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ORIGINAL RESEARCH

Surface antigenic profiling of stem cells from human omentum fat in comparison with subcutaneous fat and bone marrow

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Abstract Omentum fat derived stem cells have emerged as an alternative and accessible therapeutic tool in recent years in contrast to the existing persuasive sources of stem cells, bone marrow and subcutaneous adipose tissue. However, there has been a scanty citation on human omentum fat derived stem cells. Furthermore, identification of specific cell surface markers among aforesaid sources is still controversial. In lieu of this existing perplexity, the current research work aims at signifying omentum fat as a ground-breaking source of stem cells by surface antigenic profiling of stem cell population. In this study, we examined and compared the profiling of cell surface antigenic expressions of hematopoietic stem cells, mesenchymal stem cells, cell adhesion molecules and other unique markers such as ABCG2, ALDH and CD 117 in whole cell population of human omentum fat, subcutaneous fat and bone marrow. The phenotypic characterization through flowcytometry revealed the positive expressions of CD 34, CD 45, CD 133, HLADR, CD 90, CD 105, CD 73, CD 29, CD 13, CD 44, CD 54, CD 31, ALDH and CD 117 in all sources. The similarities between the phenotypic expressions of omentum fat derived stem cells to that of subcutaneous fat and bone marrow substantiates that identification of ultimate source for curative therapeutics is arduous to assess. Nevertheless, these results support the potential therapeutic application of omentum fat derived stem cells.

Keywords Omentum fat derived stem cells · Cell surface marker · Mesenchymal stem cells · Cell adhesion molecules · Flowcytometry

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Introduction

Adult stem cells comprise the first line repair mechanism, called into action by normal wear and tear of the body as well as by any serious damage or attack caused by disease or infection. Conceptually and from a practical standpoint, bone marrow (BM) was considered a persuasive source of stem cell for regenerative medicine from ancient days (Horwitz et al. 1999; Kuethe et al. 2004a, b; Wilson and Trumpp 2006; Kopp et al. 2005; Tsiftsoglou et al. 2009). Irrespective of it being a prehistoric source, bone marrow was not considered promising in attempting curative therapies

for all diseases (Hallam and Gribben 2010). It was postulated that bone marrow yields approximately lesser nucleated cells (De Ugarte et al. 2003a, b; Pountos et al. 2007) and frequency of mesenchymal stem cell (MSC) is seemingly low (De Ugarte et al. 2003a, b; Zhu et al. 2008; Pountos et al. 2007). It was also reported that the frequency and differentiation capacity of Bone marrow derived MSC decline with age, body mass index and tissue harvest site, again resulting in producing low stem cell number (Stolzing et al. 2008).

Hence, search for an ideal alternative source of autologous stem cells was considered utmost important. Subcutaneous adipose tissue exhibited features corresponding to such an alternative contemporary source (Zuk et al. 2002; Gimble et al. 2007, 2010). The sheer number of stem cells that can be harvested at once from fat makes this best in human body (Zhu et al. 2008; Jurgens et al. 2008; Kotaro et al. 2006; Aust et al. 2004; Varma et al. 2007). Additionally, the proliferative capacity and plasticity of subcutaneous adipose derived stem cells was found to be much more effective than of bone marrow derived stem cells (Wagner et al. 2005; Gimble and Guilak 2003; Mesimaki et al. 2009; Garcia-Olmo et al. 2008; Bai et al. 2010).

Omentum fat is yet another potent source of stem cells along with bone marrow and subcutaneous adipose tissue, and provide wide spectrum towards cell based therapy. Scientists isolated, cultured and characterised these omentum fat derived cells from rat and asserted that these cells exhibited multilineage properties of stem cells which are capable of finding its use in repair and regenerative applications (Tholpady et al. 2003; Singh et al. 2008). Subsequently, there has been a very scanty citation of similar research with human omentum fat derived stem cells (Baglioni et al. 2009; Toyoda et al. 2009). Therefore omentum fat raises the issue of rivalry in choosing the best possible source for cell based therapeutics along with bone marrow and subcutaneous fat.

Whatsoever, be it omentum fat, subcutaneous fat or bone marrow, there is no specific marker that can reliably identify stem cells (Mitchell et al. 2006; Pountos et al. 2007; Wagner et al. 2005; Katz et al. 2005; Varma et al. 2007; Vater et al. 2011). Moreover, the ultimate source of stem cell for curative therapeutics is not yet defined. Thus, this study focused on the precise characterization of human omentum fat (OF) in comparison with subcutaneous fat (SF) and bone marrow (BM) in facets of complete profiling of various cell surface markers using flowcytometry in order to identify the specific cell surface markers of each source. Additionally, we aimed at obviating the controversies existing upon the ideal source for stem cell therapy.

Materials and methods

Collection of human bone marrow

Human bone marrow samples were obtained from the iliac crest region of 5 patients with spinal cord injury (Paraplegia), who were aged between 32 and 50 (Mean age being 41) and were applied for stem cell transplantation procedure, after the approval of institutional ethical committee. Formal written consent from the donors was obtained before collection.

Adipose tissue collection

Abdominal subcutaneous fat and omentum fat was obtained from five obese male and female patients undergoing a Bariatric surgical procedure of either sleeve gastrectomy or abdominoplasty at Lifeline Multispecialty Hospital, Chennai, Tamilnadu, India, who were aged between 35 and 60 (Mean age being 48). The tissue was collected after obtaining the informed consent of the patient and abiding by the institutional ethical committee approval.

Isolation of whole cell population

Isolation of mononuclear cells from bone marrow

The mononuclear cells from the bone marrow sample were isolated using density gradient centrifugation method. Briefly, the blood is diluted with PBS (Invitrogen) and layered on to Ficoll Paque (Stemcell Technologies). The mononuclear cell layer was collected after centrifugation. The cells were further washed with PBS to remove residual Ficoll and other contaminants. Contaminating erythrocytes were eliminated by treatment with osmotic buffer. Yield of whole cell population was determined using Trypan blue dye exclusion method and characterised using flow cytometry.

