Performing a Better Bone Marrow Aspiration

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KEYWORDS

• Bone marrow aspiration • Bone marrow aspiration technique
• Bone marrow stem cells • Stem cells • Image-guided bone marrow aspiration

KEY POINTS

- Bone marrow aspiration (BMA) is the technique used to harvest stem cells for use in regenerative medicine.
- The use of ultrasound or fluoroscopy guidance represents an advance over traditional palpation-guided techniques. BMA combining anesthesia with guidance can improve patient comfort.
- Newer techniques for BMA allows for higher yields of stem cells.
- Patient preparation, equipment, anesthesia, use of guidance, and medical and other considerations for performing BMA are important.

INTRODUCTION

Patients often consider bone marrow aspiration (BMA) to be painful and difficult. Traditionally, BMAs were often performed using palpation-guided techniques that may work well in thin patients but were uncomfortable for most patients and difficult in heavier patients. Additionally, the authors' experience suggests that this procedure is often not performed in a way that maximizes yield. This article helps physicians understand how to obtain the highest possible stem cell yield while reducing patient discomfort.

BASIC SCIENCE OF STEM CELLS

The International Society for Cellular Therapy definition of a mesenchymal stem cell (MSC)[1] includes a cell line that

- Is plastic adherent
- Expresses CD105, CD73, and CD90 and lacks expression of CD45, CD34, CD14 or CD11b, CD79alpha or CD19, and HLA-DR surface molecules
- Must be capable of trilineage differentiation to osteoblasts, adipocytes, and chondroblasts in vitro

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Phys Med Rehabil Clin N Am 27 (2016) 919–939
http://dx.doi.org/10.1016/j.pmr.2016.06.009
pmr.theclinics.com

Stem cells are part of the body's natural healing processes. They are responsible for repair of injured tissues in the body on an ongoing basis.[2] Hence, healing can be enhanced by injecting or surgically placing stem cells into damaged or injured areas.

A recent PubMed search for *mesenchymal stem cells* reveals more than 40,000 publications.[3] Some studies have shown that MSCs can heal cartilage, bone, ligament, and tendon.[4–7] Interventional orthopedics is the use of percutaneous techniques under imaging guidance to deliver MSCs and other orthobiologics to promote healing and avoid the need for surgery. There are early clinical data to suggest that, in the future, many orthopedic conditions that previously required surgical intervention may be treatable with guided placement of MSCs.

Later the authors provide an overview of the types of stem cells available in bone marrow (**Fig. 1**).

Mesenchymal Stem Cells

MSCs, also known as marrow stromal cells or colony-forming fibroblasts, are multipotent adult stem cells that have shown clinical potential as therapeutic agents in regenerative medicine.[8–13] They are derived from other mesodermal tissues. Experiments in the 1980s and 1990s demonstrated that local environmental factors cause MSCs to differentiate into different cell types. For example, culturing MSCs with ascorbic acid, inorganic phosphate, or dexamethasone causes them to differentiate into osteoblasts, whereas exposure to transforming growth factor beta causes them to differentiate into chondrocytes.[11] More recent research has revealed that MSCs are actually a heterogeneous population of similar cells rather than one distinct cell type.[14]

Hematopoietic Stem Cells

Hematopoietic stem cells (HSCs) are stem cells that are responsible for the production of blood; they are also secondarily involved in muscle repair.[15] In the body they are recruited from the bone marrow when local muscle satellite cells are unable to complete muscle repair.

Endothelial Progenitor Cells

Endothelial progenitor cells are recruited from bone marrow to facilitate vascular homeostasis and neovasculogenesis.[16] This cell type may be useful for reestablishing vascularity in chronically injured musculoskeletal tissues.

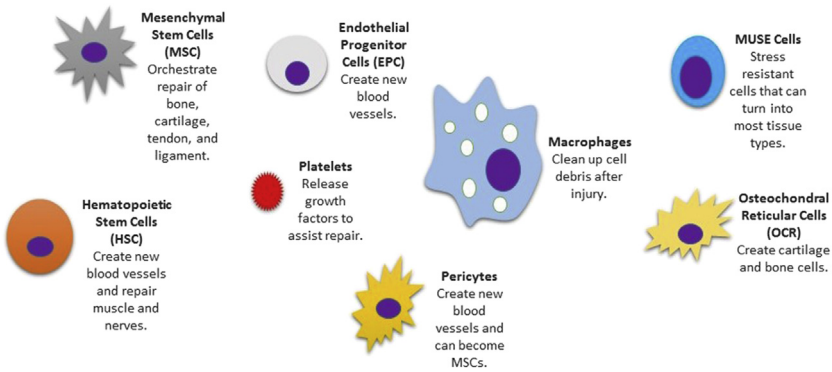

Fig. 1. The bone marrow contains many cells in addition to stem cells to help with orthopedic injuries. The focus of a BMA is to maximize MSC yield. MUSE, multilineage differentiating stress enduring. (*Courtesy of* Christopher J. Centeno, MD, Broomfield, Colorado.)