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RESEARCH ARTICLE

LIPOSTRUCTURE: EXPERIENCE OF THE DEPARTMENT OF PLASTIC SURGERY OF THE MOHAMMED VI UNIVERSITY TEACHING HOSPITAL OF MARRAKESH

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Abstract

This is a descriptive retrospective study of 42 cases of patients who underwent the lipostructure procedure at the Department of Plastic Surgery of Mohammed VI Teaching Hospital of Marrakesh, over a period of 6 years, from January 2012 to December 2017. It aims to report our experience, and to review the procedure, applications, and outcomes of lipostructure. A total of 61 procedures were performed. The average age of our patients was 28.78 years. A female predominance was noted (86%). The main indications were: burn sequelae (33%), trauma sequelae (17%), infection sequelae (10%) and facial rejuvenation (10%). In terms of local conditions, most of our patients suffered from skin scars (61.9%), atrophy (14.28%), wrinkles (9.52%), facial asymmetries (7.14%), and nasal deformities (7.14%). The samples were mainly harvested from the abdomen (42%), followed by the trochanteric region (saddle bags) in 38% of cases. 67.21% of the samples were harvested from a single donor site. The average volume collected was 74.52 ml. All the samples were centrifuged by the Regenlab system. 52% of the lipostructure procedures were performed on the face, with an average injected volume of 23.25ml. 42.62% of the lipostructures were associated with an injection of PRP, and 6.55% with a facelift.

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Introduction:-

Depending on the author, autologous adipose tissue graft is also termed lipofilling, lipomodelling, fat transfer, adipose tissue transfer, or autologous fat transplantation [1]. Autologous adipose tissue graft is defined as a technique for filling soft tissue by injecting autologous fat [2]. The basic principle of autologous adipose tissue graft is the reinjection of a sample of fat tissue after it has undergone treatment. The main objective of autologous adipose tissue graft is to restore volume, as well as enhancement of skin quality. Its use in reconstructive and cosmetic surgery is nothing new, and has been the subject of numerous studies. This technique is frequently used in various situations such as in the treatment of scars, atrophies and deformities of the face or limbs, malformations. It is further used in thoraco-mammary surgery. This technique finds indication in the context of rejuvenation of the face and hands, and as a complement to rhinoplasty or of blepharoplasty. Autologous adipose tissue graft is also used in various specialties such as ophthalmology, neurosurgery and traumatology [2]. Autologous fat transfer has received renewed interest in recent years with the development of Lipostructure® by Sydney Coleman from the 1990s onwards, and is based on a specific substrate and strict methodology. This technique, while under constant review, remains a benchmark in terms of liposuction and grafting of autologous adipose tissue. (3) Autologous fat transfer

has several advantages: the availability of adipose tissue and its biocompatibility; and the simplicity of the surgical procedure, its low cost, and its low risk of complications. (3)

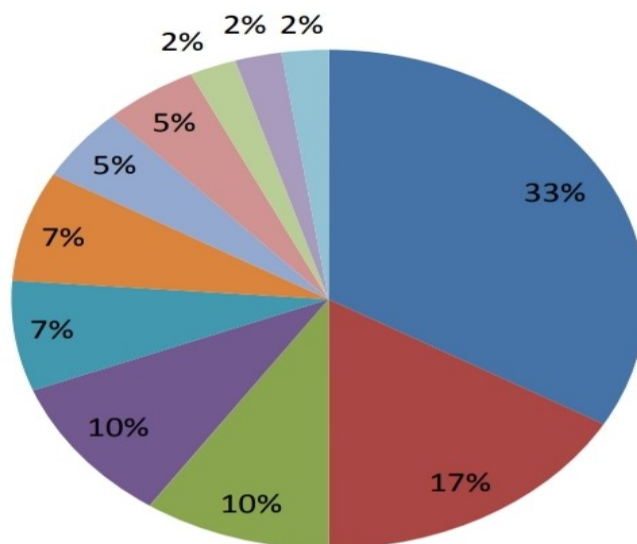
The isolated adipose tissue is composed of adipocytes and cells of the vascular stromal fraction, including adipose stem cells, preadipocytes, fibroblasts, vascular endothelial cells and a variety of immune cells. Over the past decade, regenerative cell-based strategies have shown tremendous promise, and it has become evident that vascular fraction cells and fat stem cells could improve fat graft survival, largely due to their angiogenic properties. (4) Although autologous adipose tissue graft is a technique commonly used today, it has certain limitations with regard to long-term graft survival and with respect to its oncological safety. (3) The objective of our study is to highlight the different indications, techniques and results obtained from the use of this surgical procedure by reporting the experience of our department with a review of the literature.

Patients And Methods:-

The present study is a retrospective, descriptive and analytical clinical study. Participants of the study were patients who have undergone lipostructure in the Department of Plastic, Restorative, Aesthetic and Burns Surgery at the Mohammed VI University Hospital in Marrakesh, during a period of 6 years, spanning January 1, 2012 to December 31, 2017.

The anamnestic, clinical, paraclinical, therapeutic and evolutionary data of each patient was collected from the medical files of the department archives. The information was collected using a data sheet established in advance. Statistical analysis of the data was performed using Microsoft Excel software.

Over the period of study, we recruited 42 participants who underwent lipostructure. A total of 61 procedures were performed, with an average of 7 patients and 10.16 procedures per year. A 7-fold increase in lipostructure procedures performed was observed between the start and end of our study, going from 3 to 21 operations per year. In addition, the rate of lipostructures carried out in the department compared to other hospital activities rose from 0.95% in 2012 to 3.36% in 2017. Our series was characterized by a clear predominance of females who represented 86% of the patients who underwent lipostructure: F / M sex ratio of 6. The average age was 28.78 years with extremes ranging from 3 years to 60 years. The majority of patients were between the ages of 15 and 30. The majority of patients (71%) were from urban areas, and 50% of the patients were of average socioeconomic status, while 38% had a low socioeconomic level and only 12% had a high socioeconomic level. A found a history of plastic and reconstructive surgery was found in 17 patients, or 40.47% of cases: 7 patients had a history of skin graft, i.e. 16.6% of cases; a skin-lift was noted in 5 patients, i.e. 11.9% of cases; 5 cases of inflatable prosthesis, i.e. 11.9% of cases; 3 cases of injection of platelet-rich plasma (PRP) i.e. 7.14%; 3 cases of cleft lip and palate operated on; 1 case of ocular prosthesis fitting i.e. 2.38%; 1 case of breast reconstruction; and 1 case of abdominoplasty. With regard to the lipostructure indications, 33% of operated patients presented sequelae of burns, 17% consulted for sequelae of trauma, 10% for sequelae of infection, and 10% for facial rejuvenation.