Isolation of stromal vascular fraction from subcutaneous and omentum fat tissue

Stromal vascular fraction was obtained from adipose tissue using a previously standardised protocol (Zuk et al. 2002) with modifications. The harvested tissues were washed several times with PBS, minced with scalpels into small pieces with simultaneous removal of visible blood vessels to maximum possible extent. The minced tissues were enzymatically dissociated with collagenase type I (Himedia Laboratories Pvt. Ltd) and centrifuged. The upper aqueous layer containing lipocytes was discarded and the pelleted stromal vascular fraction was washed twice with Phosphate Buffered Saline. The cells were then filtered and the contaminating erythrocytes lysed with an osmotic buffer. The resulting cells were counted and viability assay performed and characterized using flowcytometry.

Flowcytometric characterization

Flow cytometry was performed on a Becton, Dickinson FACS Aria (http://www.bd.com/) using a 488-nm argon-ion LASER and 632 nm red LASER for excitation; fluorescence emission was collected using its corresponding detectors. The antibodies used for enumeration are listed (Table 1) along with its fluorochrome, cat no and the manufacturer.

About 1×10^6 cells were stained with saturating concentrations of fluorochrome conjugated antibodies. The cells were incubated in the dark for 20 min at RT. After incubation, cells were washed three times with wash flow buffer and resuspended in 500 μl of Phosphate-buffered solution (PBS). Wash flow buffer consisted of phosphate buffer supplemented with 2% (v/v) FBS (Sigma Aldrich) and 0.1% (w/v) sodium azide, NaN_3 (Sigma Aldrich). Data analysis and acquisition was then performed using DIVA Software, Becton–Dickinson. A minimum of 10,000 events were characterized and recorded.

Statistical analysis

Data from omentum fat, subcutaneous fat and bone marrow (N = 5) were shown in Mean ± SEM, as individual variables with respect to n = 5 and *p* value

Table 1 Facets of an assortment of cell surface marker

Sl. No	CD marker	Alternate name	Fluorochrome	Cat No	Company
Hematopoietic stem cell markers					
1	CD 34	Sialomucin	PE	348057	BD Bioscience
2	CD 45	PTPRC	APC CY 7	348795	BD Bioscience
3	CD 133	Prominin 1	APC	17-1338-42	eBioscience
4	HLADR	MHC-II	PER CP	347364	BD Bioscience
Mesenchymal stem cell marker					
5	CD 90	Thy 1	PE CY 5	15-0909-73	eBioscience
6	CD 105	Endoglin	APC	17-1057-73	eBioscience
7	CD 73	NT5E	PE	550257	BD Bioscience
Cell adhesion molecules					
8	CD 29	Integrin Beta 1	PE	555443	BD Bioscience
9	CD 49d	Integrin Alpha 4	PE	12-0499-73	eBioscience
10	CD 44	HCELL	FITC	555478	BD Bioscience
11	CD 166	ALCAM	PE	559263	BD Bioscience
12	CD 13	ANPEP	APC	557454	BD Bioscience
13	CD 106	VCAM-1	FITC	551146	BD Bioscience
14	CD 54	ICAM-1	PER CP	555512	BD Bioscience
15	CD 31	PECAM-1	FITC	555445	BD Bioscience
Unique MSC marker					
16	CD 117	C-Kit/SCF	APC	17-1179-73	eBioscience
17	ABCG2	CDw338	PE	12-8888-73	eBioscience
18	ALDH	–	–	01700	Stemcell Technologies

was analyzed using two-tailed student's t test to know the probability of clinical or practical significance between the sources so as to assert the beneficial source. As the probability of variations in the sample (both within and between samples) is most noteworthy for the relevance of better sources, smallest variations might be of significant assessment and also for the wide spread characterization study needed a multiple p value analysis. We have subjected p with: p value <0.05, p value <0.01, p value <0.005, p value <0.0001.

Results

Assorted cell surface marker expression in whole cell population (wcp) of BM, SF and OF

The cell surface profile (n = 5) with respect to sundry markers including Hematopoietic stem cells (HSC), Mesenchymal stem cells (MSC), Cell adhesion molecules (CAM) and other unique markers like ALDH, ABCG2 and CD 117 were analyzed using flow cytometry for WCP of BM, SF and OF. The graphical representation of the expression profile analysed using flow cytometry are illustrated (Figs. 1, 2, 3). The comparisons of Mean ± SEM values of all three sources are detailed in (Table 2). The portrayal on comparison of the entirety of these vibrant classes of cell surface markers of each source revealed that all sources exhibited positivity for wide spectrum of markers, thus correlating towards therapeutics. Surprisingly, it was also found that the stem cells obtained from omentum fat were found to be similar to subcutaneous fat and bone marrow, in facets of cell surface marker expression, thus adding triumph to the world of regenerative medicine.

