



Differentiated Stem Cells Derived from Rabbit Adipose Tissue Exhibited *in Vitro* Adipogenesis and Osteogenesis

Dhurgham H Al-Haideri*¹ , Hameed A AL-Timmemi² 

¹Department of Clinical Science, Faculty of Veterinary Medicine, University of Kufa, Kufa, Najaf, Iraq,

²Department of Veterinary Surgery and Obstetrics, College of Veterinary Medicine, University of Baghdad, Baghdad, Iraq

A B S T R A C T

The multipotent characteristic of rabbit adipose-derived stem cells makes them available and convenient sources for isolating mesenchymal stem cells. The aim of this study was to assess the differentiation in rabbit adipose-derived stem cells pre-committed to produce several mesenchymal lineages in response to inductive extracellular cues to multipotent stromal cells. Three grams of adipose tissue was taken from a subcutaneous region of the nape of the neck and was carefully isolated to obtain mesenchymal stem cells for expanded by fourth passage. In the 4th passage, active growth of mesenchymal stem cells was observed. Furthermore, the research demonstrated the inherent ability of rabbit MSCs to induce differentiation in osteogenic and adipogenic lineages. These mesenchymal stem cells were successfully isolated from adipose tissue which differentiated into either osteocytes or adipocyte-like cells after 21 and 14 days of culturing in specific osteogenic and adipogenic media, respectively. The remarkable differentiation potential of rabbit mesenchymal stem cells is indicated by mineralized deposition to the osteocytes and lipid droplets accumulated in the cytoplasm lipid vacuoles in the adipocytes.

Keywords: adipogenesis, osteogenesis, MSCs, ASCs, rabbit

*Correspondence:

dhurghamh.alhaideri@uokufa.edu.iq

Received: 31 July 2023

Revised: 17 August 2023

Accepted: 15 October 2023

Published: 28 December 2023

DOI:

<https://doi.org/10.30539/ijvm.v47i2.1509>



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Cite:

Al-Haideri DH, AL-Timmemi HA. Differentiated stem cells derived from rabbit adipose tissue exhibited *in vitro* adipogenesis and osteogenesis. Iraqi J. Vet. Med. 2023;47(2):59-63.

INTRODUCTION

Adipose-derived stem cells (ASCs) are derived from the Adipose tissue that has different and distinct lineage potential. Adipose tissue may be easily isolated and exhibit a multipotent nature, including the ability to be greatly expanded *in vitro* and induced to differentiate into multiple MSCs types (1). In fact, ASCs are precursors for various mesoderm-type cells which include osteoblasts, chondroblasts and adipocytes (2). Induction of adipogenic and osteogenic differentiation pathways with lineage-specific induction agents like dexamethasone, IBMX, insulin, and ascorbate (3,4). In addition, ASCs have strong

osteogenic differentiation capabilities, widely applied in cellular therapy, tissue repair, and regenerative medicine (5) due to their numerous advantages and several recent studies that have shown a preference for adipose-tissue-derived mesenchymal stem cells. Zuk et al. (6) described a multilineage stem cell population originating from the adipose tissue stroma in 2001. Thus, ASC can be easily and repeatedly extracted and obtained in large quantities with minimal discomfort (7). Adipose tissue (AT) has much more MSCs than bone marrow mesenchymal stem cells (BMSCs), about 1% vs. 0.01%, compared with other sources such as the dermis, umbilical cord, dental pulp, and placenta (8). The adipose-derived stem cells differentiate into several

cell types: bone, cartilage, fat, heart, skin, and neurons. This study aimed to highlight the differentiation of adipose-derived stem cells into various mesenchymal lineages in vitro.

MATERIALS AND METHODS

Ethical Approval

The experimental design and procedures carried out in this study were reviewed and approved in accordance with animal welfare ethical standards by the Research Ethics Committee at the University of Baghdad's College of Veterinary Medicine with ethics number 1305 P.G. dated on January 18, 2023.

