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## article Title

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**THE PAST, PRESENT AND FUTURE OF FACIAL FAT GRAFTING**

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## Keywords

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## Key Points

* Autologous fat graft re-volumisation is a major adjunct to management of the ageing face. Fat graft can be in isolation but is usually combined with mini-facelift and harvested from neck, jowel or alternative sites including abdomen, arms and knees.
* The ageing face is created by a combination of loss of facial bone girth with reduced structural projection around the orbit, maxilla and malar, relative disuse hypotrophy of facial animation muscles, fat volume decrease and redistribution within the superficial and deep facial fat compartments.
* The ageing face is associated with dermal atrophy, reduced collagen, elastin and hyaluronic acid content with resultant loss of subcutaneous tissue tension and elasticity.
* Metaphorically, ageing has been likened to the change from a grape to that of a sultana, with dehydration and loss of structure, pigmentation and form.
* In facial rejuvenation, autologous fat graft can be injected into the superficial compartments using a fan distribution technique or into the deep fat sub-SMAS plane as a localized volume injection. Fat can be injected into muscle including frontalis.

## Synopsis

From the decades of circular and now apparent meaningless arguments about which skin tightening method gives the best and most lasting face rejuvenation, modern Surgeons now realize that re-volumisation is a necessary adjunct and not simply about pulling the SMAS and skin. Our understanding of the ways that all ageing tissues interact and our current perception of the ways that stem cells differentiate, mean that less aggressive surgery plus autologous fat grafting can give at least equal but usually better outcomes with far less risk or downtime. Despite this and without the genetic cure for ageing surely we are still simply “rebuking the sultana and not resurrecting the grape” with current technologies. The future has to be with genetic modification of the ageing cell. In the interim, provided patients having facial rejuvenation remain happy with low risk surgery and demonstrate good outcomes it is beholden upon Surgeons to ‘first do no harm’ and avoid litigation by keeping surgery simple.

**Introduction**

The original philosopher Confucius himself said “Real knowledge is to know the extent of one's ignorance". The concept of fat grafting is full of ignorance and misunderstanding.

* No-one really knows why fat graft survival is so unpredictable.
* No-one has identified a degenerating adipocyte being replaced by a stem cell in vivo in humans although in 2015 Debels et al in Australia came close (published in print in 2017) with an in vitro mouse model of an open wound healing under a gel cover to produce a layer of adipose tissue (1).
* Terminology is misleading - ‘fat stem cells’ are not the primordial stem cells seen in bone marrow, thymus or spleen. Fat stem cells are at least third generation differentiating cells which are more likely pleuripotential fibroblasts or mesenchymal cells coincidentally harvested from around vessels and nerves during suction harvest.
* The theory of nultiples (2) means that it is unlikely that the presumed inventor of fat grafting was actually the first to perform the procedure, although Gustav Neuber in 1883 has been credited as such. Non reproducible results, fat necrosis, oil cysts, infection and longer term poor outcomes were likely but rarely published outcomes because the concept was not universally accepted for decades.
* Bircoll in 1987 effectively stopped the use of fat injection for breast augmentation throughout the USA following a presentation to the US Plastic Surgeons about micro calcification after fat injecting into breast and a clinical conundrum with difficulty distinguishing from the calcification associated with DCIS. There were also concerns about carcinogenic potential from degradation products from lipoharvest and reinjection of fat. There was an immediate moratorium in the USA banning the use of fat graft in breast.
* Emmanuel Delay published 10 year results confirming the assumed risk of breast cancer after fat grafting were not proven and were alarmist fears (3,4).
* Thereafter Coleman started to publish outcomes from fat graft to face in 2001 (5,6).
* In the USA outstanding results from autologous fat grafts are seen in buttock augmentation by Tino Mendietta, with survival of large volume fat graft using simple tumescent fat suction and large cannula reinjection with no thought of centrifuging or layering, thus destroying many conceptual arguments (7).
* It is important to reflect on everything we ‘learn’ from meetings because amazing outcomes from novel techniques cannot usually be replicated. Sometimes the eminent speakers are presenting data that dangerously sensationalizes the topic and the technique doesn't always stand scrutiny (8). Do they always get great results? If one trawls the social media pages involving some ‘iconic’ Surgeons in the field of fat grafting the answer is a resounding no!
* The real answer is that there is clearly some truth of success and exceptional outcomes with fat grafting but results are dependent on meticulous technique in both harvest and cell preparation, together with patience, good fortune and a clear understanding of the environmental mileau that is essential for cell viability.
* Important questions to be asked include :-
  1. Is it better to use a low pressure aspiration mechanical system or simple aspiration syringe for harvest?
  2. Small cannulae or large bore cannulae to harvest fat?
  3. A tumescent or dry harvesting technique?
  4. Use adrenaline and or hyalase?
  5. Centrifuge or leave aspirate to stand and gravitationally separate?
  6. Include a platelet rich environment or wash the fat graft?
  7. Keep graft warm ischaemia time to a minimum by harvesting and injecting at the end of procedure or harvest graft before surgery and cool the graft?
  8. What is the importance of the fibrous stroma that is harvested with the lipoharvest?