However, there is a disparity in the representative values of these cell surface markers expression in

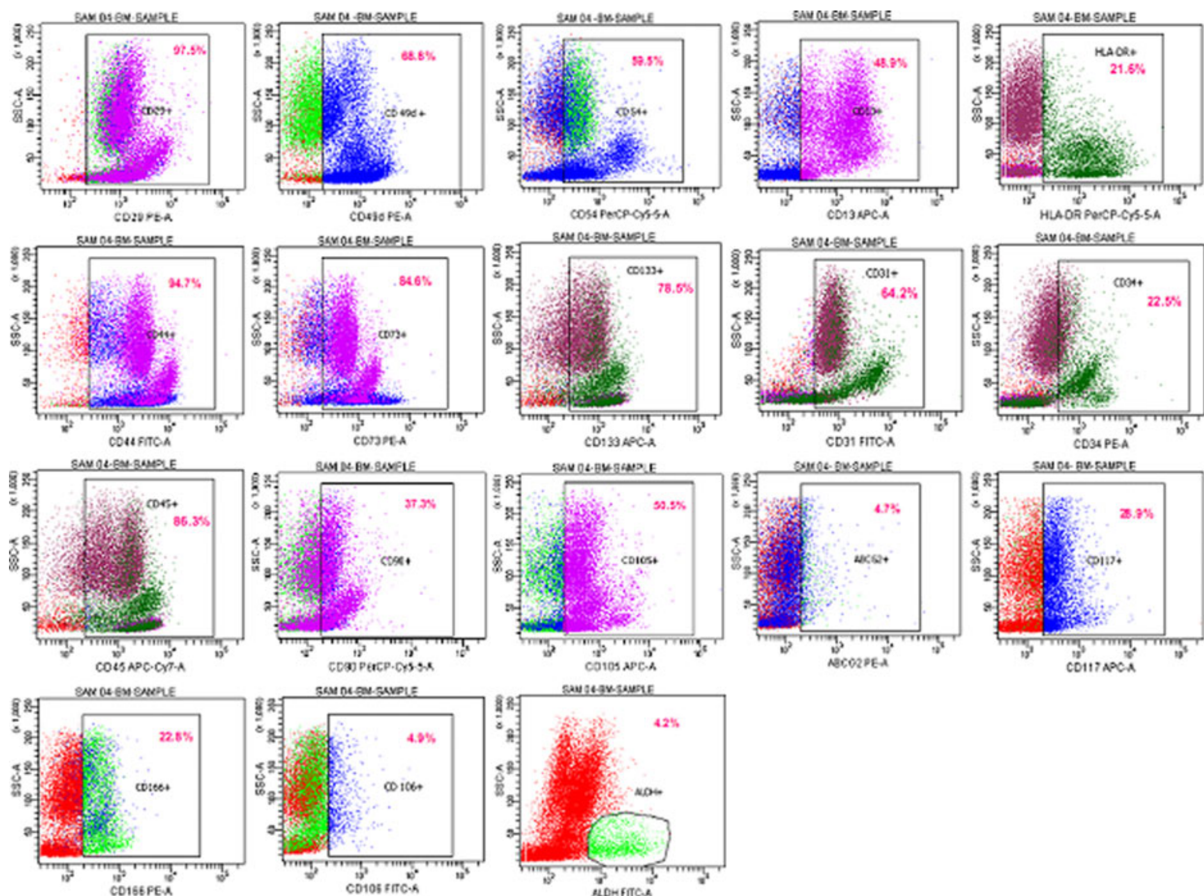

Fig. 1 Flowcytometric analysis of Bone marrow derived stem cells

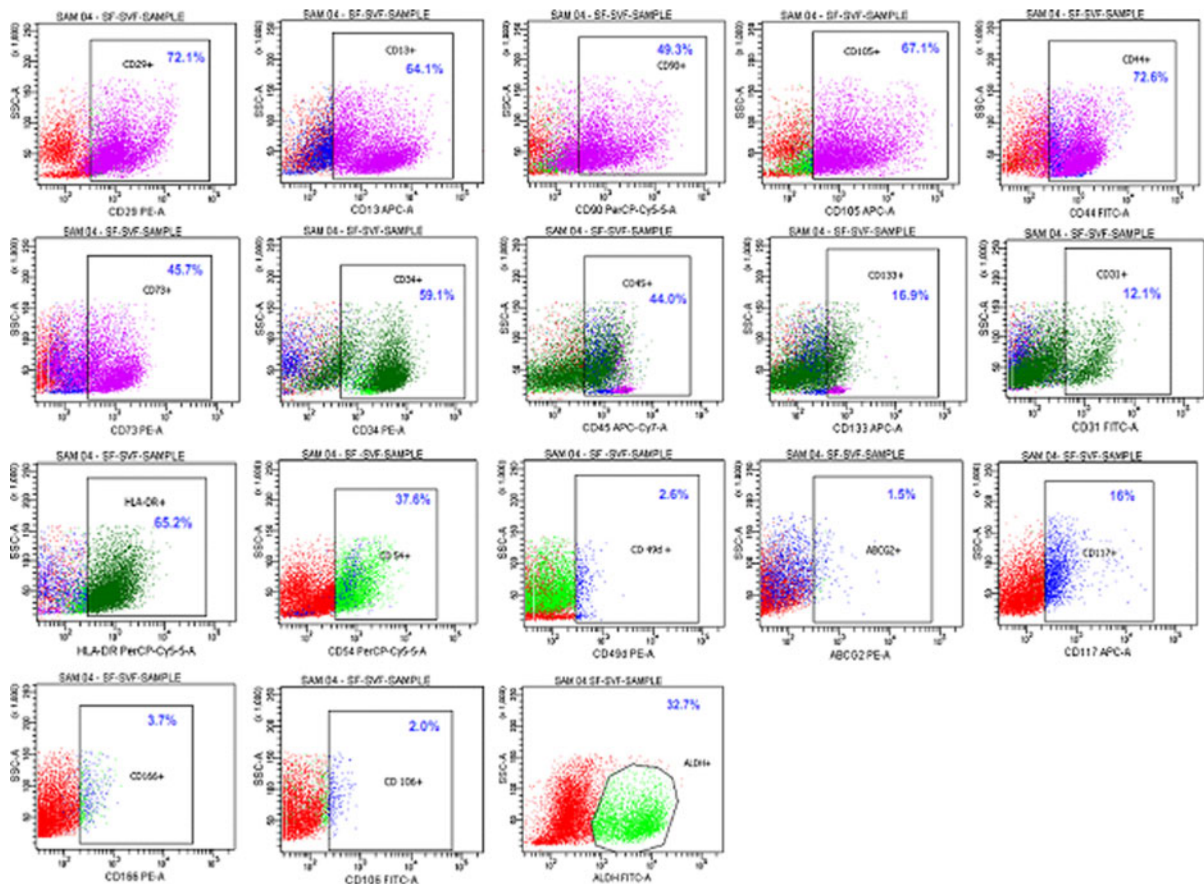

Fig. 2 Flowcytometric analysis of Subcutaneous fat derived stem cells

every source, thus making comparison an arduous and challenging task. In lieu of assorted antigenic expression, the markers were categorized and collated in detail with corresponding range of expression as outlined (Table 3). The range of expression as interpreted in Fig. 4 manifests the intense elucidation of these vivacious markers relating to its divergence in expression. Hence, it is evident that omentum fat articulates moderate to high percentage of expressions for majority of cell surface markers including certain cell adhesion molecules and mesenchymal stem cell markers similar to subcutaneous fat and bone marrow. However, unlike omentum fat and subcutaneous fat, remarkable expressions of few cell surface markers were expressed in bone marrow.

