Lipofilling in Reconstructive Surgery: Indications, Outcomes, and Complications

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Lipofilling has different potential applications both in aesthetic surgery and in procedures intended to treat pathologies [1]. Indications are increasing every day since fat grafting has been recognized as a useful and reliable technique and has become a technique used by many specialties in many different areas and pathologies. Fat grafting can work by two different ways: by volume addition (e.g., breast volume restoration in breast reconstruction) or by side regenerative phenomena (e.g., scar release in retracted breast lumpectomy scars).

As volumizer, lipofilling has an unlimited potential, only conditioned by the availability of enough fatty tissue in the donor areas, and an appropriate strategy of procedures sequencing to assure the maximal tissue uptake and the minimal lost in form of reabsorption or necrosis. This volumizing effect is usually used in spaces between the skin and the underneath bone structures, and in some anatomical spaces amenable to be grafted by the common fat grafting techniques, as the vocal cord, or the spaces surrounding the vagina.

As a regenerative agent, the fat graft can release the fibrosis of any scar, can improve the tissue elasticity, increase the vascularization, and induce the reversal of the aging and toxic agents damage to the tissues [2].

Indications can expand in the future if the technology provides solutions to improve the ability of the graft to overcome ischemia stress and the lack of nutrients, and if we can achieve the best conditions to integrate the graft in the receiving tissue. Furthermore, improvements and new technology in regenerative cells procurement, growth factors, and biological scaffolds can contribute to achieve these goals [3].

We have divided the indications in treatments by the kind of pathology. In some indications, we will suggest the volume to use, but as was exposed in the previous chapter about injection technique, this is the most experience dependent technical tip. Nevertheless, the area where we are going to apply the grafts has more features to control before deciding the volume, as the skin thickness, the age of the patient, the skin laxity, asymmetries, previous treatments with permanent or resorbable materials, and many others. Our advice is to be cautious with the former patients, avoiding overcorrection, and visit experienced surgeons to see how they decide the volume to use in each case.

Lipofilling is a relatively simple technique with a low complication rate if performed correctly. The surgeon should keep in mind that the first is do no harm, so the first common step of every lipofilling procedure, the harvesting of fat,

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must be performed with accuracy to avoid sequels at this level. Since fat transference techniques have increased its popularity in recent times, infrequent complications have been seen in clinical practice, and these will be discussed for every area.

Fibrosis, Scars, and Radiodermatitis

Any area with fibrosis or a scar is suitable to be treated by means of fat grafting, especially those retracted or depressed, improving the contour, hardness, and color, and also providing improvement of the symptoms as pain or itching [4, 5].

The graft can be of help to release the fibrosis, which is anchoring the scar to the deep planes, by means of its antifibrotic properties and also by the tunneling of the scar. The tunnels will be stuffed with the fatty tissue, providing foundation to the scar to sit on, and limiting the following fibrosis and relapse of the retraction (Fig. 1).

Scars from burns can also benefit of this treatment, smoothing and softening the burned area, decreasing inflammation, alleviating the pain, and improving the function [6].

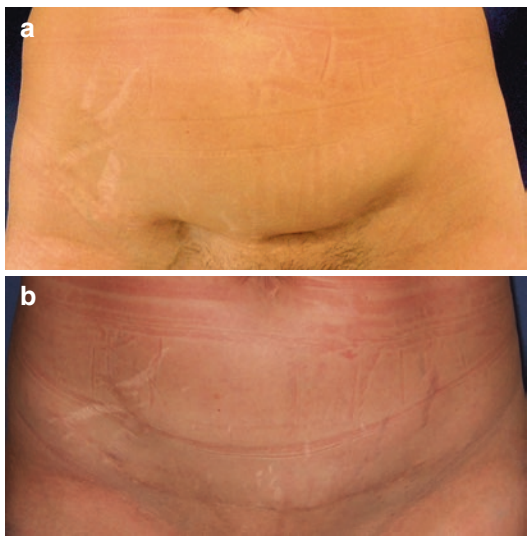

Fig. 1 (**a**) Suprapubic incision retracted and adherent after necrotizing infection. (**b**) After two procedures of fat grafting without any new incision, the scar now is flat and non-adherent

For a successful technique, tunneling and subcision of the scar is mandatory. Sharp cannulas or beveled needles can be used to ease this work, but bleeding, swelling, and posterior bruising are higher than using a blunt cannula. Multiple punctures on the skin have been proposed as a method to release the fibrosis before the graft placement. We do not recommend the use of sharp instruments neither multiple punctures of the skin because the same outcomes can be achieved by means of a 16G spatulate blunt cannula, with less trauma to the tissue and without the risk of multiple small white scars where the skin was punctured.

