfied and 39.7% satisfied; no major complications
Zhou [40]	Pros case series	Fat grafting, no comparison	Fat collected by liposuction of abdomen utilizing superwet technique, harvested fat washed three times with normal saline, centrifugation 6400 RPM for two minutes, upper oil and lower liquid phases removed, fat injected in in deep and superficial layers using cannula, middle vascular layer avoided, 25.5mL per hand	95% satisfaction; minor complications of edema and bruising resolved by two weeks, no major complications; U/S revealed significant volume increase from 8 to 27.5mL

*Retro = retrospective, Pros = prospective, RCT = randomized controlled trials

satisfaction, it is not possible to elucidate whether injectable fillers or fat grafting is superior. A single study examined the various injection methods and found that the rates of complications (pain, erythema, edema) were significantly lower when using a cannula and the proximal to

distal fanning technique. [20] Rates of complications were similar between injectable fillers and fat grafting. A meta-analysis was not possible for techniques, outcomes, and complications due to significant heterogeneity between

Table 5 Summary of studies investigating Restalyne ($N=3$)

Reference	Study Design*	Intervention	Technique	Results
Khosravanian [26]	Technique	Restalyne, no comparison	Topical 2.5% lidocaine and prilocaine 2.5% and wait 20 min, hands prepped with chlorohexidine, dorsal webspaces injected with 0.5mL per webspace, tenting skin and injecting filler perpendicular to skin to avoid veins and extensor tendon, aliquots massaged around webspace using ultrasound gel, 2mL per hand	N/A
Man [30]	Pros case series	Restalyne, comparison with Collagen	Trendelenburg position, washed with water and alcohol, no local anesthesia, held in position at rest and filler injected subcutaneous at oblique angle adjacent to dorsal veins of the hand, massage along course of filler injection with fingers in complete flexion, rest hands for 2 hours, topical mupirocin applied to entire dorsal surface of hand immediately after treatment and done once daily for 5 days	Hyaluronic acid superior to collagen in patient satisfaction ($p<0.05$); one patient had nodule formation that resolved at 6 months
Moradi [31]	RCT	Restalyne, comparison with control hand	Injected using 29-gauge 0.5-inch thin-walled needle, injections done in subcutaneous plane, no local anesthetic, done using one of three injection techniques (small bolus, micropuncture, or linear threading), 2.1mL per hand	Treatment results in higher response rates compared to no treatment at 12, 16, 20, and 24 weeks ($p<0.0001$); no major complications and 13% had injection site reactions such as swelling, redness, bruising, pain or itching; all complications resolved within four days

*Retro = retrospective, Pros = prospective, RCT = randomized controlled trials

studies and a lack of standardized outcome measure reporting.

Risk of Bias of Included Studies and Level of Evidence

The methodological quality of the majority of studies was examined using the MINORS instrument (66.7 percent) and most were considered high quality (92.9 percent). Risk of bias assessment of randomized controlled trials using the Cochrane Collaboration instrument can be found in Table 7. Only a single study had a domain that was considered at a high risk of bias. [34]

Discussion

This systematic review demonstrates that Radiesse and fat grafting are the most commonly used interventions for hand rejuvenation and rates of minor complications are low. Techniques to perform have rejuvenation are varied, however, a high-quality study demonstrated that the proximal to distal fanning technique and the use of a cannula compared to a needle were associated with fewer complications. Rates of patient satisfaction are high among all interventions and esthetic outcomes persist for a year or longer.

Hand rejuvenation is becoming an increasingly popular procedure due to its low risks and ability to substantially improve hand esthetics. Our review demonstrates that there are a number of interventions available to treat dorsal hand atrophy, which is not surprising. Fabi and colleagues found that, along with fat grafting and injectable fillers, there are over fifteen different interventions targeting dorsal hand atrophy and photoaging. [41] With so many options, plastic surgeons and other specialties such as dermatology have the ability to tailor treatments to patient-specific goals.