Regardless of the above results, it was not comprehensible to find out the ideal source of stem cells for clinical transplantation. Thus, the surface markers were analysed individually using paired student *t* test to identify any significant difference among samples of BM versus SF, BM versus OF and SF versus OF respectively as depicted (Table 4). The detailed values of these sources are represented in supplementary data (Table S1). It clearly emphasises the fact that there is no significant difference between the expression percentages of omentum fat in comparison to subcutaneous fat. However, some considerable difference between the expressions of omentum fat in comparison to bone marrow was apparent from the *p* value analysis (Table S1).

Lineage specific categorization of immunophenotype of whole cell population

Hematopoietic stem cells

In the literature was reported that bone marrow possesses a higher percentage of HSC population. We scrutinised the expression of key HSC markers CD34, CD45, CD133 and HLA-DR. Here in our study, we

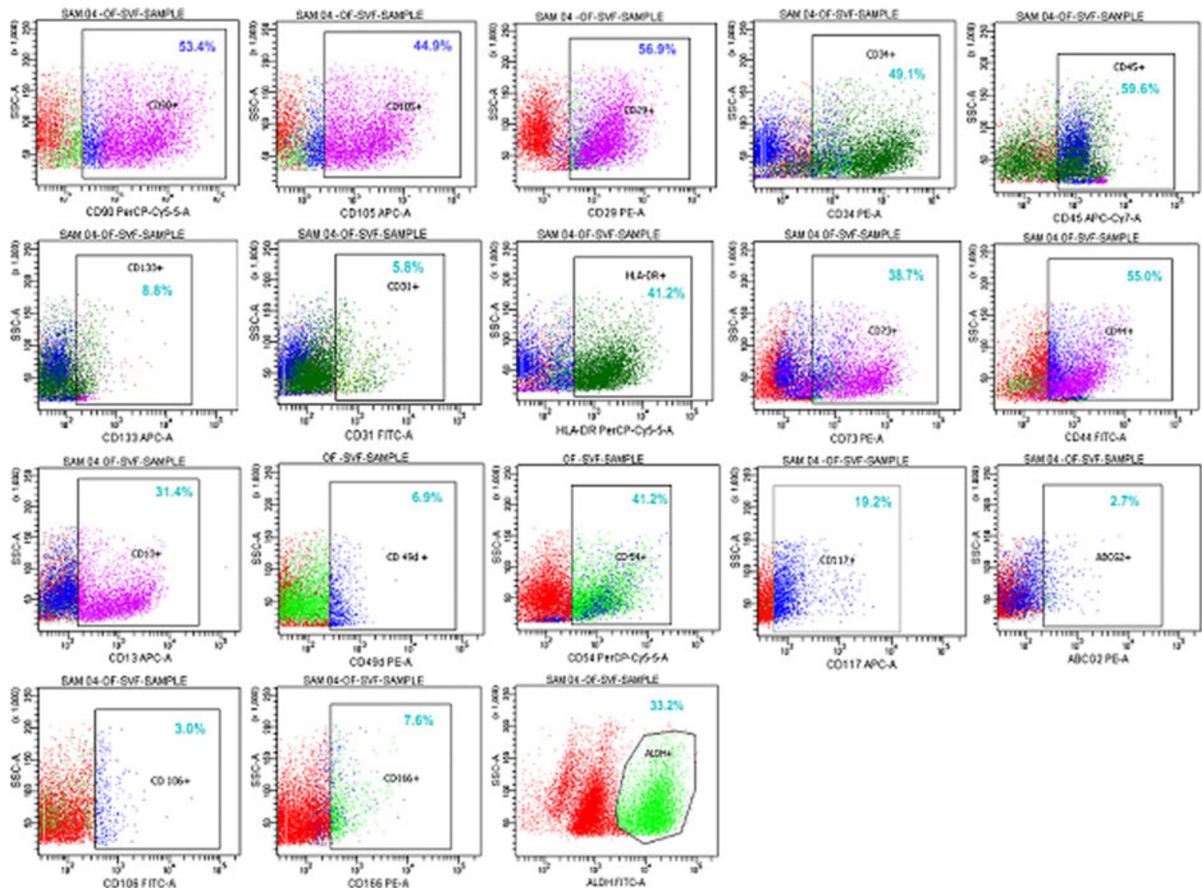

Fig. 3 Flowcytometric analysis of Omentum fat derived stem cells

found that bone marrow possesses a lower percentage of CD34 and HLA-DR than SF and OF (Fig. 5a).