Isolation and cultivation of ASCs

The rabbit was administered general anesthesia including xylazine (2%) 5 mg/kg (Alasan™, Holland) and ketamine (10%) 35 mg/kg (Alasan™, Holland) (9, 10) via intramuscular injection. Aseptic surgical preparation was carried out on the skin in the neck region, followed by a sharp incision of the skin. Three g of subcutaneous adipose tissue were harvested. The harvested tissue was immediately immersed in 50 mL conical tubes containing sterilized phosphate buffered saline (PBS). The surgical incision was closed as routine work, and the animals were administered systemic antibiotics ceftriaxone (LDP, Spain) 20 mg/kg intramuscularly for 5 days. All techniques for adipose-derived stem cell (ASC) processing were carried through a stem cell lab of College of Veterinary Medicine, University of Baghdad. The adipose tissue sample was transferred to a biosafety cabinet II and rinsed with dulbecco phosphate buffer saline (DPBS) (Gibco™, USA) in order to eliminate any residual blood. Then, the AT was minced using a sterile blade into very small pieces (Figure 1 A, B).

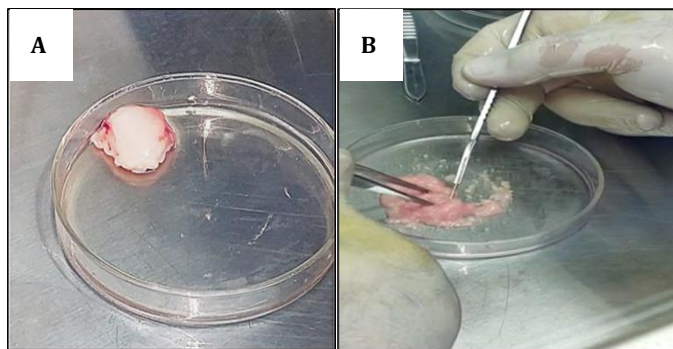


Figure 1. A photograph display the isolation process of MSCs obtained from adipose tissue. **(A)** Adipose tissue sample was cleansed using DPBS within a sterile laminar flow environment. **(B)** Adipose tissue segments were minced thoroughly with a blade until they turned into a mush

The minced tissue was collected in a fifty ml tube. After that, 10 mL of 2 mg/mL collagenase I (Gibco™, USA) was added in a ratio of 10 mL solution per 3 grams of tissue and incubated at 37 °C. Then, after the digestion, this sample

was diluted using dulbecco's modified eagle medium (Gibco™, USA) (DMEM) 10% fetal bovine serum (Gibco™, USA) 1:1, and filter cell suspension by using a 40 µm cell strainers in with 50 mL conical tubes to eliminate the undigested fragment. Then, the filtrate material was centrifuged at 700 g (g-force) for seven min. Remove and discard the resulting lipid layer upon top as well as the supernatant that was collected using pipette. Add three ml of erythrocyte lysis buffer (155 mMNH₄ Cl, 10 mM KHCO₃, 0.1 mM EDTA) to one mL of basal medium to re-suspend the pellet, allowing it to remain at the room temperature (RT) for 5 min. After that, 10 mL of DPBS was added; then mixture was centrifuged at 700 g for seven min. Remove supernatant and re-suspend the pellet with 10 mL medium and - seeded in tissue culture T-75 Flask (Thermo Scientific™). Finally, the cell culture flasks were incubated at 37 °C in a humidified environment consisting of 90% and 5% CO₂ incubator (Sanyo, Japan) for duration of 3-4 days. After that, cells that did not adhere were removed by changing media every 3 days through 12 days or until reached 80% cell confluency. The culture at 12 days was considered passage zero (P0). At this stage the monolayer cell cultures were subcultured to collect homogeneous stromal stem cells. As the following: After the old medium was discarded, the cell was harvested when the monolayer was washed 2-3 times with PBS pH 7.2. Then, 3 mL of trypsin with EDTA (0.25%) and phenol red (Gibco™, USA) solution was added and incubated for 2-3 min to detach the cell culture. The flask was gently shaken to make cell detachment faster. Then, trypsin with EDTA (0.25%) and phenol red solution action was stopped by adding 5-8 mL of DMEM (Gibco™, USA) containing 10% fetal bovine serum and an antibiotic-antimycotic (100×) 1% (Gibco™, USA). The cell solution T-75 culture flask was divided into two T-75 (Thermo Scientific™) flasks were incubated at 37 °C in 5% CO₂ and 90% humidity. The growth of cells was monitored daily until reached 80% cell confluency.

