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Evaluation of The Viability and Phenotipe of Adipose Derived Cells Harvested Using Different Harvesting and Processing Procedures: A Pilot Study

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Abstract

Background: Clinical studies demonstrated the efficacy of therapies based on the autologous grafting of adult mesenchymal stem cells to accelerate the healing and regenerative processes of the skin and mesenchymal tissues; therefore, that is considered a valuable approach in the aesthetic rejuvenation treatment to give volum restoration and skin regeneration effects.

Objective: The aim of the project consists on the evaluation of the cell viability of adiposetissue (AT) harvested using the Superficial Enhanced Fluid Fat Injection (SEFFI) procedure standardized by the Authors (AG, FPB) the harvesting procedure was performed using two different cannulas having 0.8 mm and 1 mm side-port holes respectively and cells phenotype and ability to adhere to plastic surface have been analysed. The results have been compared to those recorded in adipose tissue harvested with a liposuction system and processed with enzymatic digestion (collagenase).

Method: This study was performed on adipose tissues harvested from 7 patients (6 females and 1 male) with an average age of 48.5 years with two different techniques and 3 different cannulas. We compared the cell vitality of every sample at T0 and T72. Moreover, the samples and control were analysed to determine the phenotype. Cells were incubated with antibodies anti-human against CD90-FITC, CD73-PeCy7, CD44-PE, CD31-PECy5, CD235a- PECy7, CD34-FITC, CD45-FITC and CD146-FITC and read using the flow cytometer s3e Cell Sorter, BioRad. Results were analysed using the software Flow Jo.

Result: Lipoaspirate tissue-derived by 0.8- and 1 mm cannula from all samples proved to be vital and to possess viable cells; the average absorbance was similar immediately after plating (T0) and 72 hours after (T72) for the two cannulas, 0.8- and 1 mm cannula. The two systems proved to equally harvest vital tissue and were comparable to the cell harvested with liposuction system (harvesting cannula 3mm, 2 ovals: width 2.5mm height 5mm side portholes), and isolated from the stromal vascular fraction (SVF) by enzymatic digestion, which is the gold standard procedure to obtain adipose tissue derived cells An increase in cell viability was observed in all samples for each condition after 72 hours (T72) (0.8-, 1 mm and enzymatic digestion). Cells from all samples were able to adhere to plastic surface and could be expanded to obtain the right number of cells for the staining.

Morphologically, cells harvested by different cannula or isolated by enzymatic digestion showed differences in their morphology; they appeared as fibroblast proving their mesenchymal phenotype. The adipose derived MSCs proved their heterogeneity among individuals because differences in surface antigens were noted between 0.8 mm- and 1 mm derived cells from different donors.

Conclusion: This study proved the vitality of adipose tissue harvested using the guided SEFFI procedure using both 0.8 and 1mm side port holes' cannula. Tissue was vital in both cannulas and the values were comparable to the isolation of stromal vascular fraction (SVF) by enzymatic digestion, the gold standard procedure for adipose tissue derived cells.

Cells to be defined mesenchymal stem cells, need to adhere to plastic surface and express specific surface antigens, especially CD44, CD90 and CD73. Cell viability was confirmed by the ability of plastic adhesion. Cells derived from each individual were able to attach and proliferate for at least three passages in culture and show the typical fibroblastic morphology.

Keywords: Adipose-Derived Stem Cells, Autologous Fat Transfer, Stromal-Vascular Fraction, Clinical Regeneration Applications, Adipose Tissue Cell Viability, Adipose Tissue Manipulation, Adipose Tissue Processing, Adipose Tissue Harvesting

Introduction

Regenerative therapy based on the injection of micro fragmented adipose tissue is a promising treatment for degenerative diseases or disorders that cannot yet be successfully managed through conventional care; moreover, it is also a promising treatment in antiaging therapy [1].

It exploits the properties of the cells of Stromal Vascular Fraction (SVF) naturally present in the adipose tissue: the most used cells in current cell-based approaches are the Mesenchymal Stem Cells (MSCs) which are multipotent stem cells present in almost every organ and tissue.

Adipose tissue is a promising source of MSCs similar to the one from bone marrow as described by Zuk et al. in 2001 [2-5].

Adipose Derived Stem Cells (ADSCs) share similar characteristics with bone marrow mesenchymal cells; still, they have some advantages, including their easy availability and harvesting through a less invasive surgical procedure [6].

They can be isolated through enzymatical digestion from the SVF, which contains a large number of cells composed of interrelated cell populations: adipocyte progenitors, pericytes, endothelial progenitor cells, and transit-amplifying cells [7]. ADSCs have been shown to possess differentiation potential towards different lineages like osteogenic, chondrogenic, myogenic, hepatogenic and endothelial cells - both in vitro and in vivo [8,9]. Moreover, like all MSCs, they exhibit antifibrotic and immunomodulatory characteristics and they stimulate angiogenesis and revascularization of fat grafts [10,11].

Thanks to these characteristics, adipose tissue implantation has been used to improve skin trophism, accelerate the closure of complex wounds or ulcers, and enhancement of skin appearance after damage from radiotherapy [12, 13]. Recently M. Mantovani et al. proved the injection of micro fragmented adipose tissue as a promising therapy in Genitourinary Syndrome of Menopuase GSM syndrome in gynaecology [14]. Therefore, the micro fragmented adipose tissue graft, naturally rich in cells from SVF and ADSCs, is considered a valuable approach in the aesthetic rejuvenation treatment to give volumization and skin regeneration effects [15].

To obtain efficient engraftment and regenerative effect, superficial (subdermal plane) injection of smaller adipose tissue clusters is suggested [16,17].