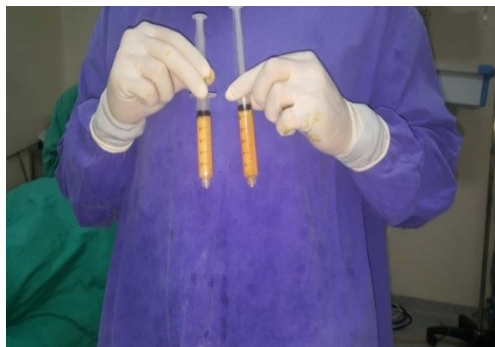
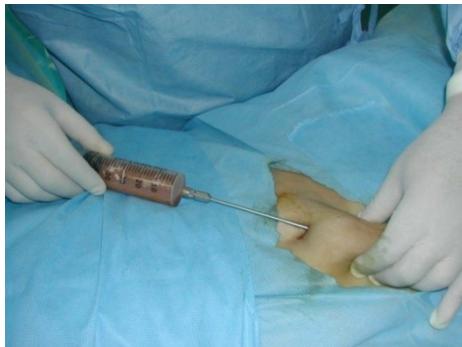
Autologous fat transfer was performed using the technique described by S. Coleman: Lipostructure®.

A plastic surgery consultation was carried out before the procedure in view of performing general clinical examination, evaluating the patient's condition, explaining the procedure, and taking pictures after agreement and informed consent of the patient, as well as a pre-anesthesia consultation.

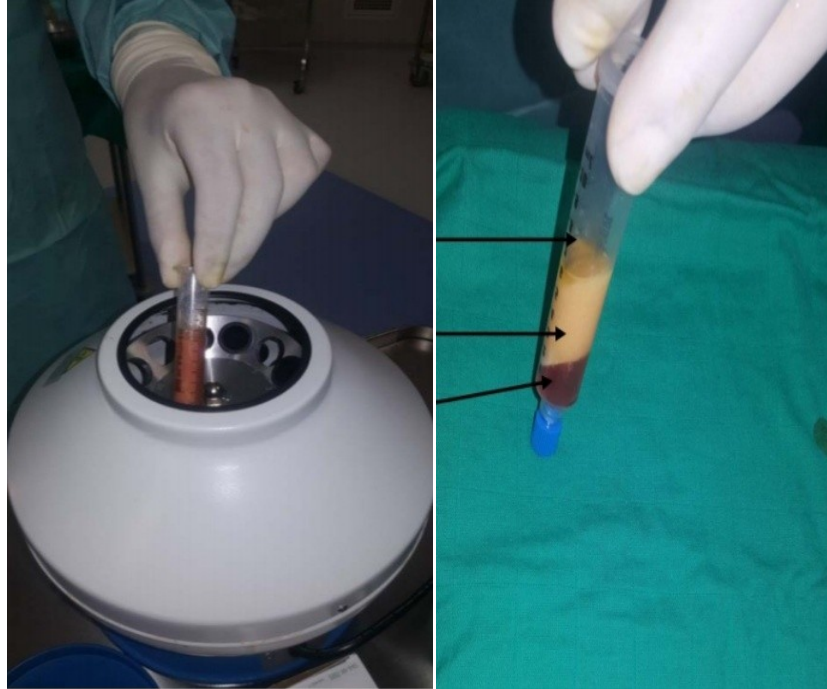
The procedure begins with precise identification of the donor sites as well as the recipient sites.



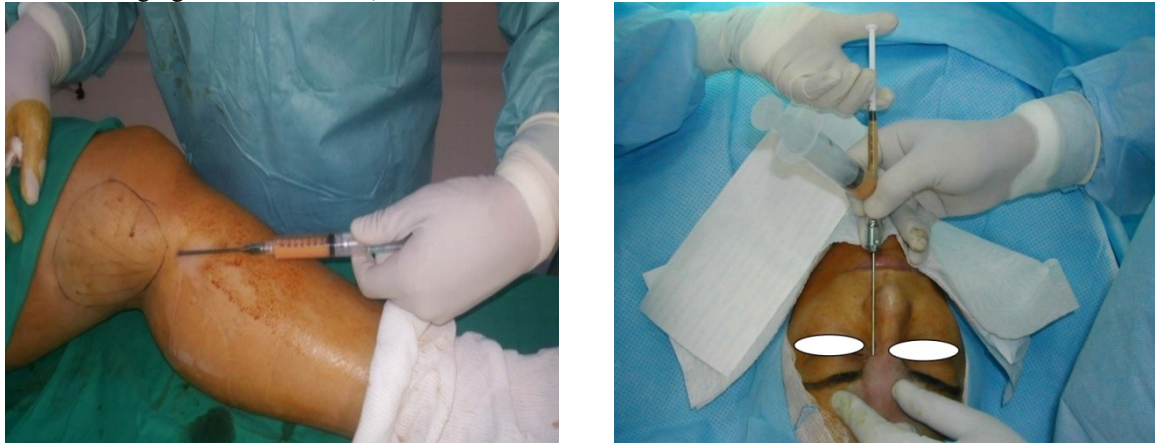
The adipose tissue is taken atraumatically, by a micro incision hidden in the natural folds, at zones with good lipid reserve or surplus adipose tissue, mainly the abdomen, followed by the trochanteric region, and less often from the thighs. The donor site is prepared by infiltration of 1% lidocain mixed with adrenaline, diluted in normal saline. All samples were taken using the Coleman or Lipostructure® technique, by manual liposuction using a 2.5 to 3mm diameter cannula, 10 to 15 cm long, with a blunt end and fairly large double openings to allow the passage of adipocytes. This cannula is mounted on a 10 ml Luer-Lock® syringe. Negative pressure is applied manually and gradually. Multiple tunnels are made during the harvest to reduce the risk of trauma and hemorrhage. The mean volume extracted was 74.52 ml, with extremes ranging from 5 ml to 200 ml, and a median of 20 ml.