Adipose-Derived Stem Cells Adipogenesis

The differentiation of ASCs to adipocytes was performed according to the protocol described by Wall et al. (11). Mesenchymal stem cells were harvested after complete confluence during the fourth passage and seeded in a T-25 tissue culture flask (SPL®, Korea) with a density of 105 cells per cm² using 5 mL of MSCs expansion medium DMEM per flask. The flask was incubated at 37 °C in 5% CO₂. When the cells in each flask reached 80-90 % confluence, they were aspirated then 5 mL of adipogenesis induction media (DMEM-low glucose, 10% fetal bovine serum, 10 mM Dexamethasone, 0.5 M 3-isobutyl-1-methylxanthine (IBMX), recombination human insulin 10 mg/ml, 10 mM indomethacin, and penicillin-streptomycin) (Gibco™, USA) was added and changed every 2-3 days. An inverted microscope (Olympus, Japan) was used to observe droplets of lipids. Lipid droplets accumulated in the cytoplasm

served as an indication for adipogenic differentiation detected by Oil Red O staining.

Protocol for Oil Red O Staining (ORO)

The media of the culture was discarded from the tissue culture flask after 14 days of differentiation, and the remaining tissue culture flask was preserved in a 4% paraformaldehyde solution for forty min at RT. The fixative agent was then aspirated and the cells were washed with PBS three times for 10 min each. The cells were then covered with sufficient Oil Red O solution, and incubated at RT for 15 min. After removing the Oil Red O solution, five milliliters of distal water were used to wash the cells in the flasks three times. After washing, hematoxylin for 1-2 min to counterstain before observing the inverted microscope.

Oil Red O Solution Preparation

To prepare the Oil Red O solution, 0.35 gram of Oil Red O stained were dissolved in 100 milliliters of absolute isopropanol and placed on the magnetic stirrer for at least one hour. The Oil Red O solution should be filtered through a 0.4 μ pore size and stored at RT. Take 3 milliliters of Oil Red O solution Solution with 2 milliliters of double distilled water, allow stand at RT for 20 min, and filter solution through 0.22 μ pore size.

Adipose-Derived Stem Cells Osteogenesis

The differentiation of ASCs to osteocytes was performed according to the protocol described by Wall et al. (11) Mesenchymal stem cells were initially collected in 1 ml of DMEM, and then inoculated in a T-25 tissue culture flask at 105 cells per cm^2 density, then grown in DMEM at 37 °C with 5% CO_2 . When the cells had attained complete confluency, after removing the medium, five milliliters of osteogenesis induction media (DMEM-low glucose with 10% FBS, 10 mM dexamethasone solution, ascorbic acid 2-Phosphate solution, L-glutamine and penicillin and streptomycin) (Gibco™, USA) were applied to flask. The osteogenic induction medium was changed every 2-3 days during the 21 days of culture. An inverted microscope (Olympus, Japan) was determined by mineralized calcium deposit in the extracellular matrix to indicate osteocyte differentiation detected by Alizarin Red S stain (Sigma-Aldrich).

