Cell technologies for spinal fusion

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Abstract

For a successful spinal fusion to occur, several vital elements are necessary. They consist of the presence of the bone-forming cell (osteoblast) or its precursor, the appropriate biological signals directing bone synthesis, and a biocompatible scaffold on which the process can occur. The most critical of these components is the osteoblast or its precursor, the mesenchymal stem cell (MSC), both of which possess the ability to form bone. As a result, many current techniques attempt to maximize the benefits derived from harvesting the ready source of MSCs from bone marrow, while minimizing the associated complications. These cellular technologies seek to improve on the harvest and concentration of the MSCs or enhance their delivery and action. This review focuses on the terminology, historical underpinnings, and current research rationale and techniques and discusses the possible future of these technologies. © 2005 Elsevier Inc. All rights reserved.

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Introduction

Spinal fusion is a common procedure used in more than 200,000 cases per year in the United States [1]. The current standard for spinal fusion is autograft because of its immunogenetic compatibility, absence of disease transmission, biomechanical strength and osteoinductive properties. However, autologous graft harvesting has been associated with various complications [2–14]. Also, in cases requiring large fusion areas, such as revision spine surgery, the amount of autologous bone available is frequently insufficient.

The use of autograft has gained interest because it avoids many of the morbidities associated with the harvest of autograft. However, allograft is coupled with various drawbacks compared with autograft, such as risk of transmission of infection, poor osteoinductive properties, less osteogenic capabilities, delayed time to fusion and potential nonunion [15–18]. Moreover, it has been noted that tensile forces, predominantly associated with posterior fusion, contribute to the increased incidence of nonunion in comparison to regions primarily subjected to compressive loads, as in anterior interbody fusions. Furthermore, allograft, more than autograft, is subjected to deleterious complications associated with such biomechanical factors [19,20]. In addition, various local and systemic factors may contribute to adverse outcomes of both autograft and allograft fusion material [21–33].

To address the various potential complications associated with autograft or allograft substrates, researchers are developing various cellular technologies to augment and potentially replace the use of autologous graft harvesting and enhance allogeneic properties. Recent investigations have focused on the role of the osteoprogenitor cells, specifically the multipotential mesenchymal stem cells (MSCs). It has been noted that a single mesenchymal-derived precursor has the potential to give rise to an adipocyte, osteoblast, or hematopoietic-supporting cell or to induce osteogenesis from mature osteoblasts [34,35]. Because these progenitor cells maintain the ability to differentiate and stimulate induction of key bone cells, they are an integral component in bone formation. Current techniques attempt to maximize the benefits derived from harvesting the ready source of osteoprogenitor cells from bone marrow.