The skin that has been under the effect of the radiotherapy can develop fibrosis in the skin and in the underlying soft tissues as a chronic sequel, among skin color changes and telangiectasia. In most severe cases, the ischemia in the tissue induced by the radiation damage can lead to the skin breaking and ulceration. Ulcerations of the irradiated skin do not usually respond to conventional topical treatments, requiring of surgeries able to remove all the irradiated skin and direct closure with healthy tissue, or covering them with flaps obtained from non-irradiated areas. Some authors have achieved good results using lipofilling, with or without enrichment with stromal vascular fraction or growth factors [7, 8]. The healthy fatty tissue of the graft is able to promote neoangiogenesis in these ischemic tissues, improving the vascularization and also helping the granulation and epithelialization of the ulceration [7, 9–11].

Acne

Fat grafting provides a new approach to the treatment of acne scars, which complements the traditional dermabrasion, chemical peeling, or laser resurfacing. In fact, fat atrophy is a subdermal damage produced by the severe acne that contributes with the scarring to the irregularities on the skin surface. As a kind of fibrosis and scar, sequels of acne can be improved by means of fat grating, and this can also provide volume of fat were this was damaged by the disease [1, 12, 13].

Fig. 2 Acne scars treatment with lipofilling. Left: before, Right: after. Amounts used are discrete, the most important is to release every scar with subcision and fill the space created with fat

Subcision of the scar is necessary to create the space to place the fat under the acne scar. Many authors suggest the use of a beveled needle but, for us, sharp instruments will produce more swelling, ecchymosis, and bleeding, which will interfere with the graft uptake. We rather use spatulate blunt cannula, but as difference with the general treatment of the scars, we will choose a narrower diameter of cannula (18G–21G) (Fig. 2).

HIV Lipoatrophy

Antiretroviral treatments used at the end of the 90s showed an exceptional effectiveness to control the disease but had a devastating side effect, the HIV-related lipodystrophy. This implies changes in the body fat distribution, with lipoatrophy in the limbs and the face, and fat accumulation in the trunk (especially intra-abdominally and in the upper back as a hump) and the neck. These changes make noticeable that the patient, otherwise healthy, is infected by the HIV [14, 15].

The features are a face with more or less sunken cheeks, depending on the degree, with a skeletonized look in the most severe cases. In the limbs, buttocks flattening and very noticeable muscles in the legs, thighs, and the arms are the main signs of the disease, concerning more to the women because they use to have more fat than men in these locations.

The options to treat the more concerning feature of HIV lipoatrophy, the facial atrophy, comprise synthetic fillers injection or lipofilling. Given that the atrophy does not improve over the time and does not have any etiological treatment, the use of reabsorbable fillers is not the first option, being preferable a permanent one. Synthetic permanent materials are sometimes related with serious local problems, which can be difficult to treat. Lipofilling is a good option because is permanent and absolutely biocompatible, and its effectiveness and durability in these patients have been demonstrated, so should be the first to be considered in the treatment's algorithm in those patients with enough fat in the potential donor areas, usually abdomen or hump [14, 15] (Fig. 3).