Once harvested the cells, two types of technique are available nowadays to isolate SVF: enzymatic and mechanical. The enzymatic method is particularly indicated in SVF isolation since it disrupts the Extra-Cellular Matrix (ECM) and the binding of adipocytes and other cells but is restricted by regulatory issues related to enzymatic procedures, especially within the European Community. Alternative mechanical methods were proposed and proved to be capable to provide cell viability without adipose tissue manipulation [18,19-21].

In SEFFI (Superficial Enhanced Fluid Fat Injection) techniques, we proved that it is possible to obtain a good potential regenerative tissue with a good amount of viable cells with mechanical procedure moreover without any substantial manipulation; using micro-cannulas with very small side port holes (0.8 mm and 1 mm), we selected the clusters dimension during the guided harvesting procedure hence we did not need any substantial manipulation in order to thin the tissue [19,20,21].

In the light of available evidence, we have tested cell viability and phenotype of adipose tissue (AT) harvested using the three types of cannulas and mimimal manipulation (cases) and compared it with the recorded result from enzymatic digestion (control).

Materials and Methods

In October 2021, we harvested adipose tissue from 7 consecutive patients (6 females and 1 male) with an average age of 48.5 years; the procedures were performed in the AA's medical facilities.

This observational study was conducted under the Declaration of Helsinki's guidelines. Before entering the study, all patients received detailed information regarding the procedure, purpose, and investigation's objective and provided written consent for participation and publication of data obtained. Inclusion and exclusion criteria are the following:

Inclusion Criteria

Body Mass Index >25 kg/m^2 < 30 kg/m^2 Age <65 years old

Exclusion Criteria

Diabetes mellitus type I and II Cardiovascular or neurologic disorders Patients in chronic drug therapy Smoke Previous abdominal surgery (laparotomy)

The procedures were performed under local anaesthesia using the following cannulas (Figure1)

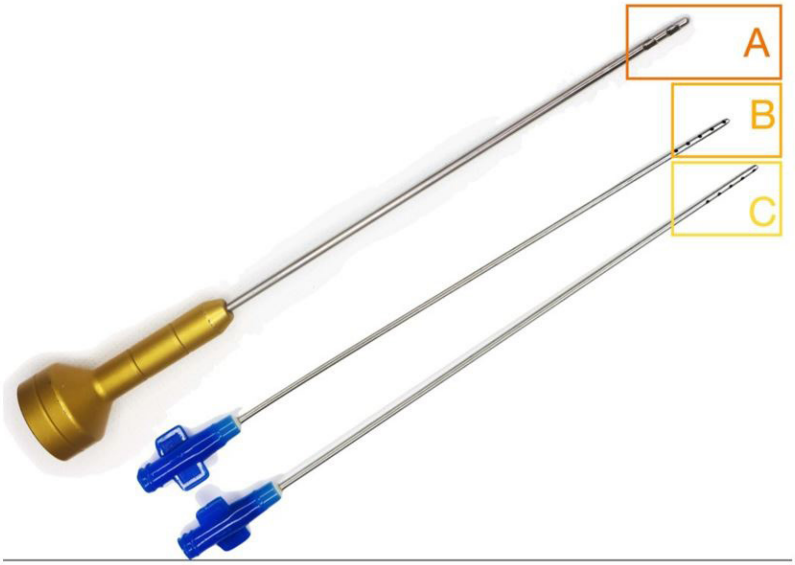


Figure 1: A: Cannula 3mm, 2 oval side port holes B: Cannula 2mm, 15 round side port holes, 1 mm diameter C: Cannula 2mm, 15 round side port holes, 0.8 mm diameter

Cannula 3mm, 2 ovals (width 2.5mm height 5mm) side port holes, (liposuction cannula), Coleman cannula
Cannula 2mm, 15 round side port holes, 1 mm diameter
Cannula 2mm, 15 round side port holes, 0.8 mm diameter

The guided harvesting procedures with a cannula C and B with side port holes 0.8 mm and 1mm were performed respectively with the medical devices SEFFILLER and SEFFICARE (Seffiline Srl, Via delle Lame 98 Bologna Italy) and the procedure was performed according to their instructions for use.

