Stem cells in veterinary medicine

Development of regenerative treatment

Stem cells play an important role in veterinary medicine in different ways. Currently several stem cell therapies for animal patients are being developed

animal models are widely used to study the properties and potential of stem cells for possible future applications in human medicine.

field of stem cell research, human and veterinary medicine are tied to one another.

Many of the pioneering innovations in the field of stem cell research are achieved by cooperating teams of human and veterinary medical scientists

The stem cell field in veterinary medicine continues to evolve rapidly both experimentally and clinically.

Stem cells are most commonly used in clinical veterinary medicine in therapeutic applications for the treatment of musculoskeletal injuries in horses and dogs.

-New technologies of assisted reproduction are being developed to apply the properties of spermatogonial stem cells to preserve endangered animal species.

-The same methods can be used to generate transgenic animals for production of pharmaceuticals or for use as biomedical models.

Small and large animal species serve as valuable models for preclinical evaluation **of stem cell applications in human beings and in veterinary patients in areas such as spinal cord injury and myocardial infarction**.

animal models in stem cell therapy

-in stem cell therapy, common disease animal models include mouse, rat, rabbit, swine, canine, caprine, equine and dolphin are used.

-Whereas for clinical models, canine, equine are dolphin are used.

-We need attention and participation from the researchers of tissue engineering and regenerative medicine, and now it is necessary to develop mutual understanding and cooperation between veterinary and human medicine fields

How Stem cell Acted.

In general, the therapeutic role of stem cells in regenerative medicine is not fully understood. It is unclear

1-whether stem cells ultimately function once **differentiated into a tissue-specific cell** such as a tenocyte or

2- whether they **primarily improve tissue repair** through **secretion of immunomodulatory and bioactive trophic factors** or

3- whether a combination of the two mechanisms occurs

Types of Stem Cells

There are two basic types of stem cells

1- Embryonic stem cells are found in the embryo.

-These cells are called totipotent or pluripotent, **which means they have the ability to reproduce into any mature cell type.**

-While embryonic stem cells were thought to offer the greatest potential in differentiating into any mature cell type,

- there are obviously **moral and ethical** concerns with harvesting these cells.

-They also have a propensity to **develop into teratomas,** a type of tumor, which is a major safety concern.

2-The second type of stem cell is the **somatic stem cell (adult stem cell)** .

- These stem cells are multipotent, which means they **can still differentiate into multiple different tissues,**
- Stem cells obtained from **any postnatal organism are defined as adult stem cells.**
- **Adult haematopoietic and MSCs,** which can easily be recovered from extra embryonic or adult tissues, **possess a more limited plasticity** than their embryonic counterparts

- but unlike embryonic stem cells, they do not develop into **teratomas.**

- Due to this, adult stem cells have a major safety.

- Adult stem cells are found in organs and tissues, such as **bone marrow, adipose tissue (fat), skin, liver, blood vessels, and neuron**

-There are no moral or ethical concerns with harvesting adult stem cells from a patient, activating them, and reintroducing them back into the patient.

From Where Stem Cell Harvesting

1-stem cells are generally harvested **from**

bone marrow (**femur of dogs and cats, sternum of horses**)

2- **adipose tissue**

-inguinal region of dogs and cats

- dorsal surface of the gluteus maximus of horses.

Why Does Adipose Tissue use?

1- Adult stem cells are highly concentrated in adipose tissue (fat).

2-Fat is also readily available in large quantities and easily accessible.

3-The technique to acquire the stem cell is less invasive and less painful than aspirating a bone marrow sample from the hip or the sternum.

4-There are up to 1,000 times more stem cells in a gram of fat than in a gram of bone marrow.