All the samples were centrifuged, by a REGENLAB centrifuge at 1500 revolutions / min for 3 minutes.



-Reinjection of the sample is done from a 1 to 2 mm micro incision using blunt-tipped micro cannulas. Sites of reinjection were as follows: 52% on the face, 15% on the upper limb, 12% on the lower limb, 10% on the nose, and 3% respectively on the eyelids, on the trunk and on the pelvic region. The mean injected volume was 23.25 ml with extremes ranging from 2 to 110 ml, and a median of 16 ml.



Among the 61 lipostructure procedures performed in our series, 33 were associated with one or more surgical procedures, i.e. a rate of 54.09%. Of these, 42.62% had a PRP injection and 6.55% had a facelift.

The mean hospital stay was 1 day, with extremes ranging from 1 to 3 days, and a median of 1 day.

The majority of our patients did not have immediate or late complications. A few cases of bruising at the donor site and edema at the recipient site were noted. No case of postoperative infection was noted.

In our series, 27 patients (64%) required only one lipostructure session, whereas 15 patients underwent multiple lipostructure sessions with a mean time of recovery of 11 months, with extremes ranging from 3 to 36 months, and a median of 9 months.

In the postoperative period, all our patients received treatment with antibiotics and per os analgesics, and a cessation of sports activity for 4 weeks. Sun exposure of operated zones was discouraged.

The therapeutic outcomes were evaluated by the degree of patient satisfaction, and by comparing the photographs before and after the procedure after 6 months of the operation.

The subjective assessment of satisfaction after 6 months of the last intervention found a satisfaction rate of 86%.



Lipostructure for Parry Romberg syndrome



Outcome of lipostructure for rejuvenation of the face



Outcome of liposuction for rejuvenation of the face



Outcome of liposuction in the context of face atrophy due to lupus



Outcome of lipostructure between the eyebrows for rejuvenation of the face

Discussion:-

Techniques employed :

Harvesting of adipose tissue

Type of anesthesia:

Lipostructure can be done either under general or local anesthesia. The choice is made according to the history of the patient, the volume of the area to be operated upon, the complexity of the operation, as well as the various associated procedures. In our study, almost all lipostructure procedures were performed under general anesthesia (96.72%). Only 2 procedures were performed under local anesthesia, which is consistent with the data in the literature. (2) (21) (22)

Choice of donor site:

No difference was demonstrated between the adipose tissue obtained, after collection and centrifugation, at the different harvest sites (23) (24). In vitro research has concluded that there is no difference between fat taken from the abdomen, thigh, flank or knee with respect to fat cell viability (25). These results were confirmed by in vivo experiments on mice (26), and clinically by a study comparing the three-dimensional imaging results of autologous adipose tissue graft for breast reconstruction and which showed no difference in longevity between the fat taken from the abdomen and thigh (27). The choice of the donor site is therefore based on its accessibility, the available fat reserves, the volume required for reinjection, and the secondary benefits of the associated remodeling. The number and size of adipocytes vary depending on the location of the adipose tissue. This is due to the difference in vascularity and sensitivity to neuroendocrine factors that regulate the process of lipolysis. Thus in women, the trochanteric region is considered less sensitive to lipolysis, which explains why adipose tissue samples in women are often taken from this region, including in our study. The most frequently used donor site is the abdomen, followed by the trochanteric region, then the thighs and knees (28) (29). This fits perfectly with the results of our study. In adults and pubescent adolescents, the collection concerns the so-called deep fat reserve, often from the abdominal region, or from the trochanteric region. In children, these reserves do not yet exist, and the harvest is therefore done in more specific areas, such as the gluteal region or the abdomen. In our study, the primary donor site in children was the abdomen followed by the thigh, and then the trochanteric region. Harvesting is most often the limiting factor in children. At some ages, the fat percentage is very low; for example, an average of 12-16% fat level is found in a 5-6 year old (30).

Preparation of the donor site:

Infiltration is the preliminary step to liposuction. It was initially developed to allow liposuction procedures to be performed under local anesthesia. Many advantages of using the tumescent solution have been described, including a reduction in pain, decreased bleeding and easy removal of adipose tissue. (31) The infiltration fluid consists of a

large volume of physiological saline in which a vasoconstrictor (adrenaline) and possibly a highly diluted local anesthetic can be added. The most commonly used local anesthetic is lidocaine. Since the subcutaneous adipose tissue is richly vascularized, the use of vasoconstrictor helps prevent bleeding and accentuate the effects of lidocaine by reducing the infusion (6). Nevertheless, there are conflicting data regarding the effect of local anesthesia on the biology of adipocytes. Lidocaine has been reported to inhibit the growth of cultured adipocytes, slow glucose transport, and decrease the metabolism, growth, and viability of these cells. However, once absorbed, its inhibitory effects on the fat cell disappear. The body of data in the literature suggests that infiltration of anesthetic into the donor site may cause temporary disturbances in the biology of adipocytes but should not have other important consequences on the viability of the graft in the long term. (24) (32) (33).

