Micro-autologous fat transplantation for rejuvenation of the dorsal surface of the aging hand

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Summary

Background: Rejuvenation of the dorsal surface of the hand for various conditions, such as cutaneous dyschromia, fine wrinkling, skin laxity, visible extensor tendons, and varicosities appear vital to prevent wrist and digit flexion resulting from hiding of the aged appearance of the hand. Numerous fillers have been applied to re-contour the aging dorsal surface of the hand and the results were variable. The micro-autologous fat transplantation (MAFT) technique, proposed by Lin et al. in 2006, has demonstrated its feasibility in facial rejuvenation. In this study, we applied the MAFT technique for the rejuvenation of the dorsal portion of the hand. Methods: MAFT was performed in 68 female patients. Fat was harvested by performing liposuction, processed, and refined by centrifugation. Purified fat was micro-transplanted to the dorsal surface of the hand in parcels of small volume.

KEYWORDS

aging dorsal hand; rejuvenation; micro-autologous fat transplantation (MAFT); fat grafting

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Introduction

The dorsal portion of the hand typically has a smooth contour, without visible or with minimal dorsal veins and extensor tendons. However, with age, the dorsal veins and extensor tendons become more obvious, and the contouring of the hands becomes uneven. Garruthers et al. studied the photographs of 35 subjects and proposed the Hand Grading Scale, which is a 5-point photo-numeric rating scale developed to objectively quantify the severity of aging of the hand. It demonstrated that the more the hand ages, the higher the score (grade 0–4), which is due to the fatty tissue loss and vein and tendon visibility.

The literature reports the application of some filler materials to rejuvenate aging dorsal hand surfaces. However, an increasing number of complications following the use of fillers for aesthetic re-contouring and re-volumizing of aging dorsal hand surfaces have been reported. Moreover, a high rate of complications, such as allergic reactions, filler material migration, injection necrosis and embolism, and foreign body granuloma, has been reported. Currently, the ideal filler materials for aging hands have not been reported.

Dr. Neuber reported the first fat grafting in 1893, which has become common because of the ease of harvesting, abundant volume, and absence of rejection reactions. However, the retention rates were unpredictable, and morbidities, such as abscess, cyst formation, nodulation, or neurovascular injury, have been reported. In the 1980s, Dr. Fournier was one of the first to describe fat augmentation to the dorsum of the hand by placing a large bolus of fat initially and massaging the fat with digital manipulation.

“Structural fat grafting,” which was proposed by Dr. Coleman, has demonstrated acceptable clinical outcomes. Moreover, several reports about hand rejuvenation using fat grafting exist. Lin et al. proposed the concept of micro-autologous fat transplantation (MAFT) in 2006 and demonstrated the reliability of the technique in facial rejuvenation. In this study, we clinically performed the MAFT technique for the rejuvenation of aging dorsal hand surfaces and determined the long-term results.

Materials/patients and methods

Patient demographics

Between January 2011 and December 2015, 68 consecutive non-smoking female patients received MAFT for the dorsal surfaces of their hands in the senior author’s private practice, at the Charming Institute of Aesthetic and Regenerative Surgery (CIARS) in Kaohsiung, Taiwan. Informed consent was obtained from all patients. The exclusion criteria included a history of trauma (to eliminate the potential interference of scar tissue or post-MAFT score of the Hand Grading Scale), other co-morbidities, and operation, or filler injection for the dorsal hand surface. Regular follow-up was conducted at an outpatient clinic at 1, 3, and 6 months (or longer when possible) after MAFT. These studies were approved by institutional review committees and are in accordance with the Helsinki Declaration. The authors confirm that they adhered to the STROBE guidelines.

Preoperative planning and photography

The patients underwent general standard preoperative procedures and were photographed (with their hands raised) after providing signed consent. Surgical planning of the hands is shown in Figure 1A.