Unexpectedly, our review indicates that there are few comparative studies investigating the more common interventions. No study compared injectable fillers and fat grafting, the two most common treatments that have demonstrated similar long-term outcomes based on our review. While it would be challenging to complete such a study, with minimal adverse events and comparable long-term outcomes, this would be of substantial benefit. Cadaveric studies have the potential to help with future recommendations for hand rejuvenation, however, clinical randomized controlled trials of these two interventions are the definitive answer for guiding treatment. It is important that future studies utilize standardized reporting measures. The Merz Hand Grading Scale was used in a number of studies included in our review and was specifically designed to grade the appearance of the dorsal hand. This scale has been validated internationally and gives surgeons and researchers alike the ability to implement a reliable and

Table 6 Summary of studies investigating other methods for hand rejuvenation (N=8)

Reference	Study design*	Intervention	Technique	Results
Brandt [12]	Pros case series	Small gel particle hyaluronic acid, no comparison	Cleansed with antiseptic, topical anesthetic, single injection to dorsum of hand distal to wrist, threading technique, massage material distally, maximum volume 4mL per hand	No major complications; two weeks after treatment vascular/tendon/bony prominence and skin turgor were improved by 60.9%, 65.2%, 73.7%, and 26.3%, respectively; at two-week mark - investigator rated average 2.8 ± 0.7 improvement ($-4 =$ markedly worst, $0 =$ no change $+ 4 =$ markedly improved); patient average improvement 2.6 ± 0.9
DePadov-a [16]	Pros case series	Biorevitalization cocktail, no comparison	Cocktail composed of hyaluronic acid and vitamins, inject patients once a week for four weeks, then once a month for four months, inject superficial dermis, use 30-gauge needle, 1mL per hand per session	80% of patients reported at least one-point improvement in photoaging
Inglefiel-d [25]	Pros case series	Dermicol P-35, no comparison	Skin cleaned, injected subcutaneous either by serial puncture or linear threading, firm massage to ensure smooth result, no vigorous hand use for 24 hours, 1.2mL per hand	23 of 24 hands very satisfied, 1 of 24 hands satisfied; minor bruising in 2 of 12, no major complications
Leclere [28]	Pros case series	Cristal 2, no comparison	Local injected at cannula point, 27G blunt and flexible cannula used, skin tented before injection, move cannula in longitudinal motion avoiding lateral movement, 1mL per hand, patients get 15mg prednisolone immediately after treatment and 24hours later	Nine patients had ecchymosis that resolved after 1 week, no other complications; at 2 weeks 9 patients needed another injection; at each follow-up (2 weeks, 4 weeks, 3 months, 6 months) overall patient satisfaction was validated by clearance of rhytids, veins, bony prominences, and dermal and atrophy
Lowe [29]	Pros case series	Ellanse Type M, no comparison	Cleaned with chlorohexidine, 0.1mL of 1% lidocaine mixed with 1cc Ellanse, luerloc connection with 20 transfers to mix, hands marked with laser viewfinder to identify dorsal veins, entry points selected to avoid veins, areas injected with local anesthetic, 25-gauge cannula used, down to SC depth and injection done retrograde, massage hand, 1cc per hand	Hand atrophy severity scores improved for all patients ($p < 0.05$); seven patients had second treatment; all patients had swelling that resolved by 48 hours, no major complication; two had slight improvement seven had good and six had extremely good subjective improvement
Redaelli [32]	Pros case series	Polylactic acid, no comparison	Trendelenburg position, topical anesthesia, 2ml injected subcutaneous per hand, 1.5–2mL subsequent sessions, done using linear technique	Average satisfaction score of 6.5 out of 10; no major complications
Rivkin [33]	Technique	N/A, no comparison	No local anesthetic as obscures contour, patient sitting up, clean with alcohol, insert using needle in space between each metacarpal joint in linear fashion, inject as pulling out needle, massage hands while patient makes fist, ice hands for rest of day, no heavy work or alcohol for 2 days, 1–3mL per hand	N/A
Tremaine [37]	Retro review	Foam sclerotherapy, no comparison	Sotradecol 0.5% solution used, sitting position, tourniquet around mid-forearm to dilate distal hand veins, 30-gauge direct puncture needle used with 3–5mL per hand, tourniquet released and hand elevated, massage performed proximal to distal, elastic bandage for 24 hours	Average of 1.4 sessions per hand, moderate improvement in vein appearance overall; minor complications of edema and erythema, coagula drained from hands in 60% of patient at two-week follow-up with total resolution in all patients at two months

*Retro = retrospective, Pros = prospective, RCT = randomized controlled trials

simple to administer outcome measure for hand rejuvenation. [42, 43] Given our findings in this study, it is not possible to recommend one intervention type over another,

although we can say that both fat grafting and injectable fillers are safe, easily completed, and have satisfactory long-term results.