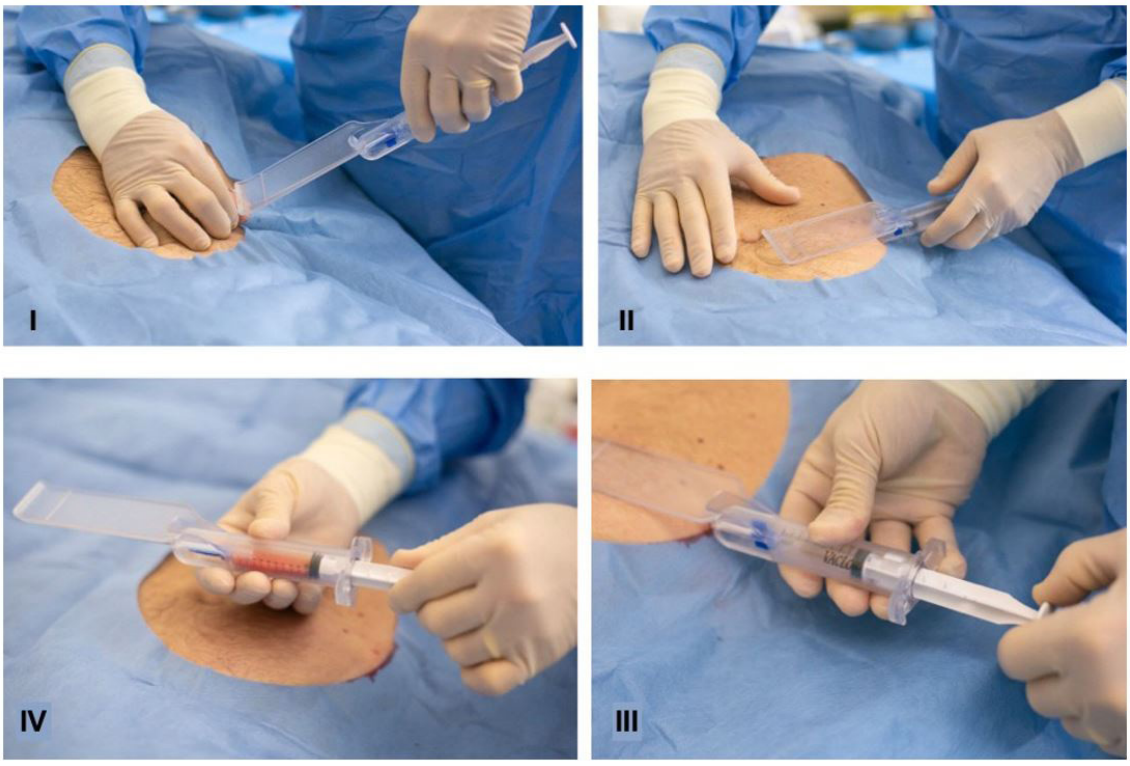


Figure 2: The harvesting procedures with cannulas with side port holes 0.8 mm and 1 mm are performed with local anaesthesia. The guided procedure: I) penetration of the tip of the cannula until the stop of the guide. II) Rotation and insertion of the cannula in the subcutaneous tissue

During the procedure, the blade of the guide touches the skin. III) The harvesting syringe with plunger lock IV) The fluid harvested tissue inside the syringe. The procedure is according to their instructions for use.

The guide included in these devices is addressed to standardize the procedure and guarantee that the harvesting of tissue is performed in the subcutaneous plane adjacent to the dermis; studies proved that the superficial adipose tissue (AST) is richer in cells of the stromal vascular fraction (SVF) comparing with deep adipose tissue (DAT) [22, 23].

The tissue harvested with liposuction technique is performed with cannula 3mm diameter; it was administrated with Klein's tumescent solution and proceeded with aspiration after the infiltration. The harvesting procedure with liposuction cannula is performed with a standard no guided liposuction.

The tissue harvested with the first two cannulas was processed without any enzymatic digestion; the tissue harvested with standard liposuction cannula was processed with a standard procedure consisting of enzymatic digestion (collagenase). The results of cell viability and phenotype of the cells harvested by the SEFFI methos are presented along with their comparison with the ones recorded after enzymatic digestion as a control.

Cell viability

We analysed seven samples: Adipose tissue using a 0.8- and 1-mm cannula were monitored for their cell viability using Presto Blue assay (Thermo Fisher scientific). 100 µl of cell suspension were plated in a 96 well plate and 10 µl of Presto blue was added to each well. For every individual and two type of cannula, triplicate was run. The cell viability alterations were analysed via absorbance spectroscopy and we reported the absorbance 570 nm after 10 min incubation (T0) at 37°C through multi-mode microplate readers (VICTOR Multilabel plate reader, PerkinElemer). Cell viability was evaluated at T0 and T (72h) and graphed. Adipose tissue harvested using Coleman cannula was processed by enzymatic treatment as quality control of tissue. The lipoaspirates were digested at 37°C in DMEM with 0.25% weight per volume percent (w/v) collagenase type I (Sigma-Aldrich) and 1% fetal bovine serum (FBS) for 180 min at 37°C. Following digestion, we filtered the resulting suspension through a sterile 100 µm nylon mesh to remove undigested parts and centrifuged the remaining suspension at 1200 g for 10 min, to extract a high-density pellet, composed of the stromal vascular fraction (SVF). The SVF thus obtained was re-suspended in 1 ml DMEM-low glucose supplemented with 10% FBS and 1%penicillin-streptomycin (all Gibco, Thermo Fisher Scientific) and cells were counted by Crystal violet to exclude a-nucleated cells. Cells were then plated at a density of 10,000 cells/cm2 in a 96 well plate in growth medium with the addition of 10% of Presto blue and stored in a humidified incubator at 37°C with 5% CO2. Cell viability was assessed after 10 minutes (t0) and after 72 hours (t72h).

Phenotypic analysis

Five samples were analysed to determine the phenotype of adipose derived cells. Adipose tissue was processed as follow:
The oily part of lipoaspirate tissue from 0.8- and 1 mm derived AT was aspirated and discarded. Then mechanically digested tissue was resuspended and plated in culture tissue flask at a density of 0.5 ml tissue/10 cm^2 in expansion medium consisted of DMEM low glucose, 10% FBS and 1% penicillin and streptomycin (all Gibco, Thermo Fisher Scientific);

Adipose tissue harvested using Coleman cannula was processed by enzymatic treatment as quality control of tissue. After digestion, the SVF obtained was re-suspended in 1 ml of expansion medium and cells were counted by Crystal violet to exclude a-nucleated cells. Cells were then plated in tissue culture dish at a density of 5000 cells/cm^2.

For both conditions, directly plated and enzymatic digested, once cells attached to plate, fresh medium was replaced. When cells reached confluence, cells were expanded at cell density of 5,000 cells/cm2 and, medium was replaced. Cells were expanded until they reached at least one million before staining.