Anesthesiology

The patients were under total intravenous anesthesia during the MAFT. The lipoaspirate was harvested mostly from the lower abdomen (or thigh) area after pre-infiltration with a solution prepared with the following ratio: 10 mL of 2% lidocaine (20 mg/mL), 30 mL of Ringer’s lactate solution, and 0.2 mL of epinephrine (1:1000). The lipoaspirate amount after liposuction was suggested to be the same as the volume of pre-infiltrating solution (regarded as wet method). Appropriate local anesthesia (lidocaine HCl 2% and epinephrine 1:50,000 injection) was used at the insertion sites, which normally included four pivot points at the central base of the web spaces, 2 cm from the margin on the dorsal hand surface (point Xs in Figure 1A).

MAFT procedure

Fat harvesting

A tumescent solution was administered at the donor site; after 10 to 15 min, the fat was harvested using a blunt tip suction cannula (diameter 2.5 mm; with three elliptical side holes). The lipoaspirate volume approximated the amount of the administered tumescent solution to ensure a high ratio of purified fat after processing by centrifugation. Low pressure
was employed during liposuction to minimize damage to the lipoaspirate. According to Lin et al., the plunger of a 10-mL syringe connected to the suction cannula was pulled back to maintain 2 to 3 mL of empty space, thereby creating a negative suction pressure of approximately 270–330 mmHg.\textsuperscript{21}

**Fat processing and refinement**

The lipoaspirate was poured into a 10-mL syringe screwed on a centrifugation cap for centrifugation. The extracted lipoaspirate was processed and purified by standard centrifugation at 1200 × g for 3 min.

**Fat transfer**

The centrifuged lipoaspirate was processed and refined by releasing it from the bottom of the lipoaspirate-filled syringe containing a bloody tumescent solution. The oil on top of the syringe was wiped, leaving only the middle portion containing purified fat to be used for the transplantation. Subsequently,
the purified fat was transferred from the 10-mL to a 1-mL syringe by connecting the two syringes using the syringe transducer.

Fat transplantation
After the purified fat was transferred, the fat-filled syringe was loaded into a MAFT-GUN (Dermato Plastica Beauty Co., Ltd., Kaohsiung, Taiwan). The fat parcel volume administered by each trigger was set by adjusting a six-graded dial to control the total injection aliquot per 1 mL of fat graft. A 16G blunt cannula was employed to administer the fat while withdrawing the MAFT-GUN. Each delivered fat parcel was set at 1/60 mL (each parcel volume, 0.017 mL) and was meticulously transplanted to the dorsal part of the hand in three layers: the dorsal deep lamina (DDL) (deep layer), on top of the dorsal deep fascia (DDF) and below dorsal intermediate fascia (DIF); the dorsal intermediate lamina (DIL) (middle layer), in between DIF and the dorsal superficial fascia (DSF); and the dorsal superficial lamina (DSL) (superficial layer), in between DSF and the skin (Figure 1B, C). The maneuver performed to transplant the fat graft is demonstrated in the "Supplemental Digital Content".

MAFT maneuver technique
1. Fat parcels in the deep layer: DDL (between DDF and DIF). First, make sure that the blunt tip of the injection cannula is tilted and inserted through a 2-mm wound cut using a #11 blade at the central base of each web space 2 cm to the margin. Maintain slight pressure on the tip of the cannula and advance to the proximal interphalanx joint. As the placement is on top of the DSF overlying the dorsal veins, care should be taken to avoid violent movements and unintentional vascular injury. Often, a 0.5 mL of fat in each digit and around 5 mL in the dorsal part of the hand are delivered to the superficial layer.

2. Fat parcels in the middle layer: DIL (between DIF and DSF). Once the cannula tip enters the incision at a slightly slant manner (i.e., more horizontal), the middle layer can be accessed (Figure 1B, C). Advance the cannula tip to the DIL. Meticulously, maintain a stable advancement of the injection cannula to prevent damage to the dorsal veins. Approximately, <0.5 mL of fat for each digit and around 5 mL of the fat in the dorsal part of the hand can be easily transplanted into this layer.

3. Fat parcels in superficial layer: DSL (between DSF and the skin). While inserting the cannula more superficially at the start of the insertion, the tip of the cannula advances to the superficial layer with some resistance (Figure 1B, C). As the placement is on top of the DSF overlying the dorsal veins, care should be taken to avoid violent movements and unintentional vascular injury. Often, a <0.5 mL of fat in each digit and around 5 mL in the dorsal part of the hand are delivered to the superficial layer.