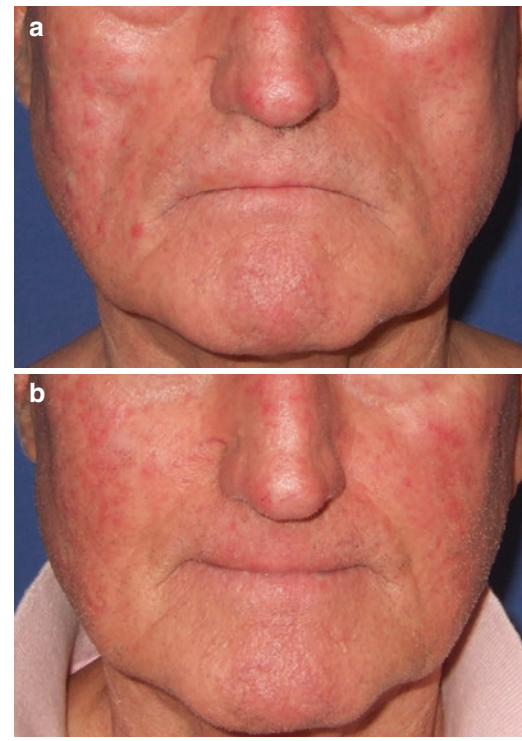

Fig. 3 Patient with facial HIV lipoatrophy. (**a**) (up) Before the treatment with lipofilling. A noticeable lack of fat in the cheek, with the skin sunk under the malar bone it the severe grade of atrophy. (**b**) (down) 1 year after grafting 9 cc of centrifuged fat, a natural correction of the atrophy is observed

Fig. 4 Patient with facial lipoatrophy, left, before lipofilling treatment, and right, 1 year after, showing hypertrophy of grafted fat (Hamster syndrome)

Lipofilling can also be used for the buttocks atrophy, but many patients have a severe atrophy of the buttocks with a limited amount of fat available. The amount of fat required to enhance the gluteal area is high compared with the face (around 500 cc each side), so many of them requesting a treatment for this area require buttocks implants additionally to the lipofilling, which can be performed simultaneously [16].

A special warning should be given about complications of fat grafting in these patients, because an excessive overcorrection can lead to an excessive full-face appearance that has been called "Hamster syndrome (Fig. 4) ". This complication is not frequently reported out of the HIV lipoatrophy context; probably in these patients the particular changes in fat metabolism pose an especial risk for it. This can be prevented obtaining the fat from volume stable donor areas in patients with well-established and stable lipodystrophy and avoiding overcorrection [14].

Parry–Romberg Syndrome, Hemifacial Atrophy

The features of the Parry–Romberg disease, hemifacial atrophy and some other entities in the maxillofacial area featured by atrophy of the facial subcutaneous tissue (among other changes in the underlying bones and muscles) are pretty similar to those of the HIV lipoatrophy. Lipofilling is the most convenient option for those changes in the facial soft tissues, while for the underlying skeletal anomalies, osteotomies or hard implants are the preferred treatment.

For those with Parry–Romberg disease, lipofilling use to be enough to achieve good symmetry and long-lasting results [17, 18]. For the other maxillofacial syndromes as Treacher Collins or Goldenhar syndrome, lipofilling is necessary as the main step in their treatment or as a secondary procedure in the following reconstructive times.

The results are quite satisfactory for the cheek area, but curiously in these cases the results in the chin are not satisfactory in terms of symmetry, being very difficult to achieve a good expansion of the thick skin of this area.

Complications can appear as those described for HIV facial lipoatrophy and we should take the same cautions, especially overcorrection avoidance given this condition is difficult to treat [19] (Fig. 5).

Breast Reconstruction

In the last decade, indications of fat grafting for breast reconstruction have become the last significant advance in breast reconstructive surgery

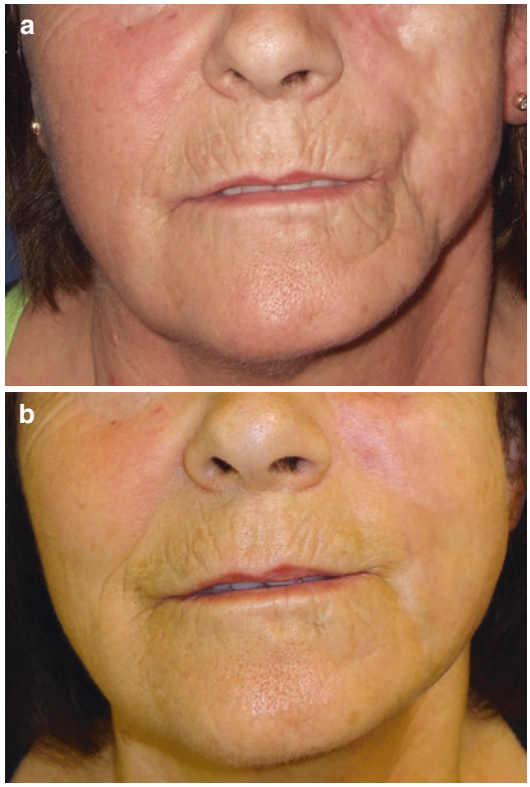

Fig 5 Patient with Parry–Romberg syndrome: facial atrophy of the left cheek (**a**). (up) Before the surgery (**b**). (down) After two procedures of lipofilling