Cells were incubated with antibodies anti human against CD90-FITC, CD73-PeCy7, CD44-PE, CD31-PECy5, CD235a- PECy7, CD34-FITC, CD45-FITC and CD146-FITC and read using the flow cytometer s3e Cell Sorter, BioRad. Results were analysed using the software Flow Jo.

Results

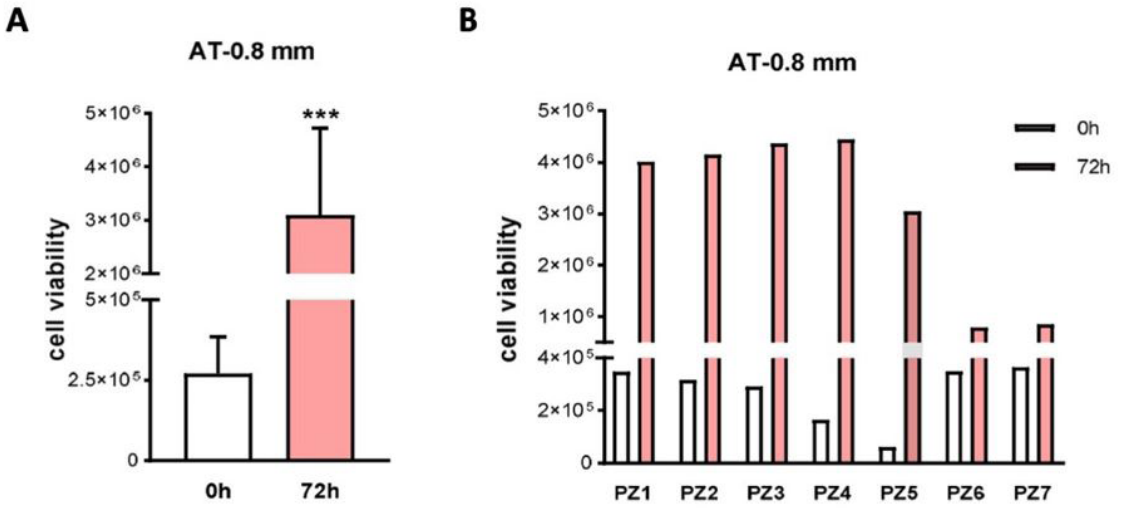
Cell Viability

Lipoaspirate tissue derived from all samples (0.8-, 1 mm and enzymatic digestion) proved to be vital and to present with viable cells.

Average of the absorbance was similar immediately after plating (t0) and 72 hours after (t72) for the two cannulas, 0.8- and 1 mm cannula. The tissue harvested with the two systems proved to present with the same vitality rate.

An increase of cell viability was observed in all samples, for each condition (0.8-, 1 mm and enzymatic digestion). The increase of absorbance signal is related to an increase in metabolic activity of cells, meaning that the adipose tissue and released cells (mesenchymal, pericytes and cell from the immuno system) are vital and proliferate during the 72 hours of incubation.

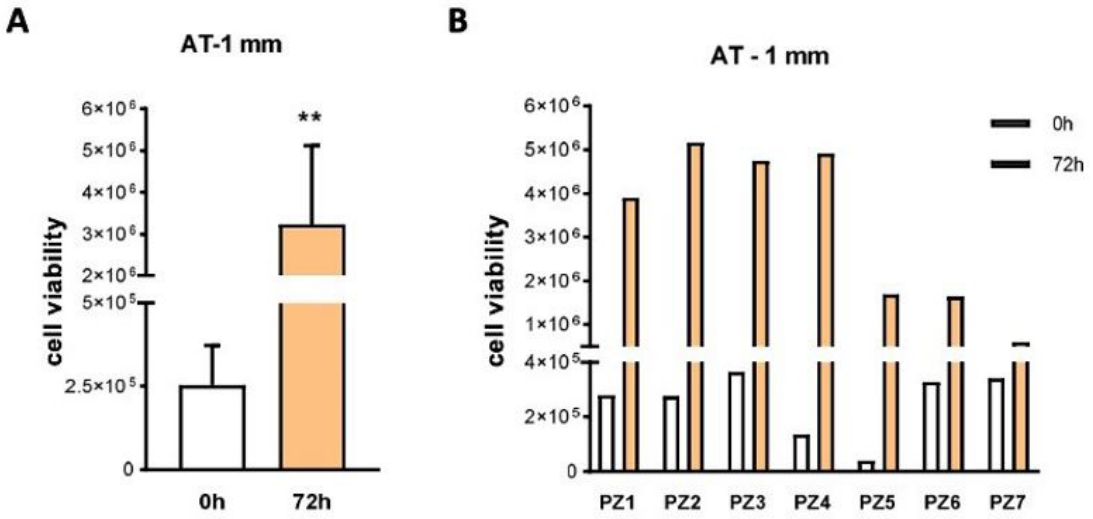
The Cell viability of adipose tissue immediately after plating (T0) harvested using cannula of 0.8 mm side port holes resulted statistically more vital, meaning that released cells from harvesting procedure and cells entrapped in the extracellular matrix are vital and metabolically active (t-test student, *** $p<0.001$). Single value of each individual (from patient 1, PZ1, to patient 7, PZ7). PZ6 and PZ7 showed a lower level of cell viability after 72 hours compared to the other 5 individuals (Figure 3).



(A) Average of absorbance value are represented as an average for time point 0 (0h) and after 72 hours of incubation (72h). After 72 hours, AT resulted statistically more vital, meaning that released cells from harvesting procedure and cells entrapped in the extracellular matrix are vital and metabolically active (t-test student, *** $p<0.001$). (B) Single value of each individual (from patient 1, PZ1, to patient 7, PZ7). PZ6 and PZ7 showed a lower level of cell viability after 72 hours compared to the other 5 individuals.