Sampling methods:-

During the harvesting phase, several techniques can be used. There is an ongoing debate in the literature regarding the ideal method that would produce the greatest number of viable and functional adipocytes. Adipose tissue can be removed by surgical excision or by liposuction. Liposuction can be either manual with application of negative pressure on a syringe using Coleman's technique, or assisted by hydropression or ultrasound. The harvest must be the least traumatic as possible. (3) (2) (34). Several studies have shown that syringe liposuction results in higher adipocyte count and viability compared to assisted liposuction (24) (28) (35). However, low pressure liposuction retains its advantage of being faster and can be used when a large volume of fatty tissue is required to be removed, such as in surgery to the thoraco-mammary region (3). Furthermore, when a tumescent solution is used to prepare the donor site, no significant difference is observed in the number of cells or their viability (36). An experimental study was performed in mice to assess the impact of different liposuction methods and showed no significant difference in graft volume or weight (24) (34) (37). Based on these data, the method used to collect the fat is less important, as the survival of adipocytes remains comparable between the different methods of harvesting. However, the short period during which the adipose tissue transplants were evaluated (4, 6 or 12 weeks) does not allow us to conclude on the effect of the different harvesting techniques on the long-term survival of the graft. In addition, recent experimental and clinical studies favor direct surgical excision over liposuction (38). Qin et al. recommend surgical excision because it maintains the structure and viability of the fat tissue removed (39). Furthermore, Pu et al. found a significant alteration of functional adipocytes in liposuction by conventional liposuction compared to adipose tissue removed by surgical excision and manual liposuction with a syringe (40). In addition, the diameter of the cannula influences cell survival, larger diameters would result in less cell damage. Studies examining the different sizes of liposuction cannulas have shown that using a larger diameter cannula improves cell viability (41). Erdim et al. demonstrated better viability of adipocytes isolated with a 6 mm cannula, compared to a 2 mm and 4 mm cannula (42). Consistent with in vitro reports, Kirkham et al. also demonstrated that fat removed with a large 5 mm diameter cannula formed larger grafts, with less immune infiltration and less fibrosis after 6 weeks in transplanted mice compared to fat grafts harvested with a 3 mm cannula (43). In addition to cannula size, reports comparing a multiperforated cannula with the Coleman 3 mm suction cannula showed no significant difference in cell viability or the size of the transplanted adipose tissue (44) (45). On the other hand, there is some evidence to support the low shear treatment of the removed fat (34) (46). The authors attribute the improved results of autologous adipose tissue graft to improved manipulation of adipose tissue. Important properties of adipose tissue correlate directly with time spent outside the body. Thus, the transfer of adipose tissue should be done as soon as possible after harvesting. Surgeons should be especially aware of this when working with large volumes of fat or during long procedures. (47) (48).

Particularities of micro and nanofat grafts of adipose tissue:

Usually collected with small cannulas 0.7 mm in diameter, micro and nanofat grafts are more used in the treatment of delicate areas of the face such as the eyelids or lips. (49) The study by Tonnard et al. (50) compared the results obtained by micro and nanoautologous fat grafts to the results of standard or macroautologous fat grafts:

- the microfat particles were taken from the abdomen using a cannula 1 mm in diameter.
- A quantity of the microfat particles were sheared into finer particles using 2 syringes and a connector. The nanoparticles were then filtered and collected.
- The macrofat particles were removed using a standard 3 mm cannula.

The study showed that micro and macrofat particles preserved normal cell architecture unlike nanofat particles which lacked adipocytes and whose architecture was disrupted. However, the nanofat grafts retained an abundant level of adipose stem cells, similar to macro and micro fat particles in terms of proliferation and differentiation. In several clinical cases, the use of nanofat grafts improved the quality of the skin six months after the operation.

Therefore, nanofat grafts may be clinically useful for skin rejuvenation due to its high content of stem cells. (50) (51)

Preparation of adipose tissue:

In order to promote retention of graft, ensure cell survival (adipocytes, preadipocytes and adipose stem cells) and reduce local complications, several methods of purifying adipose tissue have been proposed. Among which we note: washing, rolling on compress, filtration, sedimentation, and centrifugation. (3)

Regarding centrifugation, it seems that it alters the fat cells when done at high speed. When adipose tissue is removed by hydropressure-assisted liposuction, the viability of the tissue would be the same whether or not there was centrifugation (1200g for 3 minutes). However, the concentration of adipose stem cells and cells of the vascular stromal fraction is higher in the event of centrifugation, and resorption after transplant is less. (52) As for sedimentation, it is a gentle technique and does not appear to alter adipocytes (53); the same can be said of rolling the harvested adipose tissue in a compress, which is an equally effective and minimally traumatic technique (54). No technique seems to stand out significantly from the others, they are all operator-dependent and require experience (3), as has been pointed out in several meta-analyses:

The meta-analysis by Gupta et al. suggests that a technique combining gentle washing and centrifugation best respects the balance between cell survival and purity of adipose tissue (55).

- Condé-Green et al. compared in their study 3 techniques and concluded that washing and centrifugation ensures better retention at the recipient site compared to sedimentation. With regard to tissue viability, washing provides better viability while high speed centrifugation gives poorer viability. (56)

–In their review of the literature, Strong et al. concluded that there is no significant difference between different donor sites and their preparation, collection techniques, regardless of cannula size or centrifugation speed. However in humans, unlike in animal experiments, centrifugation seems to be superior to sedimentation. (31)

–Cucchiani and Corrales also compared the different techniques for separating adipose tissue and concluded that cell viability would be better with filtration then rolling on a compress and finally by centrifugation. (53)

–Herold et al compared Coleman's technique to Shippert's technique which consists in automatic liposuction with reduced negative pressure without centrifugation.

The Coleman technique allows better viability of the fat removed, but the Shippert technique seems twice as fast and simpler and still allows good viability. (57)

All in all, the results of all these studies are divergent and do not make it possible to draw recommendations or to retain a single good method of preparation. In our series, centrifugation was the method of choice for preparing fat tissue.