Mesenchymal stem cells

To emphasize the presence of significant MSC population in these three sources, the expression of CD90, CD105 and CD73 was studied. The results were confounding in all three sources. It was identified that SF possess higher expression of MSC compared to other sources, whereas BM and OF possess almost a similar percentage of MSCs (Fig. 5b). This is another proof of evidence to reiterate our hypothesis that omentum fat is also an excellent alternative source for stem cell therapeutics.

Cell adhesion molecules

Cell Adhesion molecules, as the name suggests, are known to be responsible for cell- cell communication and migration through of chemo-attractive properties. Accordingly expression of CD29, CD49d, CD13, CD54, CD44, CD31, CD106 and CD166 was examined. Most of the cell adhesion molecules are widely expressed in BM compared to SF and OF. CD 106, which is said to be an ADSC specific marker showed no positivity for BM or for adipose tissue. Similarly, CD 49d, an ADSC specific marker, is not expressed in adipose tissue, rather showed significant expression in bone marrow. The rest of the cell adhesion molecules was similarly expressed in all three sources except CD 31 and CD 166, which showed higher expression in BM than the other sources (Fig. 5c).

Unique marker

Aldehyde Dehydrogenase, a pluripotent/progenitor stem cell surface marker (Hess et al. 2006) is found to be significantly expressed in both SF and OF than bone marrow which presents <5% of ALDH. This

Table 2 Cell surface antigenic profile of BM, SF and OF

CD markers	BM	SF	OF
HSC markers			
CD34	24.74 ± 4.2	59.58 ± 3.6	47.76 ± 3.3
CD45	87.98 ± 2.0	38.04 ± 3.1	50.9 ± 10.0
CD133	75.76 ± 6.0	18.02 ± 3.0	20.62 ± 4.0
HLA-DR	22.24 ± 3.4	60.34 ± 5.7	37.18 ± 4.8
MSC markers			
CD90	31.06 ± 3.7	57.02 ± 8.2	40.54 ± 6.3
CD105	37.14 ± 4.9	63.34 ± 8.8	42.34 ± 3.8
CD73	67.88 ± 5.6	51.08 ± 8.4	38.82 ± 2.6
CAM markers			
CD29	91.58 ± 1.7	68.28 ± 5.5	52.36 ± 2.5
CD49d	66.74 ± 4.0	7.28 ± 3.4	7.06 ± 1.2
CD13	36 ± 3.7	60.54 ± 9.8	36.94 ± 6.6
CD44	90.04 ± 1.5	67.72 ± 7	63.06 ± 6.9
CD54	43.54 ± 6.4	44.9 ± 7.3	44.82 ± 3.0
CD 31	63.28 ± 7.1	10.2 ± 1.6	12.06 ± 3.4
CD 106	3.14 ± 1.0	3.62 ± 1.3	2.26 ± 0.3
CD 166	31.04 ± 3.6	5.84 ± 1.8	5.92 ± 1.3
Unique markers			
ABCG2	3.88 ± 0.3	3.96 ± 1.2	1.8 ± 0.3
ALDH	3.28 ± 0.5	26.48 ± 4	27.76 ± 2.0
CD 117	31.44 ± 1.8	24.88 ± 3.5	11.94 ± 3.7

suggests that SF and OF might possess more properties of pluripotency than BM. CD117 on the other hand, was expressed to higher levels in BM than SF and OF (Fig. 5d).

Quantitative validation of surface antigenic expression pattern within the stem cell sources

The complete profiling of cell surface expression of all 18 markers of individual samples (n = 5) of bone marrow, subcutaneous fat and omentum fat was compared. These results can be used as a catalogue for future researchers in identification of unique cell surface markers of stem cells with its expression pattern in all sources of bone marrow, subcutaneous fat and omentum fat.

Bone marrow

The values of each marker manifested variation among samples. There was a significant difference among the 5 samples of all cell surface markers except

Table 3 Range of variations in % of cell surface markers

Cell surface markers	% In BM-WCP	% In SF-WCP	% In OF-WCP
HSC			
CD34	+	+++	++
CD45	#	++	+++
CD133	#	+	+
HLA-DR	+	+++	++
MSC			
CD90	++	+++	++
CD105	++	+++	++
CD73	+++	+++	++
CAM			
CD29	#	+++	+++
CD49d	+++	□	□
CD13	++	+++	++
CD44	#	+++	+++
CD54	++	++	++
CD31	+++	□	+
CD106	□	□	□
CD166	++	□	□
Unique marker			
ABCG2	□	□	□
ALDH	□	++	++
CD117	++	+	+

□: Range from 1.8 to 10.2% (sparse expression); +: range from 11 to 24% (low expression); ++: range from 26 to 47% (moderate expression); +++: range from 50 to 68% (high expression); #: range from 75 to 92% (remarkable expression)

CD 106, ABCG2 and ALDH (Fig. 6). The flowcytometric values obtained for each sample of bone marrow derived stem cells are detailed in supplementary data (Table S2).

Adipose tissue

Similar to bone marrow, we found that even subcutaneous fat and omentum fat showed variations in cell surface marker expression among samples (n = 5). The cell surface markers CD 31, CD 106, CD 166 and ABCG2 do not show much variations among samples of subcutaneous adipose tissue (Fig. 7) and the cell surface markers CD 49d, CD 106, CD 166 and ABCG2 do not vary among samples of omentum fat (Fig. 8). The flowcytometric values obtained for each sample of SF and OF are detailed in supplementary datas (Tables S3, S4).