after the boom of the perforator flaps in the early days of this millennium. Concerns about its safety and effectiveness kept the fat grafting in the backstage of the surgical options in breast surgery both for aesthetic and for reconstructive purposes.

Based on the improvements in the fat grafting technique, currently the controversy of the effectiveness and durability of fat grafts is not an issue, but some controversy remains about its safety in the breast. This controversy refers to the potential risk of neoplastic promotion mediated by the adipose tissue stem cells (ASC) and the possible interference in breast imaging. Despite that, current evidence from the clinical series indicates that this procedure is safe in patients who have suffered a breast cancer [20–23].

Fat grafting in breast reconstruction provides a versatile option to treat many of the breast defects resulting from an oncologic surgical approach, which has offered a new approach to treat these defects in a more effective and conservative way than the options offered by the implants and flaps. Nevertheless, flaps and implants still remain the main option for mastectomy reconstruction, but even with these the fat can play an important role as an ancillary procedure to improve the results that can be obtained with the basic technique [24–26].

Fat grafts in the breast after breast cancer surgery can also give additional advantages aside of volume as an improvement of the Postmastectomy Pain Syndrome improvement. Chronic pain in the breast and surrounding areas affects up to the 60% of the patients after surgery of breast cancer, boosted by some factors, being the radiotherapy one of them [27].

The most usual complications are common with those appearing in its use in aesthetic surgery and will be presented there, as like some breast defects as tuberous breast and breast asymmetry, which can be considered both reconstructive and aesthetic problems.

Partial Defects

Breast-conserving surgery (BCS) of breast cancer can lead up to a 35% of bad cosmetic results due to the shape distortion and asymmetry from the surgery and the adjuvant radiotherapy [28]. Common features of the breast after a BCS are contour deformities, pigmentation and hard touch due to the fibrosis and the radiotherapy. Some of the morphological changes can be prevented by an oncoplastic approach, remodeling the breast at the time of the tumor removal, avoiding dead spaces that will lead to a skin retraction and distortion of the breast contour. Another option to prevent secondary defects is the use of flaps from the thoracic wall (intercostal perforator or latissimus dorsi flaps) but the use of these mean deep planes dissection, even muscle sacrifice, and new scars in an area without any disease, with a more visible sequel that the incision needed to treat the cancer. When the defects appear, fat grafting can provide a more convenient way to treat it, providing volume and contour restoration, with fewer

Fig. 6 Left: Skin retraction after breast-conserving surgery of breast cancer and radiotherapy. Right: After two procedures of fat grafting and periareolar mastopexy the shape of the breast has been restored

scars, without functional compromise and with a regenerative parallel effect of fibrosis release that can soften the hardened breast (Fig. 6). This approach has also been proposed to be applied at the same time of the lumpectomy, but with the aim of adding volume to the whole breast to avoid retraction of the exceeding envelop [29].

The cannula in a breast lipofilling procedure will cross the breast repeatedly, and this maneuver can spread a cancer in the breast, so we must be sure that the breast does not have any lesion suspicious of malignancy, given the risk of relapse or a second cancer, so a mammogram of less than 3 months before the surgery is advisable.

As we induce some changes in the breast architecture, those patients with a breast difficult to assess by imaging will be excluded of lipofilling treatment to avoid interferences in the disease control.

Total Reconstruction

Total breast reconstruction after a mastectomy is usually performed by means of implants or flaps. Both present limitations as any other technique but they are the more convenient way to do it because they can provide enough volume in a single procedure. Fat grafting in these case has many limitations as the high volume of fat needed, the inelastic tight skin which hampers the graft placement, and the need of many grafting surgeries to achieve the same volume that the healthy side. But in some cases fat grafting can be an option to provide a scarless reconstruction: patients with a single scar, with some excess of skin in the lower and inner quadrants to achieve a good cleavage definition, and without a big breast in the contralateral side (Fig. 7).