4. Secondary touch-up: No patient in our study asked for a second session. However, a secondary touch-up MAFT may be performed 4–6 months after the first session to fulfill the patients’ request.

Post-MAFT management
Regular postoperative care, including routine oral antibiotic administration, was performed for 3 days as necessary. No massaging was performed following the MAFT procedure. Any strenuous movement was prohibited and avoided for 1 month. A gentle lymphatic-drain massage was performed 7 days after surgery for quick edema relief.

Patient-rated satisfaction was measured anonymously by office staff during the patient’s final visit (at least 6 months after MAFT) using a typical 5-point Likert scale (Table 1). The Merz Hand Grading Scale (MHGS) was performed preoperatively and postoperatively (at least 6 months after MAFT) (Table 2).

| Table 1 Patient satisfaction score with micro-autologous fat transplantation (MAFT) for aging dorsal hands (N = 68) |
|---|---|---|---|---|---|
| n = 68 & Very unsatisfied (%) & Unsatisfied (%) & Neutral (%) & Satisfied (%) & Very satisfied (%) |
| 68 & 0 & 0 & 1(1.5) & 27(39.7) & 40(58.8) |

| Table 2 Comparison of the 5-point photo-numeric rating scale (Merz Hand Grading Scale), pre- and post-MAFT. |
|---|---|---|---|---|---|
| n = 68 & 0 & 1 & 2 & 3 & 4 |
| No loss of fatty tissue & Mild loss of fatty tissue & Moderate loss of fatty tissue & Severe loss of fatty tissue & Very severe loss of fatty tissue |
| Slight visibility of veins & Mild visibility of veins and tendons & Moderate visibility of veins and tendons & Marked visibility of veins and tendons |
| Pre-MAFT, n = 68 & 0 & 1 (1.5%) & 32 (47.0%) & 25 (36.8%) & 10 (14.7%) |
| Post-MAFT, n = 68 & 10 (14.7%) & 50 (73.5%) & 8 (11.8%) & 0 & 0 |
Results

The mean age was 56 years (range, 38–70 years). The entire MAFT procedure was performed in an average of 72 min. On average, the fat volume delivered was 13.9 and 13.8 mL for the right and left hands, respectively. All patients were monitored for an average of 32 months (range, 10–64 months). No major complications (e.g., infection, neurovascular injury, cyst/nodulation formation, or uneven appearance) were recorded. Only mild to moderate swelling was noted, which subsided after 7 to 10 days postoperatively.

The patient-rated satisfaction scores obtained during the final visits are shown in Table 1. Four cases of MAFT for aging dorsal hand surfaces are illustrated in Figures 2–5. The MHGS was graded 2.65 on average, preoperatively, (14.7% (10/68) patients had grade 4, 36.8% (25/68) patients had grade 3, 47.0% (32/68) patients had grade 2, and 1.5% (1/68) patient had grade 1) and reduced to 0.97 postoperatively, (11.8% (8/68) patients had grade 2, 73.5% (50/68) patients had grade 1, and 14.7% (10/68) patients had grade 0).

Discussion

Numerous clinical strategies, such as the application of autologous fat grafts and soft tissue fillers, are available for re-contouring aging dorsal hand surfaces. Most common synthetic filler materials such as hyaluronic acid, calcium hydroxylapatite, poly-L-lactic acid, and polycaprolactone dermal filler are reliable and have acceptable results in selective cases. However, their long-term feasibilities have not been established. Potential complications such as infection, deviation, incompatibility, and skeletonization remain a challenge for surgeons. Moreover, fillers are not used in all patients because of the high cost, the necessity of repeat injections, and the possibility of an allergic reaction.
Autologous tissues such as fat grafts are preferable because of their biocompatibility and effectiveness in certain cases. However, in fat grafting, dissatisfaction due to unpredictable absorption rates, potential morbidities, and a lack of evidence regarding the long-term results remains an unresolved problem. Table 3 shows studies providing detailed descriptions of fat grafting procedures for aging dorsal hand surfaces, including a series of reports of long-term follow-up.