Figure 3: Cell viability of adipose tissue harvested using cannula of 0.8 mm side port holes

The Cell viability of adipose tissue harvested using cannula of 1 mm side port holes after 72 hours, resulted statistically more vital, meaning that released cells from harvesting procedure and cells entrapped in the extracellular matrix are vital and metabolically active (t-test student, ** $p<0.01$). Single value of each individual (from patient 1, PZ1, to patient 7, PZ7). PZ5, PZ6 and PZ7 showed a lower level of cell viability after 72 hours compared to the other 4 individuals (figure 4)

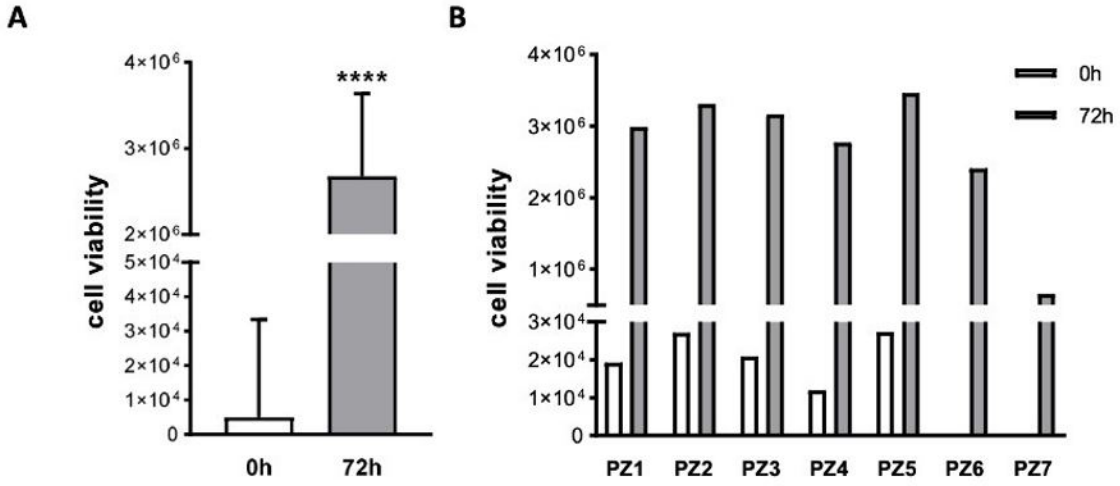


(A)Average of absorbance value are represented as an average for time point 0 (0h) and after 72 hours of incubation (72h). After 72 hours, AT resulted statistically more vital, meaning that released cells from harvesting procedure and cells entrapped in the extracellular matrix are vital and metabolically active (t-test student, ** p<0.01). (B) Single value of each individual (from patient 1, PZ1, to patient 7, PZ7). PZ5, PZ6 and PZ7 showed a lower level of cell viability after 72 hours compared to the other 4 individuals.

Figure 4: Cell viability of adipose tissue harvested using cannula of 1 mm side port holes.

The Cell viability of adipose tissue harvested using liposuction cannula and enzymatically digested (SVF), after 72 hours, absorbance of SVF cells resulted statistically more metabolically active and proliferative compared to time 0 (t-test student, **** p<0.0001).

(B) Single value of each individual (from patient 1, PZ1, to patient 7, PZ7). Only PZ7 resulted to express lower level of cell viability after 72 hours compared to the other 4 individuals (figure 5)



(A) Average of absorbance value are represented as an average for time point 0 (0h) and after 72 hours of incubation (72h). After 72 hours, absorbance of SVF cells resulted statistically more metabolically active and proliferative compared to time 0 (t-test student, **** p<0.0001). (B) Single value of each individual (from patient 1, PZ1, to patient 7, PZ7). Only PZ7 resulted to express lower level of cell viability after 72 hours compared to the other 4 individuals

Figure 5: Cell viability of stromal vascular fraction cells (SVF). SVF was derived by enzymatic treatment of adipose tissue harvested using a Coleman cannula and 10,000 cells/cm2 were plated in a 96 well plate for analysis

Absorbance at time 0 is higher in tissue compared to isolated SVF. However, absorbance after 72 hours is similar between the two cannula and enzymatic digestion method. Statistics were run compared to the time 0 of each group (test) (figure 6)

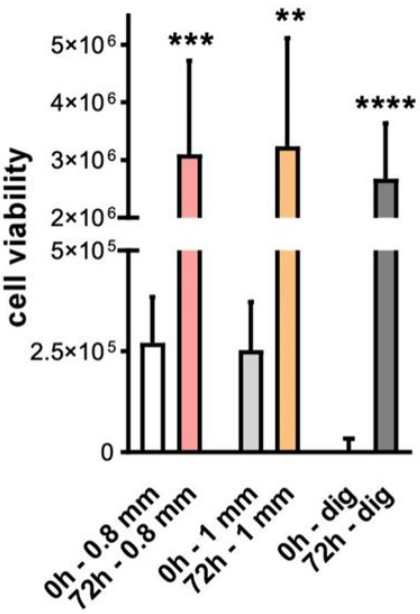


Figure 6: Cell viability of AT and SVF from 7 individuals for time point 0 (0h) and after 72 hours of incubation (72h); AT harvested with the three different cannulas

Mesenchymal Properties

Cells from all samples were able to adhere to plastic surface and could be expanded to obtain the right number of cells for the staining.