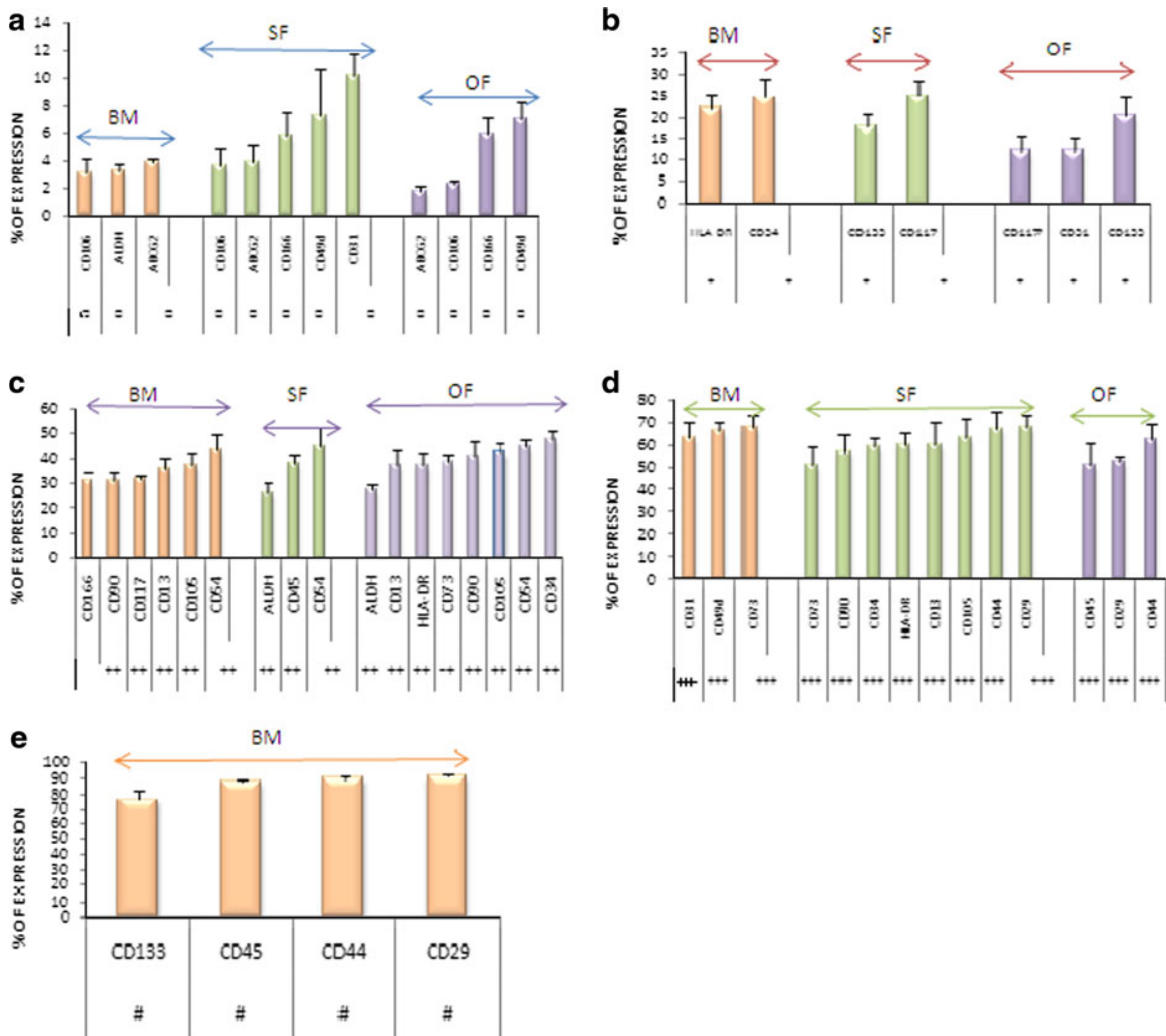

Fig. 4 Ranges of Expression of cell surface markers among BM, SF and OF. The expression profiles of cell surface markers are categorized based on their range of expression using Mean ± SEM values. The categorization of expressions is as follows: The sparse expression of the cell surface markers (**a**); low expression of the cell surface markers (**b**); moderate expression of the cell surface markers (**c**); high expression of the cell surface markers (**d**); remarkable expression of the cell surface markers (**e**)

Discussion

On the frontline, unlike some literature references stating a higher expression of CD 133 and CD 45 in cord blood (Kern et al. 2006; Rebelatto et al. 2007), our sources of stem cells of interest possess significant expression of these markers. However, bone marrow showed remarkable expression of CD133 and CD45 in comparison to SF and OF. Similarly, unlike other data reported in literature (Zuk et al. 2002; Aust et al. 2004; Tholpady et al. 2003; Gronthos et al. 2001; Boquest et al. 2005), our results revealed that CD 34 and HLADR showed significant expression in subcutaneous fat and omentum fat in comparison to bone marrow. This is indicative for the fact that apart from bone marrow or cord blood being used as a therapeutic tool for blood related diseases (Dann et al. 1997; Lawson et al. 2003; Kumar et al. 2009; Ruggeri et al. 2010), SF and OF could also be used as a source of stem cell for efficient HSC transplantation.

Secondly, we found that there are controversies among various citations over MSC specific markers

Table 4 *p* value of 18 cell surface markers of BM, SF and OF

CD markers	*p* value BM versus SF	*p* value BM versus OF	*p* value SF versus OF
HSC markers			
CD34	***	****	–
CD45	$	**	–
CD133	***	****	–
HLA-DR	****	–	*
MSC markers			
CD90	*	–	–
CD105	*	–	*
CD73	–	***	–
CAM markers			
CD29	**	$	–
CD49d	$	$	–
CD13	*	–	**
CD44	**	**	–
CD54	–	–	–
CD31	**	***	–
CD106	–	–	–
CD166	***	*	–
Other unique markers			
ABCG2	–	–	–
ALDH	***	$	–
CD117	–	–	–

–: no significant difference; *: significant difference ($p < 0.05$); **: significant difference ($p < 0.01$); ***: $p < 0.005$ significant difference; ****: $p < 0.0001$ significant difference; $: very highly significant difference

such as CD 90, CD 54, CD 44, CD 29, CD 105, CD 166, and CD 13 (De Ugarte et al. 2003a, b; Zuk et al. 2002; Kotaro et al. 2006; Aust et al. 2004; Rebelatto et al. 2007; Gronthos et al. 2001; Boquest et al. 2005; Katz et al. 2005; Mitchell et al. 2006). Thus, it is unambiguous that prevalence of marker specificity for MSC with respect to all sources is quite vague. There is hardly any distinct categorization towards MSCs and CAM populations available until now.