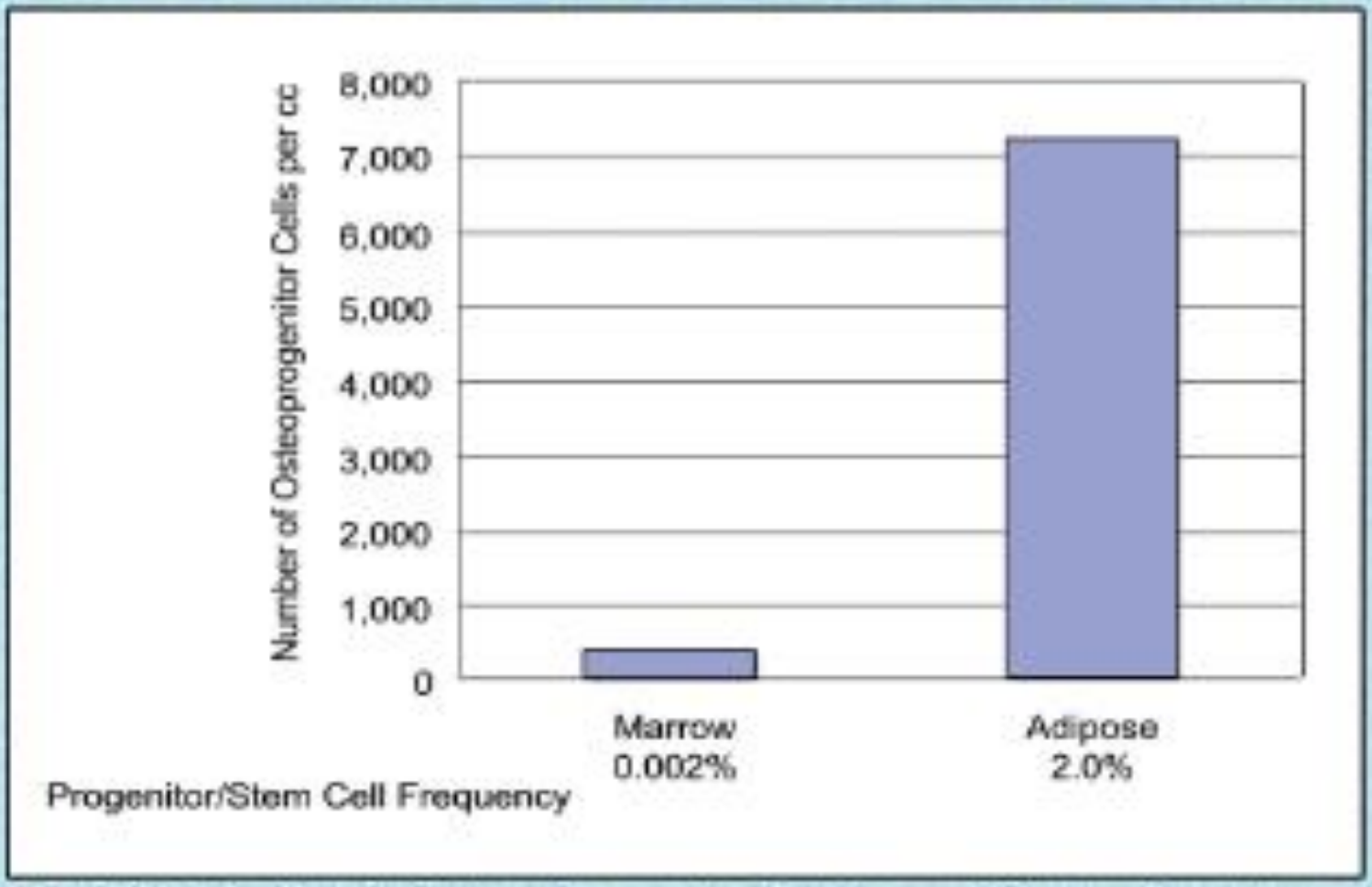
-**At this concentration , the procedure provides an:**

1-abundance of stem cells to treat in-clinic,

2-same day without the need and additional expense of an outside culturing facility.

* Stem cells are extracted from the fat **among a mixture of cells termed the**
* **Stromal Vascular Fraction** (SVF).
* **The SVF is rich in :**
* complementary cells and
* bioactive peptides that contribute to cell proliferation and tissue regeneration,
* and also impart anti-inflammatory effects.

Bone Marrow vs. Adipose



Daniels, E.J., Scientific Data Series in Regenerative Cell Therapy, 2004, MacroPore Biosurgery

Accordingly, stem cells derived from bone marrow aspirates, for instance, are cultured in specialized laboratories for expansion to millions of cells.

-Although adipose-derived tissue also requires processing prior to use, the culturing methodology for adipose-derived stem cells is not as extensive as that for bone marrow-derived cells.

New sources of mesenchymal stem cells

New sources of mesenchymal stem cells are being researched, including stem cells present in

- **the skin and dermis** which are of interest because of **the ease** at which they can be harvested with minimal risk to the animal.

- **Hematopoetic stem cells** have also been discovered to be travelling in the blood stream and possess equal differentiating ability as other mesenchymal stem cells,
- again with a very non-invasive harvesting technique

There has been more recent interest in the use of **extra embryonic mesenchymal stem cells**. Research is underway to examine the differentiating capabilities of stem cells found in the

- **umbilical cord,**
- **yolk sac and**
- **placenta of different animals.**

-these stem cells are thought to **have more differentiating ability than their adult counterparts, including the ability to more readily form tissues of endodermal and ectodermal origin**

Stem cells are thought to mediate repair via five primary mechanisms:

1- providing an anti-inflammatory effect.