Reinjection of adipose tissue:

Although there are a large number of studies that focus on improving techniques for harvesting and preparing adipose tissue, fewer studies have looked at recipient sites and different injection techniques that may improve outcomes. (22) Adipose compartments have varying sensitivities to neuroendocrine impulses. This could be the explanation for the varying results obtained with adipose tissue transplantation depending on the recipient site. Thus, the best results obtained would come from recipient sites in which there is already adipose tissue which will serve as a recipient matrix for the new graft. (2) It is also important to determine the capacity of the recipient site in order to plan the optimal amount of fat graft to be harvested based on volume and mechanical compliance (22). Strong et al. recommend slow reinjection in a poorly mobile area for better graft retention (31). Studies of fat graft survival have shown that mobile areas of the face, such as the nasal glabella and lips, are less amenable to correction than less mobile areas, such as the lateral and malar areas. (38) In addition, multiple small volume injections are better than a single large volume injection (58), and the quality of vascularity also plays an important role in the success of autologous adipose tissue graft (38).

It also seems preferable to perform the transplant as soon as possible (less than 4 hours at room temperature) after the adipose tissue removal in order to avoid changes in the properties of the removed tissue. (37) (59).

With respect to the size of the injection cannula, several authors use cannulas of different sizes depending on the nature of the recipient site. Ozsoy et al. (41) observed greater viability of adipose tissue if infiltrated with cannulas

less than 2.5 mm in diameter. However, Erdim et al. (42) found no significant difference in cell viability with needles of different gauges. In addition, the small caliber cannulas appear to reduce trauma to the recipient site, thus limiting the risks of bleeding, hematoma formation and poor diffusion of oxygen to the graft. (38).

In addition, some studies support the positive effect of external pretreatments such as microneedling (60), external volumetric expansion (61) and fractional carbon dioxide laser (62) in improving vascularity and survival of the graft.

Adipose-derived stem cell transplants:

Stromal vascular fraction (SVF) is a complex resulting from washing, enzymatic digestion and centrifugation of fat collected by liposuction. The SVF extraction is carried out in several stages: washing with a saline phosphate buffer in order to eliminate the cellular debris, digestion with collagenases at 37 ° C to release this cellular mixture embedded in the extracellular matrix between the adipocytes, and centrifugation to separate SVF from digestion buffer and adipocytes (4). In 2006, Moseley et al. (63) reported fat grafts enriched with ASC or SVF in order to improve graft survival. The technique was then developed by Matsumoto et al. (64) and has been termed cell-assisted lipotransfer (CAL). Numerous preclinical studies in animals have since demonstrated improvements in graft volume with CAL (65), leading to the initiation of human trials. To date, two randomized controlled trials have been performed in humans. The Koh et al. study (66) evaluated microfat grafts enriched with ASC in 10 patients with progressive hemifacial atrophy or Parry-Romberg syndrome and found that volume retention improved significantly in the group receiving CAL (47% resorption in control subjects against 21% in CAL). Likewise, the Kolle et al. (67) study found improved retention in patients receiving fat grafts enriched with ASC. In total, these studies show that CAL significantly improves the survival of adipose grafts. However, studies of longer duration providing safety data are needed before the clinical adoption of this technique. The risk of malignant transformation or recurrence has not been demonstrated in existing clinical studies on fat grafting, but long-term studies remain limited, especially with regard to fat grafts enriched with human cells.

PRP-associated adipose tissue transplant

In our series, 42.62% of the lipostructures were combined with an injection of PRP. Several preclinical studies such as Liu et al. (74), Pires et al. (75), Nakamura et al (76), and clinical studies such as Cervelli et al. (77), Gentile et al. (68), and Keyhan et al. (78) suggest that the combination with PRP allows better survival of the adipose graft. These results are explained by the effect of PRP on increasing vascularity, increasing viable adipocytes, and decreasing necrotic areas and fibrous areas. On the other hand, some studies like Font de vila et al. (79) and Salgarello et al. (80) did not show any significant benefit from the combination of PRP. However, the absence of randomized, homogeneous and controlled studies, and the variable modalities of use of PRP which differ from one study to another do not allow this technique to be validated with certainty (22).

Indications and therapeutic results:

Skin scars:

Lipostructure is widely indicated in the treatment of skin scars. In our study, scars represented the main indication (61.9%). Adipose tissue plays not only the role of a volumetric filler in the treatment of cutaneous scars but also allows, by its regenerative capacities, to improve skin quality. It thus constitutes a good alternative to other surgical procedures. Mojallal et al. have shown that the use of adipose tissue as a graft stimulates collagen synthesis, thereby improving the thickness and consistency of the skin (82). The studies by Klinger et al. (83), Pallua et al. (84), and Jaspers et al. (85), showed a functional and aesthetic improvement of the scars treated by lipostructure, objectified by an improvement of the various parameters of the total POSAS score (the patient and observer scar assessment scale) on scar color, vascularization, consistency, thickness, regularity and relationship to surrounding skin. Besides the aesthetic aspect, a functional gain is also observed. Retractable bridges and adherent scars can severely limit limb function and become a source of physical and occupational disability. In association with or following local procedures, lipostructure improves the function of the affected limb (87) (88). Several systematic reviews, such as those by Fredman et al. (87), Riyat et al. (89), Condé-Green et al. (90), and Negenborn et al. (91), who focus on scars of different etiologies, evaluated the overall effectiveness of autologous adipose tissue graft in aesthetic and functional improvement of scars as well as in pain relief.

All these properties suggest that this technique may have, in addition to its mechanical filling effect, a favorable effect in the treatment of painful scars by promoting angiogenesis and reducing tissue inflammation. This may explain the difference in results between reinjection of autologous fat and older techniques (indentation, skin flaps, distal or nerve hood, venous graft, and neuroma resection). Neuropathic pain is a localized sensation of discomfort

and is difficult to treat with conventional analgesic techniques. It is characterized by pain like burns or electric shocks with clinical examination of hypoaesthesia or, on the contrary, allodynia. It is often associated with non-painful sensory signs (paraesthesia, numbness, pruritus). The results of the technique of injection of autologous fatty tissue in the treatment of painful scars and, in particular, of scar neuromas are very satisfactory. The injected fat creates a protective envelope surrounding the nerve, reducing its compression and recreating an environment favorable to local vascularization, thus reducing local pro-inflammatory factors. It therefore appears that this intervention becomes a very appropriate surgical option in the therapeutic arsenal for the treatment of painful scars due to its effectiveness and very low morbidity. (93) (92) (94).