Table 7 Cochrane collaboration risk of bias tool assessments of included randomized studies ($N=7$)

Reference	Selection bias- Random sequence generation	Selection bias- Allocation conceal	Reporting bias- Selective reporting	Other bias- Other sources of bias	Performance bias- Blinding (participants and personnel)	Detection bias- Blinding (outcome assessment)	Attrition bias- Incomplete outcome data
Busso [14]	Low	Low	Low	Low	Low	Low	Low
ElKahky [18]	Low	Low	Low	Low	Low	Low	Low
Goldman [22]	Low	Low	Low	Low	Low	Low	Low
Man [30]	Low	Low	Low	Low	Low	Low	Low
Moradi [31]	Low	Low	Low	Low	Low	Low	Low
Sattler [34]	Low	Low	Low	Low	Low	High	Low
Wu [38]	Low	Low	Low	Low	Low	Low	Low

Long-term outcomes were well established in this study. With an average follow-up time of a year, most studies had the ability to comment on the long-term viability of interventions. There does not appear to be a clear difference in long-term viability when comparing fat grafting to injectable fillers. The average volume of fat grafting was significantly higher than the amount used with injectable fillers (15mL per hand in fat grafting versus 1.5mL per hand in Radiesse), which is not unexpected given fat atrophy is a known sequela of fat grafting. [44] As an example of the ability for fat grafting to show persistent effects, Agostini and colleagues found that after 38 months, patients who had 15mL of fat grafting still had very much improved or significantly improved hand esthetic outcomes as evaluated by blinded plastic surgeons. [10] A number of studies found similar results with Radiesse at the twelve-month end point. [34, 38] One potential caveat of fat grafting is that because harvesting fat is from distant sites like the thighs, the inherent risks of surgery are potentially increased (bleeding, infection, pain, etc.).

A cost analysis is crucial when considering two interventions that have both proven safe and efficacious in the long term. A brief review of the literature indicates that there are no studies specifically comparing the cost of any treatments related to hand rejuvenation. Both injectable fillers and fat grafting come with their associated costs. A single 1.3mL Radiesse syringe, which would generally be sufficient for one hand, costs between \$650 USD and \$800 USD. [45] Combined with the surgeon's injection fee and assuming the usage of two syringes in total, the cost would likely be between \$2200 USD and \$2400 USD. [46] The cost of fat grafting is more challenging to extrapolate. A review of the American Society of Plastic Surgeons annual statistics report from 2019

reveals that the cost of fat augmentation of the face is approximately \$2100 USD, [46] which is likely similar to the cost of fat augmentation to the hand. Overall, both procedures are likely not dissimilar in cost.

The strengths of this review include the use of a wide search strategy to identify relevant articles, utilization of high-quality studies, and clinically meaningful results. There are limitations to this study. Although our search was broad and comprehensive, we only included articles that were published in the English language. Second, while our results are meaningful, they are not generalizable to other common esthetic procedures that utilize injectable fillers or fat grafting. Third, we could not complete a meta-analysis due to heterogeneity between studies and a lack of standardized reporting measures. Finally, although the MINORS and Cochrane instruments are validated by numerous studies, they do not provide a measure of study relevance and do not give a sense of the writing quality.

Based on our systematic review, we have a number of recommendations for hand rejuvenation procedures. We recommend either fat augmentation or Radiesse as these are the most studied interventions, have low rates of complications, and have similar long-term esthetic outcomes. We recommend a proximal to distal fanning technique with the use of a cannula. We also recommend using local anesthetic for patient comfort.

Conclusions

Hand rejuvenation is a safe and effective method to reduce the appearance of aging hands. A variety of techniques are described with similar esthetic outcomes. Further studies are necessary to compare injectable fillers to fat grafting

and should use standardized outcome measures, such as the Merz Hand Grading Scale, and focus on long-term esthetic outcomes beyond one year.

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