2- homing to damaged tissues and recruiting other cells, such as endothelial progenitor cell, that are necessary for tissue growth,

3- supporting tissue remodeling over scar formation .

4- inhibiting apoptosis, and

5- differentiating into **bone, cartilage, tendon, and ligament tissue .**

- To further enrich blood supply to the damaged areas, and consequently promote tissue regeneration, **platelet-rich plasma** could be used in conjunction with stem cell transplantation.

Why utilize Platelet Rich Plasma with Stem Cell therapy?

Platelet Rich Plasma or PRP allows for an adjunctive autologous value add to the stem cell fraction.

-Platelet Rich Plasma is derived from a autologous whole blood sample from the patient and once processed **yields many healing growth factors.**

- **PRP can help with :**

-survival of the cells upon introducing to the patient,

-**reduce inflammation**

-as well as **provide cyto-protective properties** when transit is necessary

The clinical applications of stem cells

Sources of stem cells for Veterinary applications

- Veterinary applications of stem cell therapy as a means of tissue regeneration **use of adult-derived mesnchymal stem cell.**
- There are three main categories of stem cells used for treatments:
- **Autologus mesenchymal stem cells**, derived from the patient prior to use in various treatments.
- **Allogeneic stem cells** derived from a genetically different donor within the same species .
- **Xenogeneic stem cells**, or stem cells derived from different species, are used primarily for research purposes .

Investigatory Uses

While investigation of cell-based therapeutics generally reflects human medical needs,

the high degree of frequency and severity of certain injuries in **racehorses** has put veterinary medicine at the forefront of this novel regenerative approach.

-Also Companion animals can serve as clinically relevant models that closely mimic human disease.

Veterinary medicine

Research has been conducted on horses, dogs, and cats can benefit the development of stem cell treatments in veterinary medicine and can target a wide range of injuries and diseases such as

-spinal injuries

- cardiac defects and myocardial infarction

-gastrointestinal issues

-renal conditions,

-and bone repair

- stroke,

-tendon and Ligament damage

- osteoarthritis and osteochondrosis

-Muscular dystrophy

both in large animals, as well as humans.

Hard-tissue repair

Bone has a unique and well documented natural healing process that normally is sufficient to repair fractures and other common injuries

-Stem cells have been used **to treat degenerative bone diseases**.

The normally recommended treatment for dogs that have **Legg-Calve-Perthes** disease is to remove the head of the femur after the degeneration has progressed. Recently, mesenchymal stem cells have been injected directly in to the head of the femur, with **success not only in bone regeneration, but also in pain reduction-**

Because of the **general positive healing capabilities of stem cells**, they have gained interest for the **treatment of cutaneous wounds.** This is important interest for those with reduced healing capabilities, like **diabetics and those undergoing chemotherapy.**

Soft-palate defects in horses are caused by a failure of the embryo to fully close at the midline during embryogenesis.

After the surgeon has sutured the palate closed, **autologous mesenchymal cells are injected into the soft palate.** The stem cells were found to be integrated into the healing tissue especially along the border with the old tissue.

Ligament and tendon repair

- Autologous stem cell-based **treatments for ligament injury, tendoninjury,osteoarthritis, osteochondrosis, and sub-chondral bone cysts** have been commercially available to practicing veterinarians to **treat horses** since 2003.
- **in dogs** have been available to veterinarians in the United States since 2005.
- Over 3000 privately owned horses and dogs have been treated with autologous adipose-derived stem cells.

* **Joint repair**
* **Osteoarthritis** is the main cause of **joint pain both in animals and humans.**
* Horses and dogs are most frequently affected by **arthritis.**
* Natural **cartilage regeneration is very limited** and no current drug therapies are curative, but rather look to reduce the symptoms associated with the degeneration.
* **Different types of mesenchymal stem cells and other additives are still being researched to find the best type of cell and method for long-term treatment**

* **Muscle repairs**
* Stem cells have successfully been used to ameliorate **healing in the heart after myocardial infarction in dogs.**

*Nervous system repairs

*Spinal cord injuries are one of the most common traumas brought into veterinary hospitals

-Eight weeks later, dogs treated with stem cells **showed immense improvement** over those treated with conventional therapies.

-Dogs treated with stem cells were **able to occasionally support their own weight,** which has not been seen in dogs undergoing conventional therapies-

-Treatments are also in clinical trials to **repair and regenerate peripheral nerves .**

ophthalmology.

--Stem cells are also in clinical phases for **treatment in ophthalmology.**

- **Hematopoietic stem cells** have been used to **treat corneal ulcers** of different origin of several **horses** .

-Stem cells were also **able to restore sight** in one eye of a **horse with retinal detachment.**

Thanks for your Attention