Expanding the skin previously can be of help to perform a total breast reconstruction by means of fat grafting. Two different strategies can be used in this way: internal expansion and progressive deflation with simultaneous grafting, or external expansion using an external vacuum device and grafting [30–33]. These need two or more procedures to achieve the final result.

Ancillary Procedure

As in the case of the partial defects, fat grating has revolutionized the breast reconstruction surgery being nowadays a step more in the reconstructive process, being used as an ancillary procedure, before or after the main reconstructive procedure [34].

Fat grafting can be applied before the implant based reconstruction to increase the thickness of

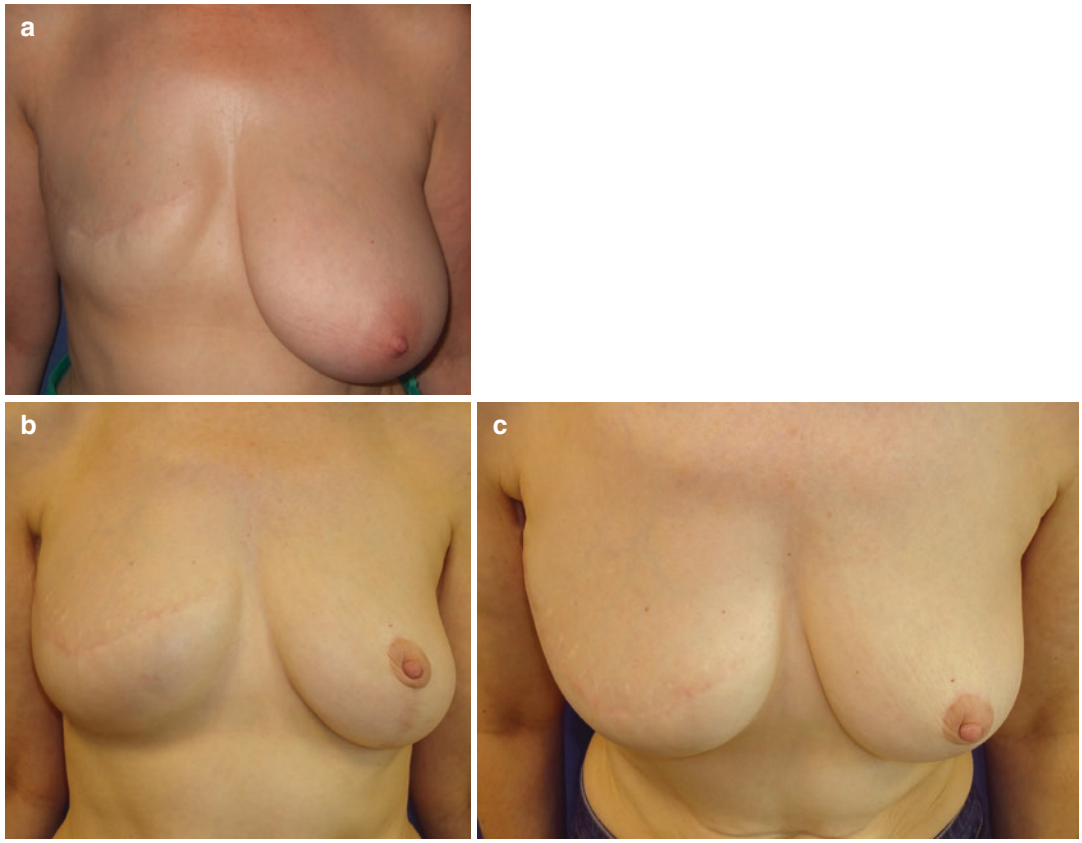

Fig. 7 (**a**, up) Right mastectomy, with enough remaining skin in the lower and inner quadrants (**b**, left) that can help to achieve a natural shape of the reconstructed breast after two fat grafting procedures (**c**, right) including a good cleavage definition

the skin with the objective of avoiding implant extrusion. If the breast has been irradiated, fat grafting seems to provide regeneration of this area that will limit the problems of the implants applied in previously irradiated area, as contracture, upper displacement, and extrusion [35–37].