In 1993, Dr. Carpenada emphasized that "40% of tissue 1.5 ± 0.5 mm to the margin of fat grafting survived," which means that the central portion of a fat parcel of which the radius is >2 mm becomes necrosed because of poor direct diffusion and impaired plasmatic imbibition in the initial 24–48 h after fat grafting. According to his theory, small parcels of fat grafting are favorable, and the ideal radius of each fat parcel is preferably between 1 and 2 mm. In addition, for "structural fat grafting," Coleman further stated that in specific locations such as the periorbital area (which has thinner skin), each delivered fat parcel should be 1/50 to 1/30 mL (0.020 to 0.033 mL) to avoid potential central necrosis and subsequent complications. In 2014, Dr. Yoshimura proposed dynamic tissue remodeling and demonstrated a surviving zone (100 to 300 μm) and regenerating zone (600 to 1200 μm) where fat could be successfully grafted. Micro-ribbon model by Dr. Khouri et al. also indicated that a radius of 1.6 mm (surviving zone, 0.3 mm; regenerating zone, 1.3 mm) is the key to fat grafting in relation to diffusion and perfusion (Table 4).

Evidence-based medicine from Dr. Carpaneda’s theory showed that the favorable radius (r) of injection parcels for fat grafting should be between 1 and 2 mm. By mathematical calculation (spherical volume is $\frac{4}{3}\pi r^3$; thus, there will be 240 and 30 spheres at a radius of 1 and 2 mm, respectively, in 1000 mm, i.e., 1 mL fat grafting), we proposed the concept of MAFT for fat grafting. The central dogma of MAFT emphasized that each of the delivered parcels should be $<1/100$ mL.

Figure 4  (Case 3) A 54-year-old woman presented for fat grafting to restore her aging dorsal hands. MAFT was performed to deliver 15 mL fat graft in her left and right dorsal hands (preoperatively in A and B, left). Sixty-four months after the MAFT session, the fullness and restoration of both dorsal hands were maintained (postoperatively in A and B, right). The appearance of her left dorsal hand was changed, i.e., from severe loss of fatty tissue and moderate visibility of veins and tendons (MHGS, grade 3) to mild loss of fatty tissue and slight visibility of veins (MHGS, grade 1). The appearance of her right hand was changed, i.e., from moderate loss of fatty tissue and mild visibility of veins and tendons (MHGS, grade 2) to no loss of fatty tissue (MHGS, grade 0).