I hope through this chapter and the other chapters within this book will answer at least some of these questions.

**Past**

* Fat was first recorded as being transferred to face in an attempt to improve an adherent post-osteomyelitis peri-orbital scar by Neuber, a German Surgeon in 1893, and then by Hollander to electively augment face and breast contour defects sixteen years later( 9). Fat was used extensively for reconstruction within the early developing years of Plastic Surgery as a specialty after the world wars but the fat was commonly transferred as composite dermofat grafts and after the 1980’s as vascularized dermofat and fascial flaps but it soon became recognised that donor site morbidity, fat necrosis and calcification could result in disfigurement at least equal to the original defects.
* Ilouz and Fournier, as pioneer French Plastic Surgeons, first introduced the concept of lipomodelling or liposculpting and started the liposuction revolution of the 1980’s (10, 11). I had the honour of allowing the use of my practicing privileges at the renowned Princess Grace Hospital in London to ‘oversee’ Pierre Fournier perform one of his famous autologous fat grafts to face in 1991. Remember this was before Sydney Coleman and all that has followed since. Fournier was operating on a Saudi Princess and he brought his own instruments that included what he declared were ‘vetinary hypodermic needles’, which were marginally less in caliber than the now conventional Coleman fat harvesting cannulae. The fat was beautifully and simply aspirated from the abdomen without any fuss into four 5ml syringes, centrifuged, separated and a quantity re -injected via small cutaneous needle puncture into the lips. Well, this was amazing and something that really wasn't within the armamentarium of any British Plastic Surgeon that I was aware of at the time. The lips looked extremely swollen and in my ignorance, quite worrying. I was astounded when he confided that the 2 unused syringes would be kept frozen by the patient and brought to him at the follow up clinic in about 3 months for reinjection to the lips in the event of partial graft loss!
* This now very much reminds me that this great pioneer of fat grafting was already aware of the survival characteristics of fat graft and the importance of the patient understanding the possible need for regrafting, and giving responsibility to the patient in the whole process.
* In the Coleman technique:-

1. Fat is harvested with adjunctive tumescence,
2. Fat is centrifuged
3. Oil layer is removed
4. Water and debris layer is removed
5. Coleman considers that the middle 50% of each 1 ml injecting syringe contains the most useful Adipose Derived Stem Cells (ADSC), the rest can be discarded.

* Of course as procedural popularity increases so too does the risk to patients. If Sydney Coleman can ask online for $20,000 as a surgical fee for a 1 hour operation then of course there will be unscrupulous involvement by others and inevitable patient disappointment and possibly disfigurement from which only the lawyers benefit.

**Understanding the superficial and deep fat spaces on the face**

* It is only thanks to Dr Bryon Mendelson and others over recent years that we can conceptually grasp the anatomical interrelationships between the superficial fat layer, the superficial musculoaponeurotic system (SMAS), and the deep fat compartments within the face. Mendelson in particular has also highlighted the importance of skeletal remodeling during the ageing process and suggests replacing skeletal foundation with hydroxyapatite during some facial rejuvenation (12, 13). This is of course the foundation upon which the soft tissues of the face sit, including ligaments enclosing fat compartments (Fig. 1).
* Whilst the ageing face demonstrates collagen and elastin deficiency, muscle wasting and bone resorption, there is also significant loss of fat in areas that naturally support these structures. Basically the face has a superficial laminar fatty layer directly behind skin but in front of the SMAS layer. Deep to the SMAS are vertical or obliquely running arteries, veins and nerves. The nerves and arteries shouldn’t really be traumatised by blunt needle insertion of fat or filler but blunt trauma to the facial vein in the buccal area must be avoided if possible. These structures lie in loose areola tissue alongside condensations of fascia, including the deep retaining ligaments in the frontozygomatic, zygomatic and mandibular areas. Unfortunately cadaveric studies do not show the natural interacting mobility between the units.
* My view on the fat pads is that if there is a facial hollow then there is no point expecting a significant and permanent improvement from facelift alone whether as a minilift or an aggressive lift. Facelift does not elevate or relocate the deep fat pads and these slide or ‘roll’ into a new and often only temporary position during facelift. SMAS elevation merely improves skin position and the superficial fat layer and the hollows can actually look worse in some individuals. Facelift in isolation therefore is not the answer in some cases of facial rejuvenation and a combination with fat graft is usually the treatment of choice (Figs. 2,3,4, Video 1).