Morphologically, cells harvested by different cannula or isolated by enzymatic digestion showed differences in their morphology. They appeared as fibroblast proving their mesenchymal phenotype. Moreover, the adipose derived MSCs proved their heterogeneity among individuals because differences were noted between 0.8 mm- and 1 mm derived cells form different donors (figure 7)

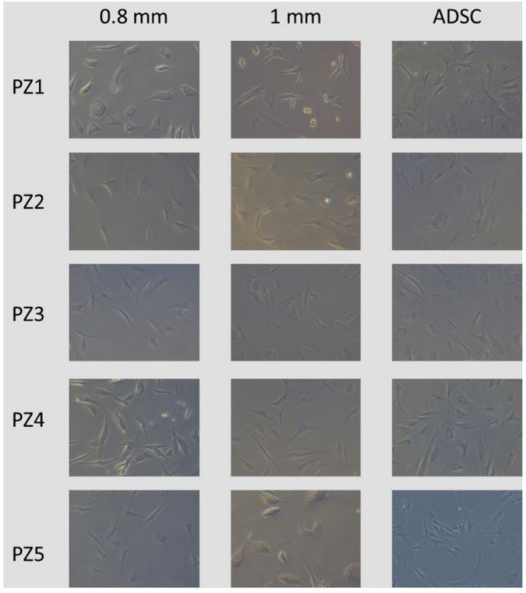


Figure 7: Morphology of adipose tissue derived cells harvested using 0.8- and 1 mm cannula and by enzymatic digestion (ADSC) for each individual (PZ1 – PZ5). Images were capture using a Leica light microscope and a 10X magnification

Flow cytometry analysis proved that cells are mesenchymal cells as they resulted positive for mesenchymal markers CD90 and CD44, poorly positive for CD73 and negative for CD146 and for the endothelial markers CD31 and hematopoietic markers CD34 and CD45.

CD44 was highly expressed, around 100%, in all samples from the two cannulas and in enzymatically digested tissue (ADSC). CD73 was poorly expressed and interestingly, there was the difference of CD90 expression in cells derived by the three methods: enzymatically digested cells (ADSCs) were strongly positive followed by the 1 mm derived cells and the 0.8 mm derived cells showing the lower expression of CD90. Difference between the three groups was significantly different (Two-way ANOVA). The negativity for the other markers means the absence of hematopoietic and endothelial progenitors' cells in the cell culture. (figure 8)

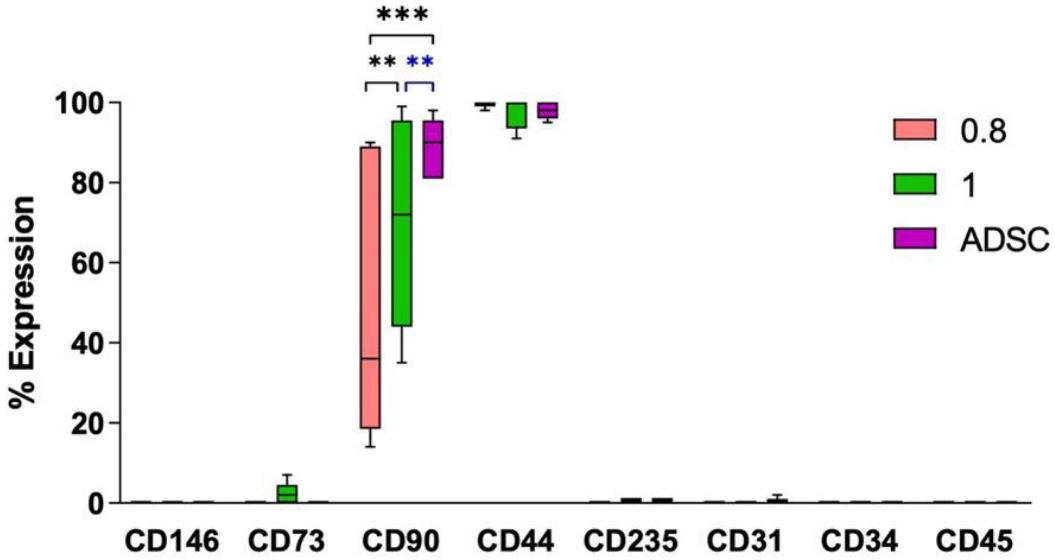


Figure 8: Phenotype of cells derived by adipose tissue harvested using 0.8- and 1 mm cannula and by enzymatic digestion. Two-way ANOVA statistical analysis was performed (** p<0.01; *** p<0.001)

This result showed a great variety between donors and how this is depending on harvesting procedure and culture methods. The following graphs showed the diversity of expression for each individual. This is in agreement with the knowledge of cells variability between individual, age, sex and anatomical locations (figure 9).