Protocol for Alizarin Red S Staining (ARS)

The medium was carefully removed from the flask after 21 days of culturing and rinsed once with DPBS. Fix cells with 4% formaldehyde solution for 30 min at RT. After fixation, rinse the flask twice with distilled water for ten min each. After aspirating the tap water, the flask received sufficient 2% Alizarin Red S solution to cover the cells completely and was then incubated at the RT for 30 min.

The Alizarin Red S was removed, and the cells were rinsed four times with 5 ml of distal water and aspirated after each wash. Finally, 5 milliliters of distal water were added to the flask to prevent the dryness of the cells in the culture. The Alizarin Red S stained cell culture was examined under an inverted microscope.

Alizarin Red S Solution Preparation

To prepare the Alizarin Red S solution, 2 g of Alizarin Red S were dissolved in 100 milliliters of double distilled water. The pH of the solution was then adjusted to 4 using HCL (1 N). The solution should be filtered through a filter 0.22 μ pore size and stored at 4 °C in a dark place.

RESULTS

Adipose-derived stem cells were obtained from adipose tissue in the subcutaneous portion of the nape of the neck in rabbits. They displayed a heterogeneous cell population upon seeding and growth in a cell culture flask. The adherent cells exhibited various morphologies that include small rounded, spindle and large flattened shapes. As the cells proliferated and approached the confluence, most of them displayed a fibroblast-like morphology. Notably, the small, rounded cells attached to the surface of the cell layers, but these cells gradually diminished with repeated passages. In contrast, the fibroblast-like cells became more abundant and homogeneous in morphology, reaching a purity of over 80-90% by passage 4 (Figure 2 A). Rabbit ASCs were adipogenic differentiation after 14 days to adipocytes. Lipid droplets accumulated in the cytoplasm lipid vacuoles (red-orange color) in the adipocytes that were stained with Oil red O (Figure 2 B). Rabbit ASCs were osteogenic differentiated after 21 days and were demonstrated the mineralized deposition to the osteocytes by staining with Alizarin Red S. (Figure 2 C).

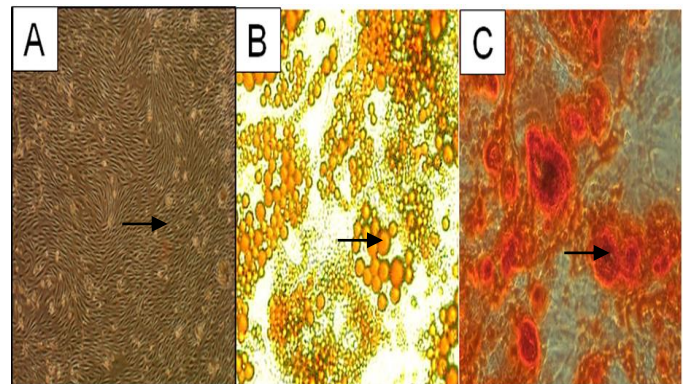


Figure 2. (A) Adipose-derived stem cells of fibroblast-like cells were observed attached to the tissue culture plastic at passage 4, cells exhibited characteristic spindle shape (arrow). (B) Adipose-derived stem cells adipogenic differentiation. Lipids droplets were detected by the orange color of Oil red O stain (arrows). (C) Adipose-derived stem cells osteogenic differentiation. Calcium deposition is demonstrated by the red color of Alizarin Red S stain (arrow (arrow))