**Methods of fat harvest**

* It is obvious that opinions on methods of fat graft harvest, preparation of graft and reinjection techniques vary. The face needs a fill volume of fat cells, an adipocyte lattice structure and stem cells.
* Most Surgeons have veered away from aggressive face-lifting techniques and instead are combining a less aggressive facelift technique with fat re-volumisation (Fig. 5).
* Fat is also ideal to fill temporal fossa hollows and bulk the ageing and creasing forehead and with care fat graft can benefit the periocular area, the nasolabial and nasojugal folds, lips and even earlobes (Fig. 6).
* Facial fat graft can be harvested locally from jowels or neck but if larger volumes are required then the lower abdomen is adequate in most circumstances. 30mls plus of fat can be easily aspirated using classical 2 mm cannulae and 10 ml syringes. The syringes are capped and left to stand in a cool environment for about 10 minutes.
* The contents of the syringe fractionate into a lower watery layer which can be easily tapped by removing the plunger and cap and observing the fat graft drop into the syringe. An absorbent gauze swab can further remove the water and concentrate the remaining graft.
* The supernatant fraction is oil from disrupted adipocytes and this can be poured out of the syringe or blotted out by capillary action using a ribbon gauze. Care must be taken to avoid the graft slipping out of the syringe as it is tipped though (Video 3).
* The remaining fat in the 10 ml syringe is then transferred to 1 ml syringes and left to stand. At time of transfer the middle 50% of graft within the syringe is believed to contain the all important ADSC’s.
* For large volume fat graft the best equipment for fat harvest is the Aquavage system. This works on a similar principle to underwater seal drains and the fat is harvested in a sterile no touch environment.

**Injecting technique (Videos 2, 3, 4).**

* Blunt cannulae must be use for injecting the processed fat. I personally use long cannulae inserted via blunt subcutaneous intranasal puncture to all areas of the face below the infraorbital rim. The principle for successful graft is to present healthy fat graft to healthy tissue. If the start point is low volume host tissue then there is a restriction of how much can be injected at that visit.
* Bolus fat graft should not be put into the superficial fat compartments and only with care into the deep face compartments.
* It is vital to reduce the oil content within the injected graft to prevent inflammation and irregularities in contour.
* Some argue that platelet rich fat graft improves survival by promoting re-vascularisation (14).
* Some argue that only the exact amount of fat graft to correct the contour defect should be injected on the first occasion and repeat fat graft is then inevitable to maintain the result, but that less volume will be required each episode as graft survival improves on each occasion. Others argue that if predicted graft loss is about 60% then that amount extra must be injected to cater for it.

Opinions vary and the science is not exact.

**The Future.**

* Understanding that fat graft has an unpredictable survival means that we need to be smarter with the use of this commodity. Superficially placed fat must be inserted in fan shaped, cross over, thin passages to avoid inflammatory ‘oilomas’, contour irregularity and lumps. Deep pocket fat graft should paradoxically be placed in individual compartments without aggressive movements of the cannula to avoid vein perforation and to concentrate on the primary compartment deficit. Small volumes only are required to give significant result and avoid lumpy deposits of fat necrosis remembering that adipocyte survival is to some extent, initially dependent upon nutrients delivered around the periphery of the fat graft and if the central core is too far away from nutrients it will die.
* Stem cell technology and nanotechnology delivery systems are already making significant contributions within the aesthetic sector but there is a huge potential for further advances in fat graft survival. For those with disfigurement and pathology genetic manipulation of allogeneic material already holds huge possibilities that could also potentially benefit the cosmetic patient.
* Composite grafting with autologous fat graft and hyaluronic acid is already commonly utilized. The two can be injected alongside each other as a primary procedure or more commonly only the hyaluronic acid is injected at between three and six months after cosmetic rejuvenation in relatively small volumes to maintain the results of the primary procedure. Adjunct injection of hyaluronic acid avoids secondary fat grafting and provided the patient is fully informed of costs, this is the preferred option in most cases.
* The ultimate solution is obviously to reverse the ageing process but this Holy Grail is not going to happen in our lifetime.

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