Hence, in order to avoid this uncertainty and to get a coherent clue of the presence of construed MSC in these sources, we have categorized only CD 90, CD 105 and CD 73 as positive markers, as reported and confirmed by ISCT (Dominici et al. 2006). It is widely apprehended in our previous work and several other literature references that majority of the MSC specific surface markers are exquisitely revealed in ex vivo conditions upon culturing (Wagner et al. 2005; Kern et al. 2006; Rebelatto et al. 2007). Several literature references failed to report CD 73 as an MSC specific marker (Varma et al. 2007; Boquest et al. 2005; Katz et al. 2005). However, we found that like SF and BM, OF expressed similarly higher levels of CD 90, CD 105 and CD 73 (Tables 3 and 4), proving its plasticity towards stem cell therapeutics. This indicates that omentum fat proves to be an efficient source of therapeutics even with regard to mesenchymal stem cells.

Subsequently, the molecular mechanisms that underlay the roots for migration of stem cells in vivo to the site of injury, necessitates a complex multistep cascade of events capable of resisting shear forces coupled with transendothelial migration. This clearly emphasizes the imminent activity of cell adhesion molecules in transendothelial migration and homing of stem cells. In lieu of this, we found that, expression profile of few cell adhesion molecules among these cell sources were inconsistent with the existing reports with respect to percentage expression as well as tissue specificity (De Ugarte et al. 2003a, b; Zuk et al. 2002; Gimble et al. 2007; Gronthos et al. 2001; Katz et al. 2005; Pittenger et al. 1999).

CD 49d being an ADSC specific marker (Zuk et al. 2002; Rebelatto et al. 2007; De Ugarte et al. 2003a, b; Katz et al. 2005), was found to be very sparsely expressed both in subcutaneous fat and omentum fat tissue, whereas surprisingly highly expressed in bone marrow. This suggests that CD 49d could not be an ADSC specific marker and was found to render a pivotal support in bone marrow derived stem cell migration. Similarly, CD 106 (VCAM) reported as an ADSC specific marker (De Ugarte et al. 2003a, b; Zuk et al. 2002; Gronthos et al. 2001; Katz et al. 2005; Pittenger et al. 1999), was neither expressed in ADSC nor in bone marrow. This is indicative of the clue that there is no significant role to be played by CD 106 in stem cell therapeutics. CD 54 (ICAM) on the other hand, is moderately expressed in all sources showing no significant difference in overall expression. This illustrates the significance of CD 54 among all sources.

Similarly, CD 29, an important integrin family member and CD 44 are remarkably expressed in bone marrow (Table 3) and bind to selectin as known from the in vivo mechanism of bone marrow niche (Zhu et al. 2006; Sackstein et al. 2008; Dimitroff et al. 2001; Brooke et al. 2008). CD 29 and CD 44 also are widely

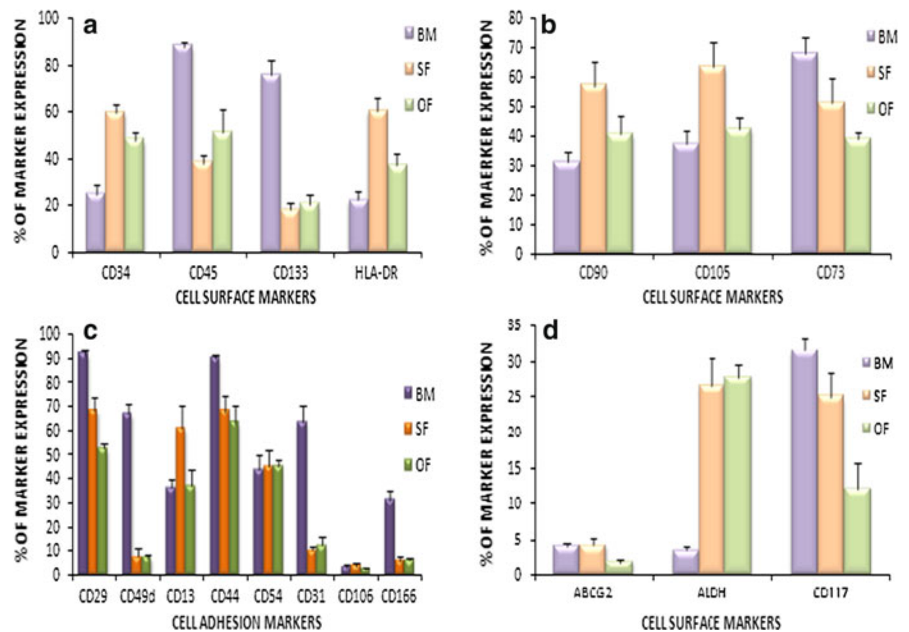

Fig. 5 Lineage specific marker categorization. The cell surface marker expression is depicted based on their lineage using Mean ± SEM values. The lineage specific categorizations are as follows: Hematopoietic stem cell markers (**a**); mesenchymal stem cell markers (**b**); cell adhesion molecules (**c**); other unique markers (**d**)