Figure 5  (Case 4) A 53-year-old woman presented for fat grafting to rejuvenate her aging dorsal hands. MAFT was performed to deliver 10 mL fat graft in her left and right dorsal hands (preoperatively in A and B, left). Fifty-four months after the MAFT session, the fullness and rejuvenation of both dorsal hands were maintained (postoperatively in A and B, right). The appearance of her dorsal hands was changed, i.e., from moderate loss of fatty tissue and mild visibility of veins and tendons (MHGS, grade 2) to no loss of fatty tissue (MHGS, grade 0).
<table>
<thead>
<tr>
<th>Author/Year/Nationality</th>
<th>Case no./Age/Classification</th>
<th>HarvestingMethod/Cannula size</th>
<th>Refinement</th>
<th>Placement/Cannula/Amount</th>
<th>Dressing/Immobilization</th>
<th>Key contribution</th>
<th>Comments by Authors of present study</th>
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<tr>
<td>Dr. Aboudib et al./1992, June/Brazil</td>
<td>72 cases/38 (35–78)/25 cases, single operation, 47 combined with rhytidoplasty</td>
<td>Syringe or high pressure vacuum/2- to 3-mm</td>
<td>Wash in saline solution, close or open system</td>
<td>2-mm needle or 18-gauge needle/10 mL syringe</td>
<td>NA/NA</td>
<td>Fat exposed &gt;15 min, cytoplasmic lysis of up to 50% of the cells occurs.</td>
<td>Close system to avoid fat cell damage. Three cases had complications: two skin irregularity and one infection. Satisfaction rate reached 98.62%.</td>
</tr>
<tr>
<td>Dr. Butterwick KJ/2002, Nov./US</td>
<td>14 cases/53.5 (41–64)/One hand centrifuged fat, the other non-centrifuged fat</td>
<td>10 mL syringe low vacuum pressure (approximately 2 mL)/12-gauge Klein finesse cannula</td>
<td>Centrifugation: 3600 rpm for 3 min; Non-centrifugation: Syringes were placed upright for 15 min</td>
<td>18-gauge blunt cannula/1 mL syringe</td>
<td>NA/NA</td>
<td>Prefer blunt tip injection cannula with 1 mL syringe.</td>
<td>Support the use of centrifuged fat (compare to non-centrifuged fat) for longevity and improve aesthetic result at 3 and 5 months for fat augmentation of the aging hands.</td>
</tr>
<tr>
<td>Dr. Coleman RS/2002, Dec./US</td>
<td>22 cases in 8 years/NA (36–83)/NA</td>
<td>10 mL syringe to create slight negative pressure/3 mm</td>
<td>Centrifugation, 3000 rpm for 3 min</td>
<td>17-gauge blunt cannula/1 mL syringe</td>
<td>A protective barrier of Micro-foam tape is placed for 3–4 days/Elevate hand above heart and cold compresses as tolerated</td>
<td>Emphasize each delivered parcel should be as small as 0.02 to 0.1 cc.</td>
<td>The suggestive volume for each hand is more than 20 cc. Protective dressing is highly encouraged.</td>
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<tr>
<td>Dr. Butterwick KJ et al./2006, May/US</td>
<td>10 cases/53 (41–66)/One hand fresh fat, the other frozen fat</td>
<td>10 mL syringe low vacuum pressure (approximately 2 mL)/12-gauge Klein finesse cannula</td>
<td>Decant 15 min then, centrifugation for 3 min at 3600 rpm</td>
<td>Parcel &lt;0.1 cc, can be as small as 0.02 cc/at least 20 cc of fat</td>
<td>NA/Elevation</td>
<td>It is noteworthy in this study that the comparative advantage of frozen fat over fresh fat.</td>
<td>No continuous study similar to this evaluating the appearance of fat that has been frozen a longer period (&gt;17 days) is conducted.</td>
</tr>
<tr>
<td>Dr. Rohrich RJ et al./2015, Dec./US</td>
<td>NA</td>
<td>10 mL syringe, dry method/14-gauge</td>
<td>Centrifugation, for 1 min at 1200 rpm</td>
<td>14-gauge blunt cannula/10 mL syringe</td>
<td>Gauze wrapped with a non-compressive Kerlix and for 24 h/Elevated for 48 h</td>
<td>Place fat grafts above the dorsal deep fascia. Decompartmentalize the superficial and intermediate laminae, allowing even distribution of fat.</td>
<td>The approach addresses the prominent aged anatomy of the hand, providing excellent contour and aesthetic outcomes.</td>
</tr>
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<tr>
<td>Orgel MI et al./2016, May/US</td>
<td>NA</td>
<td>10 mL syringe, tumescent method/2- to 3-mm cannula</td>
<td>Centrifugation for 3 min at 3000 to 3600 rpm</td>
<td>17-gauge blunt cannula/1- to 3-mL syringe</td>
<td>Soft dressing/Elevated for 24 h</td>
<td>Emphasized the autologous fat grafting stands out the most promising choice.</td>
<td>A review of the literature to reveal many options for hand restoration.</td>
</tr>
<tr>
<td>Present study, Lin et al./2017/Taiwan</td>
<td>68 cases in 5 years/56 (38-70)</td>
<td>10 mL syringe low pressure, negative 270 to 300-mmHg (maintain 2 to 3 mL of empty space)/2.5 mm patent cannula</td>
<td>Centrifugation for 3 min at 3000 rpm</td>
<td>16-gauge patent cannula/1 mL syringe with MAFT-GUN</td>
<td>Soft dressing with flesh-color bandage for 2 days/Elevated for 48 h</td>
<td>Illustrated the concept of micro-autologous fat transplantation, which eliminated the potential complications of fat grafting.</td>
<td>Large series report (68 cases) with long-term follow-up, 32 months on average (range, 10-64 months) study after a session of MAFT procedure. The patient-rated satisfaction scores revealed 58.8% of patients were very satisfied and 39.7% were satisfied about their outcome.</td>
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</table>