DISCUSSION

This study found that ASCs adhered to tissue culture plastic surfaces within 3-4 days of incubation. The cells had fibroblast-like small, rounded, spindle, and large flattened shapes. Cells grew like fibroblasts. Previous observations were similar (12). ASCs are a diverse population of undifferentiated cells that can be obtained from different organs and differentiated into various cell lineages depending on specific stimuli and culture conditions (13, 14). To differentiate ASCs, *in vitro* osteogenic and adipogenic factors are directly added to the culture medium. In addition to their capability of adhering to plastic, stem cells have differentiating ability into osteoblasts, adipocytes, and chondroblasts both *in vitro* and *in vivo* (15). Mesenchymal stem cells with adipogenic induction medium contain specific factors, dexamethasone and 3-isobutyl-1-methylxanthine (IBMX), to induce differentiation of Adipose-derived stem cells to adipocytes (16). The available evidence indicates that the secretion of different factors that promote substances will likely play a role in the functioning of mesenchymal stem cells. This is performed to investigate a putative mechanism that explains the regeneration ability of ASCs (17). The findings of this study demonstrated the multipotentiality of adipose-derived stem cells up to the fourth passage. This characterizes the osteogenic induction of mesenchymal stem cells to osteocyte differentiation, a characteristic of osteogenesis and the initiation of mineralization (18). The deposition of minerals such as calcium is essential for the mineralization process during osteogenic differentiation. (19, 20), and dexamethasone, L-glutamine, and ascorbic acid can promote ASCs to undergo accelerated maturation during osteogenic differentiation (21, 22), these results agree with (23). Similarly, adipocyte differentiation has been achieved by studying lipid-filled vacuoles (24). The results agree with previous reports of osteogenic and adipogenic capability to transdifferentiation (25, 26). The results also align with previous studies, which show that a passage in mouse MSCs caused adipogenic and osteogenic to decline with aging (27, 28). An earlier investigation revealed that isolated bone marrow-derived mesenchymal cells were more adipogenic (29). According to the evidence, adipogenic MSCs can be encouraged to trans-differentiate along the osteogenic path. It has also been demonstrated that human ADSCs in the late passage have better osteogenic properties (30). In conclusion, rabbit ASCs were isolated from adipose tissue and differentiated into osteocytes by Alizarin Red S staining and adipocytes by Oil Red O staining. According to this study, Indomethacin, dexamethasone, and insulin promote ASC differentiation. These findings may help tissue engineering researchers develop sequential growth factor delivery systems.

ACKNOWLEDGEMENTS

N/A

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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قابلية تمايز الخلايا الجذعية المأخوذة من النسيج الدهني للأرانب الى خلايا دهنية وعظمية مختبرياً

ضرغام حميد الحيدري، حميد علي كاظم التميمي

فرع السريريّات، كلية الطب البيطري، جامعة الكوفة، كوفة، النجف، العراق، فرع الجراحة والتوليد البيطري، كلية الطب البيطري، جامعة بغداد، بغداد العراق

الخلاصة

تمتلك الخلايا الجذعية اللحمية ذات المنشأ الدهني من الأرنب خصائص متعددة منها سهولة الحصول عليها، وذلك لعزل الخلايا الجذعية. تهدف هذه الدراسة الى تقييم تمايز الخلايا الجذعية اللحمية ذات المنشأ الدهني غير المتخصصة الى خلايا متخصصة استجابة للإشارات من خارج الخلايا الى الخلايا الجذعية المتعددة. حيث تم اخذ ثلاثة غرام من النسيج الدهني تحت الجلد لمنطقة مؤخره العنق لغرض استزراع الخلايا الجذعية ولغاية اربع زراعات ثانوية. ولوحظ النمو النشط للخلايا في الزرعة الثانية والرابعة بالإضافة الى ذلك أظهر البحث قدرة الخلايا الجذعية في الأرانب على إحداث تمايز الى خلايا عظمية ودهنية. وتمايزت الخلايا الجذعية بنجاح الى خلايا عظمية و خلايا شحمية بعد ٢١ و ١٤ يوماً من الزراعة في وسط مخصص للعظم والدهون، وعلى التوالي. وتم التأكيد في هذه الدراسة على قدرة التمايز للخلايا الجذعية وذلك بترسبات المعدنية الملحوظة في الخلايا العظمية والفجوات الدهنية في سائتو بلازم الخلايا الشحمية. الكلمات المفاحية: الخلايا الدهنية، الخلايا العظمية، الخلايا الجذعية المزنكائمية، الخلايا الجذعية المشتقة من الدهون، أرنب