The scars of burns constitute a special case. Bruno et al. reported in their immunohistochemical study that burn scars cannot be considered quiescent since they are characterized by maturation blockage and a strong pro-inflammatory response. (95)

In addition, Brongro et al. reported their experience in the treatment of burn scars with autologous adipose tissue graft and observed a good satisfaction rate in their patients and an improvement in the quality of the skin after 1 year of follow-up. Their histological evaluation also showed tissue and vascular regeneration and new collagen deposits. (96) The face of a burns patient is often deformed and is notable for its atrophied appearance, associated with heterogeneity of the skin coating. In the Viard et al. study on the place of lipostructure in the sequelae of facial burns, the aesthetic results showed an improvement in skin texture, thickness and flexibility so that the results were considered good in 86% of cases (97). Klinger et al. also noted an aesthetic gain in the after-effects of burning of the face, as well as an improvement in facial expression, skin texture, suppleness and elasticity, thus playing an important role in social reintegration and psychological state of the patients. (98) Besides its favorable effect on neuropathic pain which is quite frequent in patients with sequelae of burns, lipostructure also allows a good functional improvement. Indeed, Barani et al. found functional improvement in 65% of patients. (99) Few articles question the effect of lipostructure in the treatment of after-effects from burns. The Gal et al. study did not observe any improvement in scars treated with autologous adipose tissue graft compared to those treated by injection of physiological saline. This study was carried out in a pediatric population and the results were analyzed at 3 months after only one lipostructure session. The limited follow-up and the completion of only one session of treatment leave uncertainties around the analysis of the results. (100).

Radiodermatitis is also a special case. It is due to exposure to ionizing radiation. Skin lesions can be early or late. Autologous adipose tissue graft is particularly useful in the management of chronic radiation dermatitis, the pathophysiological mechanisms of which include cell depletion, destruction of cutaneous capillary vessels, self-sustaining inflammatory fibrosis and then non-inflammatory sclerosis. (101)(102). The series by Rigotti et al. (103), and the Plaquevent-Mastroieni study (102) found an improvement in chronic radiation dermatitis treated with autologous adipose tissue graft in a large part of their patients. Scarring is correlated with the number of sessions performed, allowing, in some cases, to avoid much more cumbersome surgical treatment or, when additional surgical treatment is required, it is performed under conditions of improved skin trophicity.

Lipodystrophy and atrophy of the face:

Facial contour modifications by atrophy can be caused by numerous etiologies such as lupus, scleroderma, Parry Romberg syndrome, and anti-HIV tritherapy. In all of these cases, any major functional or bone damage should first be addressed. For morphological correction, it is legitimate to start treatment with an adipocyte transplant, regardless of the degree of atrophy. If several adipocyte transplant sessions, three on average, have not yielded a satisfactory result, then it is appropriate to perform reconstruction using a muscle or fascio-adipose flap. In addition, the adipose tissue graft results in flexibility at the subcutaneous level, which facilitates dissection and detachment of the skin, often very difficult and dangerous in these cases. (2).

Scleroderma:

Scleroderma is an autoimmune disease characterized by microvascular abnormalities, and progressive fibrosis of the skin and organs (104). Magalon et al. 2015 (104), Sautereau et al. (105), Hunt et al. (106), Griffin et al. (107) have shown that microinjection of adipose tissue in the face and in particular periorally in patients with systemic sclerosis allowed functional and aesthetic improvement by enhancing the quality of the skin, and improving dryness of the mouth, mouth opening, as well as pain. Furthermore, Magalon et al. 2017 (108) found a good to very good satisfaction score with a rate of 75% of patients after a follow-up of 6 months and 1 year.

Lupus:

Lupus panniculitis is a rare cutaneous form of systemic lupus erythematosus, which mainly occurs in the face and which is more common in young women. It is characterized by a lymphocytic infiltrate of the adipose tissue, with fibrotic progression and scarring, which may lead to unsightly atrophies that persist indefinitely despite the remission of the dysimmune process. (109) (110). Polivka et al. reported two cases of sequelae of lupus panniculitis treated by grafting of autologous adipose tissue, and which gave very good aesthetic results persisting from 3 years to 4 years after surgery (109). Moreover, Huang et al. also reported a case of a patient treated with lipostructure of the gluteal region and who presented a good aesthetic result allowing a good reconstruction of the gluteal contour and a good volumetric restoration after a follow-up of 6 months. (111)

Parry Romberg syndrome:

Lipostructure also finds its indication in progressive hemifacial atrophy or Parry-Romberg syndrome, which is a rare, atrophying condition characterized by acquired, idiopathic, unilateral and progressive damage to the skin, subcutaneous, and sometimes bone structures of the face. A retrospective study was carried out in 2012 in our department by the team of Professor Benchamkha, concerning 12 cases followed-up for Parry Romberg syndrome (112). The results obtained after an average follow-up of 18 months demonstrated a satisfaction of 83% in these patients. In addition, a literature review was carried out by Rodby et al. (113) on 31 articles on the treatment of Parry Romberg syndrome by autologous adipose tissue transplantation. In a total of 147 patients, the results evaluated by the practitioners in 100 cases and the patients in 47 cases, concluded that among the practitioners, 50% of the therapeutic results were considered excellent, successful, and ensured good symmetry of the face, whereas 46% of the results were considered good, while only 3% were considered barely satisfactory and 1% unsatisfactory. While for the patients, the outcomes were judged satisfactory in 87% of cases, fairly satisfactory in 9% of cases, and only in 4% of cases were they rated unsatisfactory (113). In addition, several benefits have been reported over the other reconstructive techniques used. Lower costs were noted in 40% of cases, and shorter operating time in 50% of cases. A retrospective study carried out by Van der Cruyssen et al. (114) about the different surgical techniques used in the treatment of Parry Romberg syndrome through 10 years of practice concluded that lipostructure is a minimally invasive method, and allowed for good aesthetic results, was valid in the treatment of minimal to moderate forms, and had the advantage of usability in the active phase unlike other therapeutic methods thus providing a good psychosocial impact on the patient (113) (114). Moreover, Balaji et al. found that 90% of the patients included in their study were not satisfied with the aesthetic results until after 3 months of follow-up (115).