0.3 mL or smaller aliquots/10 to 25 mL for each hand, slight overfilled 0.017 mL per aliquot/13.9 and 13.8 mL for right and left hands, respectively
(0.01 mL) (i.e., a fat parcel in a spherical shape with a radius of approximately 1.3 mm has a volume of 0.01 mL) to prevent central necrosis and subsequent potential morbidities (Figure 6 and Table 4). Furthermore, the patented instrument, the MAFT-GUN, possesses an innovative and precise controlling mechanism that accurately and consistently delivers fat parcels at the following volumes: 1/60, 1/90, 1/120, 1/150, 1/180, and 1/240 mL. Therefore, the MAFT-GUN enables surgeons to precisely control parcel volume to prevent central necrosis and subsequent complications (Supplemental Digital Content). The clinical results obtained using MAFT have demonstrated the feasibility of this approach and the importance of controlling the fat parcel size in achieving favorable outcomes. Specifically, the patent mechanism with accurate and consistent control of the parcel volume is critical to avoid occasional dislodgement of larger parcels, which in turn could result in nodulation and skin irregularity after fat grafting.

Moreover, the human dorsal hand surface is composed of three layers, namely DDL, DIL, and DSL, which are partitioned by DDF, DIF, DSF, and the skin. Surgeons, must be familiar with these anatomic locations where fat parcels would be micro-transplanted to achieve better therapeutic results.

Using the patented instrument, the MAFT-GUN, surgeons can precisely deliver each parcel to the dorsal hand surface.
Theoretically, the 16 G injection cannula is preferable to 16 G, which corresponds to a diameter of 1.6 mm. Anatomically, the dorsal veins of the hand have diameters around 1.27 ± 0.48 mm. Theoretically, the 16 G injection cannula would not easily induce intraluminal penetration. Third, the suggested volume of each parcel to be administered into the dorsal hand surface using MAFT-GUN is 1/60 mL (0.017 mL); this volume is very minimal, and the extrusion pressure is also relatively low. Hence, the possibility of an intravenous administration with high retrograde flow pressure is almost completely eradicated. Nevertheless, caution should be taken during the transplantation to avoid any unintentional vascular insult. Meticulous performance with a steady maneuver and appropriate anesthesia are crucial during the MAFT procedure.

In this study, the estimated fat retention rate was approximately 50% after one session of MAFT. The long-term outcome (up to 64 months) was reliable. However, a second session of MAFT may be considered 4–6 months after the first procedure for patients who request additional fullness. Those who have severe soft-tissue deficiency in the dorsal hand surface were informed preoperatively of the need for a second touch-up. Because of increased thickness resulting from fat grafting after the first session, a larger volume of fat may be needed in the second session to ensure good results.

With aging, soft tissue loss is inevitable and the skin of the dorsal surface of the hand becomes thinner, thereby revealing extensor tendons and dorsal veins. Volume restoration by successful fat grafting results in re-contouring of aging dorsal hand surfaces. Moreover, the rejuvenating effect of fat grafting could also improve the skin texture and eliminate aging-related changes such as skin pigmentation and senile keratosis.

In conclusion, this study presents the development of a simple and reliable procedure based on the MAFT technique for aging dorsal hand surfaces. Favorable outcomes (very satisfied, 58.8% and satisfied, 39.7%) were noted in patients who had one session of MAFT. The advantages of MAFT in such clinical candidates include not only volume restoration of aging dorsal hand surfaces but also skin texture improvement with sustainable long-term effectiveness, which further confirms that the technique is a reliable and simple strategy for the rejuvenation of the dorsal surface of aging hands.

Conflict of interest

Dr. T-M Lin owns the patent right for the micro-autologous fat transplantation (MAFT-GUN) and is the scientific adviser of Dermato Plastica Beauty Co., Ltd., Kaoshing, Taiwan, which is the manufacturer of the MAFT-GUN. The other authors declared no potential conflicts of interest with respect to the research, authorship, and publication of this article.

Funding

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Appendix A. Supplementary data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.bjps.2017.09.012.

References