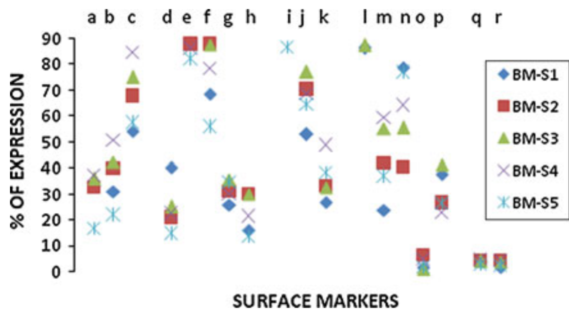

Fig. 6 Cell surface marker profile (n = 18) of samples within bone marrow. This figure represents a systematic comparison of expression profile variation among 5 samples of bone marrow. The details of cell surface markers denoted by *a–r* are mentioned below: (*a* CD90; *b* CD105; *c* CD73; *d* CD34; *e* CD45; *f* CD133; *g* CD177; *h* HLADR; *i* CD29; *j* CD49d; *k* CD13; *l* CD54; *m* CD31; *n* CD44; *o* CD106; *p* CD166; *q* ABCG2; *r* ALDH)

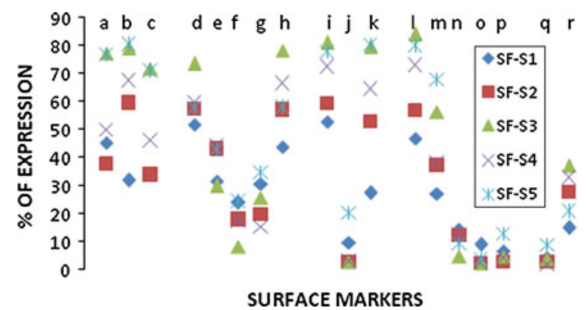

Fig. 7 Cell surface marker profile (n = 18) of samples within subcutaneous fat. This figure represents a systematic comparison of expression profile variation among 5 samples of subcutaneous fat. The details of cell surface markers denoted by *a–r* are mentioned below: (*a* CD90; *b* CD105; *c* CD73; *d* CD34; *e* CD45; *f* CD133; *g* CD177; *h* HLADR; *i* CD29; *j* CD49d; *k* CD13; *l* CD54; *m* CD31; *n* CD44; *o* CD106; *p* CD166; *q* ABCG2; *r* ALDH)

expressed in adipose tissue despite the absence of selectin binding niche mechanism in them (Zuk et al. 2002; Gimble et al. 2007; Aust et al. 2004; Gronthos et al. 2001; De Ugarte et al. 2003a, b; Katz et al. 2005). CD 13, rather than being an important monocyte/macrophage marker, plays a vital role in angiogenesis and migration (Mins-Osorio et al. 2006; Pasqualini et al. 2007). It is expressed in higher percentage in SF and moderately expressed in both BM and OF. This apparently proves the fact that these sources including stem cells from omentum fat can be used as a source for regeneration of treating vascular diseases and ischemic diseases as well.

Finally, omentum fat not only exhibits similarity to BM and SF with regard to expression pattern to HSC, MSC and CAM, but also shows similarity in CD 117 and ALDH expression. Despite being a bone marrow specific marker, both OF and SF showed clear expression of CD 117 (Wilson and Trumpp 2006; Felipe Prosper et al. 2001; Heissig et al. 2002), is found to be similar in both SF and OF. This is inconsistent with certain reports (Wagner et al. 2005;

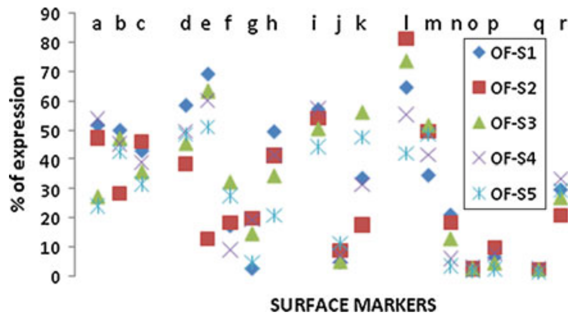

Fig. 8 Cell surface marker profile (n = 18) of samples within Omentum Fat. This figure represents a systematic comparison of expression profile variation among 5 samples of omentum fat. The details of cell surface markers denoted by *a–r* are mentioned below: (*a* CD90; *b* CD105; *c* CD73; *d* CD34; *e* CD45; *f* CD133; *g* CD177; *h* HLADR; *i* CD29; *j* CD49d; *k* CD13; *l* CD54; *m* CD31; *n* CD44; *o* CD106; *p* CD166; *q* ABCG2; *r* ALDH)

Gronthos et al. 2001; Boquest et al. 2005; Katz et al. 2005). The pluripotent marker ALDH, was highly expressed in SF and OF in comparison to BM (Hess et al. 2006; Lioznov et al. 2005). This is indicative of the fact that adipose tissue might possess more pluripotency than bone marrow. It is evident that the cell surface markers of omentum fat are highly similar to those of subcutaneous fat and bone marrow in all aspects. This enables us to audaciously suggest that omentum fat is an effective and alternative source for clinical transplantation.

Furthermore, this systematic study of the surface antigenic properties of all 18 surface markers of individual samples for three major stem cell sources (n = 5) will remain a catalogue for easy reference of expected surface expression, paving way for further in depth research.

Summary

We found from this study that, identification of an ideal source for stem cell therapeutics is strenuous. However, it can be concluded that omentum fat has emerged as an alternative source for stem cell therapeutics in addition to the existing widely accepted sources such as subcutaneous fat and bone marrow. Furthermore, this study will serve as a database for future research, possessing the expressions of wide range of markers (n = 18), specific for OF, SF and BM. Nonetheless, substantiation and imperativeness of this work requires execution of the same kind of research work upon culturing of every source. This might unveil the existence of uncertainty among sources and among cell surface markers.

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