After the reconstruction, fat grafts can help to provide a smoother transition between the clavicle and the upper pole of the implant or flap, a better defined cleavage when applied in the inner quadrants, and can also supplement the volume of the flaps and even the implants, improving the satisfaction of the patient with her reconstruction [26]. Moreover, fat grafting enhanced latissimus dorsi flap, provides us the same results in terms of volume and shape than those obtained by the DIEP flap (the contemporary "gold standard" of breast reconstruction) in a more predictable surgery and with less limitations than the microsurgical procedure (Fig. 8).

Poland's Syndrome

Fat grafting is an option of treatment for Poland's syndrome among the implants and the transference of the latissimus dorsi [38–40]. Like in the case of the breast reconstruction, fat grafting can be used as a primary treatment or as an ancillary treatment, supporting implants and flaps. As primary treatment can be successful in those cases with a mild deformity, but in most severe cases, with severe chest wall compromise (sometimes involving also the ribs) could be insufficient to provide a good result. In these cases, the use of implants or flaps is mandatory,

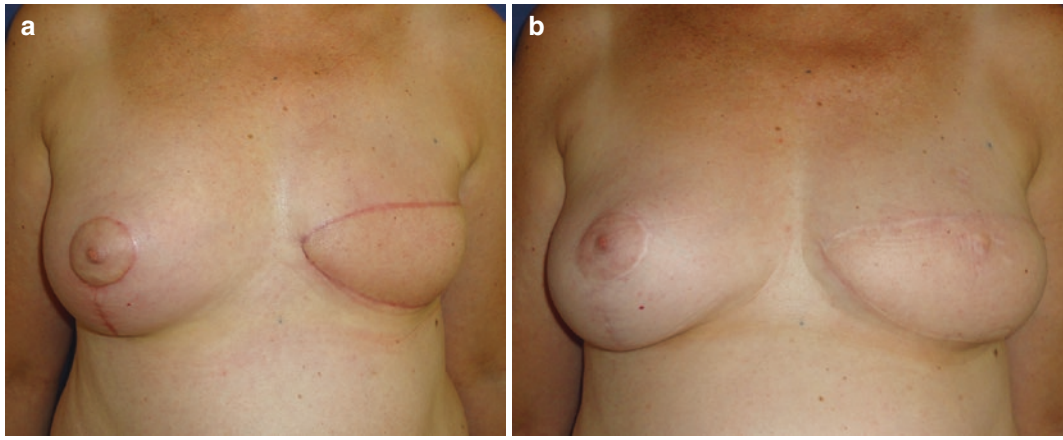

Fig. 8 (**a**, left) Left mastectomy reconstructed with latissimus dorsi pedicled flap without implant. (**b**, right) After two procedures of fat grafting, the flap has gained the volume of the contralateral side, with a permanent and more natural shape and touch than what is achieved when using implants

and fat grafting can help to achieve a more natural result, improving the contour and adding volume where needed [40].

Pectus Excavatum

Nowadays, the standard technique for the correction of pectus excavatum is the minimally invasive repair of pectus excavatum (MIRPE), which implies the use of a metal bar, which pushes out the sternum and corrects the deformity. Custom-made silicone implants placed in a subcutaneous pocket are another surgical option. The invasive techniques for pectus correction may not eliminate the need for ancillary methods of extrathoracic remodeling and aesthetic refinement of minor or remnant defects, and this is the main role of fat grafting in this pathology [41, 42].

Lipofilling have not succeed as a primary treatment of pectus excavatum because there are some important factors limiting its effectiveness: the funnel deformity in the moderate and severe cases require of a thickness increase to be corrected that is hardly attainable in only one procedure, the firmly adherent skin of the presternal area to the deep plane makes difficult the placement of the graft, and these patients usually are young and slim being difficult to harvest enough transferable fat.

Autoimmune Diseases

Many of the autoimmune diseases have changes in the subcutaneous fat, skin and fibrosis, which can be managed with the use of lipofilling. Diseases as rheumatoid arthritis have features like hands and feet fat atrophy that give them an aged look, with noticeable tendons and veins, and in the feet can lead to pain in the sole due to the lack of fat cushion. Increasing the fat thickness there can help to hide the skin underlying structures, and makes the patient feel more comfortable when steps on.