Malformations:

1. **Craniofacial malformations:** Any malformation modifying the facial contour may be subject to volumetric restoration by autologous adipose tissue graft. In our study, craniofacial malformations constituted 5% of the indications for lipostructure.
2. **Otomandibular syndrome:** The term otomandibular dysplasia covers all the malformations associating hypoplasia or agenesis of the ear associated with mandibular hypoplasia and the associated soft tissues. The skin is generally of good quality, but may present hypotrophic, dyschromic, well-defined areas, often related to damage to the underlying subcutaneous tissues. Hypoplasia can also affect the muscles or the parotid gland. Injection of autologous fatty tissue has been shown to be effective and leads to reliable and long-lasting results. It is suitable for low volume deficits or as a complement to another reconstructive method (local or microsurgical flaps). In severe forms, it can be offered during the growth of the child's face but will most often require several operative steps. (30) (125) (126) (127).
3. **Cleft lip:** Many techniques are used in the treatment of cleft lip to restore continuity of the lip to obtain a natural appearance. However, contour irregularities or scarring may persist. Autologous fat tissue transplantation can modulate scar formation and allow soft tissue growth. Zellner et al. compared patients who underwent primary cleft lip repair with and without immediate autologous adipose tissue graft. The postoperative photographs were analyzed by three examiners and revealed a statistically significant improvement in the appearance of scars and the contour of the repair of the grafted clefts. Immediate autologous adipose tissue graft may be a promising strategy to improve lip appearance, contour, and healing during primary cleft lip repair. It is a safe and effective way to improve symmetry and improve facial proportions in patients with cleft lip. (128) (129) (22)
4. **Thoraco-mammary malformations:** Two main types of malformations can be distinguished: volume anomalies, and form and symmetry anomalies. Pectus excavatum, or funnel thorax, is the most common congenital thoracic malformation. In 86% of cases, the deformity is visible from birth. It gradually increases with the growth of the subject. There are many different surgical techniques to correct this malformation; they

can be classified into two categories, modeling sternochondroplasties and filling techniques (exogenous or autologous material). Autologous adipose tissue graft is of great benefit, whether when used in isolation in minor or lateralized forms, or in addition to a thoracic prosthesis or a sternoplasty technique to correct residual defects. (30). Poland syndrome is the association of mammary hypoplasia with a chest malformation, the minimal expression of which is agenesis of the sternal head of the pectoralis major muscle. Adipose tissue transfer allows the treatment of malformations that are difficult to access with other techniques, especially the in anterior axillary region. The major forms with total agenesis call for breast reconstruction techniques after cancer, even if these interventions give imperfect results. Adipose tissue transplantation appears as a complementary treatment, but also as the only treatment in cases of agenesis. (130) (2) (131).

5. **Breast reconstruction:** Breast pathologies requiring volumetric restoration are hypotrophies, malformations, surgical sequelae of the treatment of breast pathology, and mainly breast reconstructions. (2) (132) (130). The thoraco-mammary autologous adipose tissue graft has completely changed the indications for breast reconstruction: it is a simple, reliable technique, widely used but not yet standardized with variations for each step of the procedure depending on the operators. It can be indicated for breast reconstruction exclusively, or after reconstruction by simple prosthesis, by latissimus dorsi flap and prosthesis, or by autologous flap, as well as in the aesthetic sequelae of conservative treatment with or without radiotherapy, thus making it possible to correct any residual deformation, the visibility of the edges of an implant but also the after-effects of radiotherapy. This technique makes it possible to improve the thoraco-mammary region but also to improve the volume, shape, projection, consistency and contours of the breast, and thus makes it possible to reproduce a natural appearance of the mammary region. (103) (130) (133) (134) (135) (136). In the study by Missana et al. the aesthetic outcome was considered good to very satisfactory in 86.5% of cases, and moderate in 13.5% of cases. This was explained by an insufficiency of the adipose tissue to be collected in these patients (134). In the study by Delay et al. about autologous adipose tissue graft in breast surgery, 83%, i.e. 734 cases, of the indications being for breast reconstruction, the results were considered good to very good in the majority of cases and no results were considered bad, with percentage variations depending on the indication. Thus, in the sequelae of breast-conserving treatment, 93% of the results evaluated after a 1-year follow-up by 2 plastic surgeons, using clinical examination and comparative photographs, were considered good to very good. In addition, patients were satisfied in 40% of cases and very satisfied in 50% of cases (137) (136). The low rate of complications, the secondary benefit provided by liposuction and the high rate of patient satisfaction regardless of the breast reconstruction technique make this technique a preferential choice in the therapeutic arsenal of breast reconstruction. (135) (61). One or two sessions of autologous adipose tissue graft are necessary to obtain the optimal result, depending on the local tissues and the volume of the contralateral breast. This number may increase in the case of exclusive breast lipomodelling. (1) (135) (61) (138). In our study, no patient was operated on for breast reconstruction.