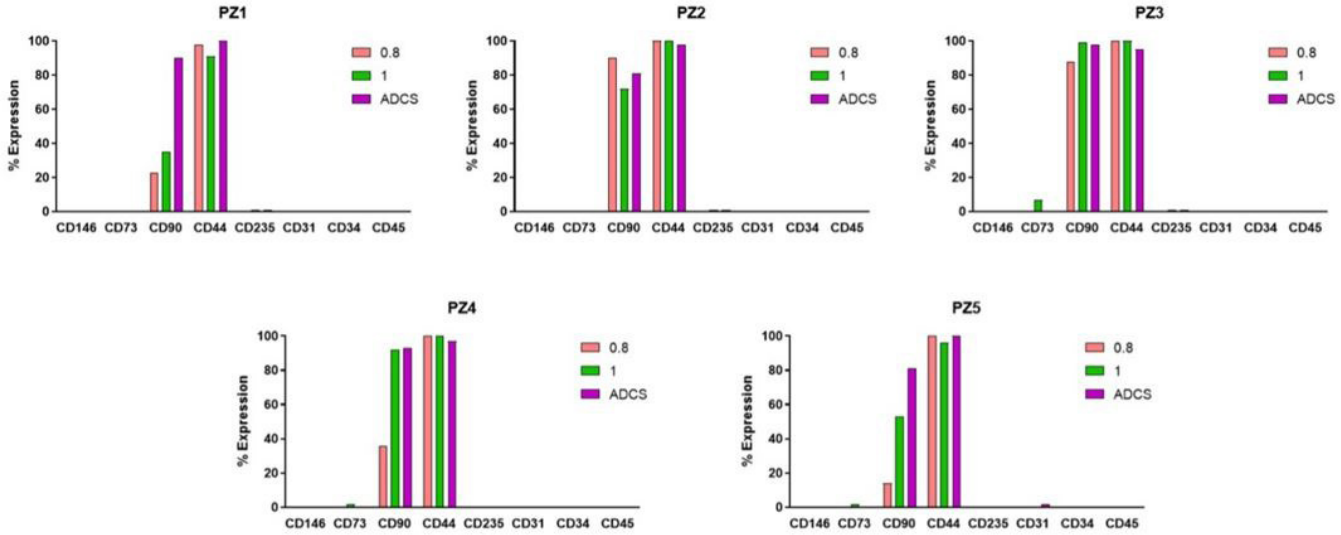


Figure 9: Expression of markers by flow cytometry for each individual

Discussion

The results proved the vitality of adipose tissue harvested using the 0.8 and 1 mm side port holes' cannulas, as the harvested cells showed to be vital and the values were comparable to the cell isolated from the stromal vascular fraction (SVF) by enzymatic digestion, which is the gold standard procedure to obtain adipose tissue derived cells.

In order to be defined mesenchymal stem cells, they need to adhere to plastic surface and to express specific surface antigens,especially CD44, CD90 and CD73 [24].

Cell viability was confirmed by the ability of plastic adhesion. Cells derived from each individual were able to attach and proliferate for at least three passages in culture and show the typical fibroblastic morphology. The differences in morphology and markers expression among cannulas agree with the selection of different size clusters and release of cells entrapped in the tissue based on cannula's port-holes size. Moreover, inter-individuality is a variable that need to be taken in account. SVF is a very heterogenous population, and it contains MSCs, fibroblasts, endothelial cells, pericytes, adipocytes and cells from the immune system [25].

Therefore, in the attachment, differences can be seen. Differences were seen also on the surface markers expression.
Cells were all positive for the CD44 which binds several ligands including hyaluronic acid, osteopontin, chondroitin, collagen, and fibronectin. CD44 is involved in cell proliferation, adhesion, migration, haematopoiesis, and lymphocyte activation.

CD90 expression was lower in two individuals. It was shown that CD90 marks a rare adventitial population and human adventitial $CD90^{+}$ cells fulfilled standard MSC criteria, including plastic adherence, spindle morphology, passage ability, colony formation, and differentiation into adipocytes, osteoblasts, and chondrocytes [26]. The other mesenchymal marker tested, CD73, a glycoprotein that acts as an enzyme involved in signal transduction and modulate a variety of biological effects [27]. CD73 also has non-hydrolase function, which is also a signal and adhesion molecule that regulates cell- extracellular matrix interaction [28].

However, therole of CD73 in regeneration therapy of MSCs is rather limited. It was shown how the morphological subset of flat cells lacked CD73 [29] and its expression can be significant different in MSCs from different sources [30].

Conclusion

The presented data shows that adipose tissue harvested with small diameter cannulas with small diameter side port holes is vital and viable cells can be derived from it. These cells are an heterogenous population and they show mesenchymal stem cells properties. This study proved the quality in terms of vitality and stemness of the Superficial Adipose Tissue (SAT) guided- harvested with small cannulas (2mm diameter) and small side port holes (0.8 and 1mm) without any substantial manipulation comparing with the SAT and Deep Adipose Tissue (DAT) harvested with liposuction cannula and enzymatically processed; the evidences of this study is promising for minimally invasive guided regenerative procedures with minimally manipulation of the adipose tissue.

References

1. Ceccarelli S, Pontecorvi P, Anastasiado1 E, Napoli C (2020) Cinzia Marchese Immunomodulatory Effect of Adipose-Derived Stem Cells: The Cutting Edge of Clinical Application Frontiers in Cell and Developmental Biology.

2. Zuk PA, Zhu M, Mizuno H, Huang J, Futrell JW, et al. (2001) Multilineage cells from human adipose tissue: implications for cell-based therapies. Tissue Eng. 7: 211-28.

3. Zuk PA, Zhu M, Ashjian P, De Ugarte DA, Huang JI, et al. (2002) Human adipose tissue is a source of multipotent stem cells. Mol Biol Cell. 13: 4279-5.

4. Zuk PA (2010) The adipose-derived stem cell: looking back and looking ahead. Mol Biol 359 Cell 21: 1783-1787.

5. Crisan M, Yap S, Casteilla L, Chen CW, Corselli M et al. (2008) A perivascular origin for mesenchymal stem cells in multiple human organs. Cell Stem Cell 3: 301-313.

6. Nguyen A, Guo J, Banyard DA, et al. (2016) Stromal vascular fraction: a regenerative reality? Part 1: current concepts and review of the lit- erature. J Plast Reconstr Aesthetic Surg. 69:170-9.