Lupus and scleroderma can show facial depression deformities caused by scars along with skin and subcutaneous fat atrophy. In “coup de sabre” scleroderma of facial skin, changes can mimic those of Parry–Romberg disease and the differential diagnosis should be established. Fat grafting can reduce the aesthetic and functional impact of the disease increasing the facial volume and improving the quality of the skin, and even the mouth opening in the scleroderma [43, 44].

The use of fatty tissue and stromal vascular fraction (SVF) has been proposed to treat the symptoms in the hand of the systemic scleroderma: Raynaud phenomenon, finger retraction, and skin ulceration. Fat is injected at the hand palm and in the dorsum, SVF is injected under

the skin in the fingers, and they reduce the fibrosis and the vessel hyper reactivity, reducing the risk of amputation [45, 46].

Dupuytren Disease

Dupuytren disease has as a main feature a fibrotic cord retracting the fingers (mostly the 5th and the 4th). The classic approach so far has been the surgical cord resection, with or without skin plasties, with a high rate of relapse. A new treatment using collagenase is used nowadays with the advantage of being no invasive, but the relapse can also appear. Lipofilling is another option, breaking the cord by means of needle subcision and grafting directly the fibrotic area [47].

Due to the antifibrotic properties of the stem cells contained in the graft (which inhibit the proliferation of the contractile myofibroblast) and the placement of the fatty tissue right inside the cord, relapses are limited being a less invasive treatment than the open resection option, especially in a disease that have no effective option to avoid the relapse [48].

Urinary and Bowel Incontinence

Even though lipofilling has been used in these indications, references about this use are week, probably because it is not easy working in these delicate spaces with cannulas, with risk of urethral or bowel perforation, and other strange complications reported as pseudolipoma, with results not equal to those that can be achieved with other techniques [49–51].

Vocal Fold Paralysis

In the event of vocal fold palsy, the vocal fold is unable to medialize, changing the features of the voice. Any procedure that increases the volume of the paralyzed cord can help improve the quality of the voice. Synthetic materials as calcium hydroxyapatite are used with this purpose, but lipofilling can also be used with the advantages of being softer and permanent. The fat is injected under direct microlaryngoscopy into the defective vocal fold [52].

Eye Enucleation

Loss of fat volume in the eye socket can occur after enucleation. This limits the ability to wear ocular prosthesis because the orbit is not able to retain the implant. Adding more fat by means of lipofilling can help to increase the volume of soft tissue and help to retain it there, improving the general aesthetics of this zone [53, 54].

Vulvovaginal Atrophy/Lichen Sclerosus

Vulvovaginal involutive diseases, as senile atrophy and lichen, painful episiotomies scars, and others, which use to have the common features of skin stiffness, dryness, irritation, soreness, and pain (dyspareunia) with urinary frequency and urgency are tributary of treatment using lipofilling as volumizing agent and with the benefit of the immunomodulation of the stem cells. Lipofilling can provide relief from pain, volume, softness, and humidity [55]. Alternative treatments are hyaluronic acid or platelet growth factors (PRP) injections, being reported good results.

Foot

Loss of foot sole fat cushion can have many etiologies, as autoimmune and rheumatic diseases, diabetic foot, ischemia, previous local trauma, surgeries or radiotherapy, age related among many others. Most of these patients have used custom made insoles to reduce the pain and discomfort in walking, but if these are unsuccessful fat thickness restoration is sometimes the only one available option for them [56, 57]. This indication is not well reported, but by the authors experience in some patients the improvement worth the surgery.

Lipofilling is applied in the sole from the toes web spaces and can also be applied in the heel from the instep [58]. Volumes used are very different to one patient to another due to the different features of the atrophy in each one. The volume used is limited by the stiffness of the sole skin, and we should avoid an excessive volume infiltration because a compartmental syndrome is one of the overpressure risks in the limbs. We recommend to use only the volume enough that do not bleach the skin, keeping in mind that this volume is less than the expected volume if we compare with face, breast, or buttocks procedures.

In diabetic foot, fat grafting is a promising option to provide cushion to insensitive areas exposed to pressure ulceration [59], and is also an option for painful scarring impairing walking [60].

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