Esthetic indications:

1. **Facial rejuvenation:** Autologous fat tissue transplant has an important role in facial rejuvenation due to its filling properties and the role of fat stem cells. Skin and subcutaneous tissue have been shown to change in thickness with age (139). Autologous adipose tissue graft corrects ptosis of the integuments which is linked to a loss of tone of the skin, fascia, ligaments and muscles, and tissue atrophy which affects all integumentary layers, which is at the origin of aging in each subunit of the face. Indeed, our face is perceived in three dimensions, that is to say in volume. This volume is reflected in an interplay of shadows and lights forming zones which thus constitute the aesthetic sub-units of the face. A cosmetic repair should involve the entire subunit, and one or two incisions are made allowing access to the different areas to be corrected. Fat atrophy varies according to the compartments, with a predominance in the deep malar region, revealing a flattening of the cheekbone. The mere fact of filling this compartment corrects the deformation. Eyebrow ptosis is the result of multiple tissue thinning and relaxation of the frontal muscle. Bitterness folds are the result of atrophy of the two paramental triangles. Maxillary retrusion, a consequence of centropacial aging, is at the origin of an accentuation of shadows in the perinasal region. Altogether, there are two types of aging faces: the full face, with excess skin fat but ptosis, and the hollow face which is the site of major atrophy and ptosis. (2) Traditional approaches to facial rejuvenation have used surgical techniques that focus on excising skin, muscle and/or fat unlike modern approaches that focus more on filling atrophied facial compartments. The initial stage of facial aging with isolated fat atrophy can be treated with adipocyte transplantation alone. The more advanced stage, with ptosis of the integuments, should benefit from a facelift associated with adipocyte grafting. (17) Unlike other liposuction indications, facial rejuvenation requires a small volume of adipose tissue injected to achieve the expected aesthetic results. It grafts better on the recipient site and thus allows for enhanced viability of the

graft. (21) (140) Dasiou-plakida et al. have shown in a study spanning 17 years and involving 1720 patients that autologous fat tissue transplantation is a safe method and provides good long-lasting aesthetic results (49). In a systematic review by Groen et al. (141) on the efficacy of autologous adipose tissue graft in facial rejuvenation, the satisfaction rate in a total of 630 patients included in 6 studies was 81%, and the results were considered good by surgeons in 89 % of cases. (142) (143) (144) (145) (146) (140). The eyelids are a special case; autologous adipose tissue has several aesthetic indications here. Mainly, in the correction of dark circles (147), facial rejuvenation, as an adjunct to blepharoplasty (148) and in the treatment of hollow eyelids and malar bags (149). In a systematic review by Boureaux et al. (150) involving 60 studies and including 1159 patients, of which 95% of the indications were aesthetic, the results of autologous adipose tissue graft on the eyelids were considered satisfactory in all the articles studied. Since the skin on the eyelids is usually thin, the peri-ocular region is most susceptible to contour irregularity problems, and therefore, deep fat implantation is recommended to ensure a good aesthetic result. (22)

2. **Hand rejuvenation:** The appearance of hands is a telltale sign of a person's true age. Studies have shown that people are able to roughly estimate a person's age from their hands (151) (152). The effects of aging on the hands include dermatoheliosis or photoaging, which results in wrinkles and irregular pigmentation of the skin in the form of lentigines, purpura, punctate hypopigmentation, actinic keratosis, seborrheic keratosis and telangiectasia. Aging also leads, through the effect of dehydration and the lack of collagen, to tissue atrophy and the formation of wrinkles on the dorsal face of the hands and to greater visibility of the extensor tendons and the sub-cutaneous veins which become bluer and tortuous. Due to its filling and tissue regeneration capabilities, autologous adipose tissue graft is a possible procedure in hand rejuvenation. (151) (153) (154)
3. **Rhinoplasty:** The current development of minimally invasive techniques in cosmetic surgery leads to the proposal of alternatives to surgical rhinoplasty. The injection of autologous adipose tissue into the nose is becoming a particularly interesting alternative in the management of the sequelae of rhinoplasty, especially in patients who refuse a new conventional surgery. The ideal indications for autologous adipose tissue graft are the filling of small missing reliefs such as the after-effects of lateral osteotomies or inverted V-shaped malformations, improving the quality of the skin of the nasal dorsum, particularly if it is thin and scarred, as well as increase in nasal skin tissue for secondary rhinoplasty. However, no improvement in respiratory function is obtained by this technique, which only allows correction of imperfections. (155) (156)
4. **Mammoplasty:** Autologous adipose tissue graft is a good therapeutic option to correct imperfections secondary to mammoplasty or implant treatment. In breast augmentation, the indications for autologous fat transfer differ from mammoplasties with implants. Autologous adipose tissue graft is suitably indicated for patients who desire mild to moderate breast augmentation. (136)

G / Contraindications and limits

Contraindications for adipose tissue grafting are rare. They mainly concern very thin patients who have little or no reserve of fatty tissue to collect. In clinical practice, the main problem after adipose tissue transplantation is the rate of resorption with an average volume reduction which can vary from 25 to 70% of the total volume injected. (22)

Complications

When extracting adipose tissue, complications seem minimal and related to the sampling technique used. The possible complications are: (3) (2) (102)

-Edema: this is the most common complication, and can persist for several weeks. It can be prevented or reduced by having the patient lean forward, and the use of ice packs or nonsteroidal anti-inflammatory drugs. (141)

- Bruises: they appear especially when the cannula is passed too superficial or if too much fat has been grafted compared to the elastic capacities of the local tissues. Application of creams or fatty substances to the recipient site helps prevent skin suffering. (141)

- Hematomas: rare

-Pain or paraesthesia

On the recipient site, autologous adipose tissue graft can be complicated by: (3) (2) (102)

-An infection

- A lesion of noble structures, which vary according to the recipient site. In the study by Delay et al. only one case of pneumothorax was noted. In the face, it may be parotiditis, infraorbital injection by perforation of the infraorbital septum, or lesion of branches of the artery, vein or facial nerve. (135)

- Migration: it occurs when a large quantity of fat is deposited in a zone under tension. This is why a correction in several sessions is desired when a large volume of fat is required.

Conclusion:-

Injection of autologous adipose tissue is currently part of our routine practice due to its simplicity, safety, and reproducibility.

The results obtained from lipostructure® in most studies, including our own, are consistent and give very satisfactory results. It is a safe and effective therapy that we recommend for the various indications mentioned above. Treatment with lipostructure® can therefore become one of the most reliable treatments if further evidence of efficacy is gathered and a concrete protocol is established.

However, although most of the reported results were positive, no definitive conclusions can be drawn due to the lack of consistency in intervention and follow-up in the different studies performed.

Our knowledge and use of the regenerative power of adipose tissue is still in its infancy and opens up great prospects for the future in the field of surgery in general, and for plastic and reconstructive surgery in particular.

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