7. Tallone T, Realini C, Bohmler A, Kornfeld C, Vassalli G, et al. (2011) Adult humanadipose tissue contains several types of multipotent cells. J Cardiovasc Transl Res. 4: 200-10.

8. Huang JI, Beanes SR, Zhu M, Lorenz HP, Hedrick MH, et al. (2002) Rat extramedullary adipose tissue as a source of osteochondrogenic progenitor cells. Plast Reconstr Surg. 109: 1033-41.

9. Fraser JK, Schreiber R, Strem B, Zhu M, Alfonso Z, et al. (2006) Plasticity of human adipose stem cells toward endothelial cells and cardiomyocytes. Nat Clin Pract Cardiovasc Med. 3: S33-S7.

10. Blaber SP, Webster RA, Hill CJ, Breen EJ, Kuah D, et al. (2012) Analysis of in vitro secretion profiles from adipose-derived cell populations. J Transl Med. 10: 172.

11. Guo J, Dardik A, Fang K, Huang R, Yongquan G (2017) Meta-analysis on the treatment of diabetic foot ulcers with autologous stem cells Stem Cell Research & Therapy. 8:228.

12. Del Papa N, Di Luca G, Sambataro D, Zaccara E, Maglione W, et al. (2015) Regional implantation of autologous adipose tissue- derived cells induces a prompt healing of long-lasting indolent digital ulcers in patients with systemic sclerosis. Cell Transplant. 24: 2297-05.

13. Rigotti, Gino MD, Marchi, Alessandra MD, Galiè, et al. (2007) Clinical reatment of radiotherapy tissue damage by lipoaspirate transplant: a healing process mediated by adipose-derived adult stem cells. 119: 1409-22.

14. Mantovani M, Gennai A, Russo PR (2021) A new approach to regenerative medicine in gynecology. Int J Gynecol Obstet. 0:1-8.

15. Coleman SR (2001) Structural fat grafts: the ideal filler? Clin Plast Surg 28: 111-9.

16. Gennai A, Saponaro A, Iozzo I (2009) El rol del lifting endoscópico fronto-témporo- orbitario enel nuevo concepto de rejuvenecimiento facial: mini invasivo, tensión moderada, restauración de volúmenes. Cirugia Plástica Ibero-Latinoamericana 27-34.

17. Zeltzer AA, onnard TPL, erpaele VAM (2012) Sharp -needle intradermal fat grafting (SNIF). Aesthet Surg J 32: 554-61.

18. Senesi L, De Francesco F, Farinelli L, Manzotti S, Gagliardi G, et al. (2019) Mechanical and Enzymatic Procedures to Isolate the Stromal Vascular Fraction from Adipose Tissue: Preliminary Results. Front Cell Dev Biol. 7: 88.

19. Gennai A, Bernardini FP (2015) R3 facial rejuvenation through minimal incisions vertical endoscopic lifting (MIVEL) and superficial enhanced fluid fat injection (SEFFI): endoscopic repositioning, tissue regeneration, volume restoration. Aesthetic Med. 1: 54-60.

20. Bernardini FP, Gennai A, Izzo L, Zambelli A, Repaci E, et al. (2015) Superficial Enhanced Fluid Fat Injection (SEFFI) to correct volume defects and skin aging of the face and periocular region. Aesthet Surg J. 35: 504-15.

21. Bernardini FP, Gennai A (2016) Fluid Fat Injection for Volume Restoration and Skin Regeneration of the Periocular Aesthetic Unit. JAMA Facial Plast Surg. 18: 68-70.

22. Trivisonno A, Di Rocco G, Cannistra C, Finocchi V, Farr ST, et al. (2014) Harvest of superficial layers of fat with a microcannula and isolation of adipose tissue-derived stromal and vascular cells. Aesthet Surg J. 34: 601-13.

23. Di Taranto G, Cicione C, Visconti G, Isgrò MA, Barba M, et al. (2015) Qualitative and quantitative differences of adipose-derived stromal cells from superficial and deep subcutaneous lipoaspirates: a matter of fat. Cytotherapy 17: 1076-89.

24. Dominici M, et al. (2006) "Minimal criteria for defining multipotent mesenchymal stromal cells. The International Society for Cellular Therapy position statement." Cytotherapy 315-7.

25. Pablo B, Anish S, Majumdar (2015) "Adipose tissue-derived stromal vascular fraction in regenerative medicine: a brief review on biology and translation." Stem cell research & therapy. 8:1-145.

26. Michelis, Katherine C, et al. (2018) "CD90 Identifies Adventitial Mesenchymal Progenitor Cells in Adult Human Medium- and Large-Sized Arteries." Stem cell reports. 1: 242257.

27. Meng F, Guo Z, Hu Y, Mai W, Zhang Z, Zhang B, et al. (2019) CD73-derived adenosine controls inflammation and neurodegeneration by modulating dopamine signalling. Brain. 142: 700-18.

28. Yan A, Joachims ML, Thompson LF, Miller AD, Canoll PD, et al. (2019) CD73 promotes glioblastoma pathogenesis and enhances its chemoresistance via A2B adenosine receptor signaling J Neurosci. 39: 4387-402.

29. Haasters F, Prall WC, Anz D, Bourquin C, Pautke C, Endres S, et al. (2009) Morphological and immunocytochemical characteristics indicate the yield of early progenitors and represent a quality control for human mesenchymal stem cell culturing J Anat. 214: 759-67.

30. Darzi S, Werkmeister JA, Deane JA, Gargett CE (2016) Identification and characterization of human endometrial mesenchymal stem/stromal cells and their potential for cellular therapy. Stem Cells Transl Med. 5: 1127-32.