

CELL TYPES OF THE DENTAL PULP BEHIND THE ODONTOBLAST

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ABSTRACT

The dental pulp represents the central part of a tooth consisting of loose connective tissue with a high variety of cells. Some of the most important cells from the dental pulp are: the odontoblasts, fibroblasts, ecto-mesenchymal cells, defence cells like macrophage, granulocytes neutrophils, lymphocytes, mast cells and plasma cells or antigen-presenting cells. Other cell types present in the dental pulp are the pericytes and the endothelial cells. Data from the literature showed that the dental pulp could be a source for the multipotent stem cells. All of these cells are crucial for maintaining the functions of the healthy teeth.

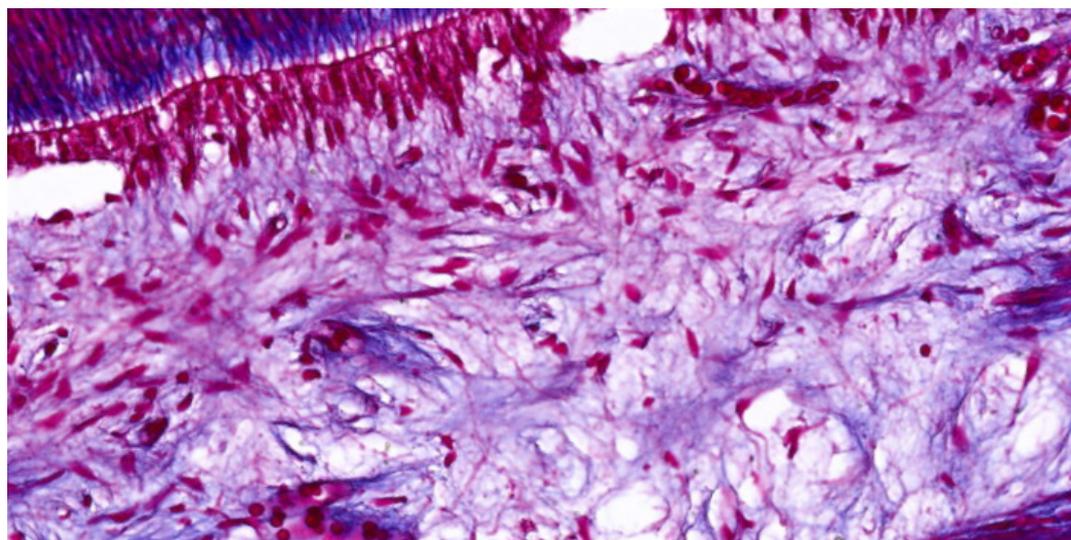


Figure 1. Dental pulp, trichrome staining method, X200.

INTRODUCTION

The dental pulp is a soft connective tissue which has a support role for the dentin (figure 1). From the histological point of view, four distinct zones can be distinguished: the odontoblastic zone at the periphery of the pulp, a cell free zone of Weil, a cell-rich zone, where cell density is high and central zone rich in vessels and nerves (1). The main cells of the pulp are the odontoblasts, fibroblasts, undifferentiated ecto-mesenchymal cells, macrophages, and other immunocompetent cells. The dental pulp was also proposed as a source of multipotent stem cells (2).

The odontoblasts, the most representative cells of the pulp, disposed on a layer along the interface between the dental pulp tissue and dentin. They function as a natural barrier between mineralized tissues, dentin, and soft tissues, dental pulp, in the vital tooth (3). The odontoblasts are found in the periphery of the dental pulp and exhibit unique morphological characteristics (4). They extend their cytoplasmic processes named the odontoblast processes into the dentinal tubules within dentin (5).

FIBROBLASTS

The fibroblasts are the most abundant cells of dental pulp and they play pivotal roles in the normal physiologic function of the pulp. The fibroblasts are much more numerous in the coronal part of the pulp, where they form the cell-rich zone. The main function of these cells is to form and maintain the extracellular matrix of the dental pulp, which consists of collagen and ground substance. In young pulp the fibroblasts actively synthesize matrix and have the following morphological features: oval shape, pale stained nucleus with fine granular chromatin and a quite abundant cytoplasm. As demand synthesis decreases with age, the fibroblasts appear as flattened spindle shaped cells with reduced cytoplasm and a flattened nucleus with condensed chromatin. When they are properly stimulated, the fibroblasts of dental pulp have ability to ingest and also to damage collagen. Dental pulp cells, especially dental pulp fibroblasts, are known to synthesize various mediators of inflammation, such as IL-6 (6), IL-8, and vascular endothelial growth factor (VEGF) in response to caries-related bacterial components (7).

UNDIFFERENTIATED ECTO-MESENCHYMAL CELLS

Undifferentiated ecto-mesenchymal cells are the main source of the connective tissue of the dental pulp. Depending on the stimulus, these cells may give rise to odontoblasts and fibroblasts. Undifferentiated ecto-mesenchymal cells are found in the cell-rich zone and in the central zone of the dental pulp and are often related to blood vessels. By light microscopy, undifferentiated ecto-mesenchymal cells appear as large, star-shaped cells with a large nucleus, centrally located. These cells have an abundant cytoplasm and fine, branched cytoplasmic extensions. With age, the number of undifferentiated ecto-mesenchymal cells decreases, which limits the regenerative potential of the dental pulp.

INFLAMMATORY CELLS

A large number of macrophages are found in the dental pulp and are considered to be the major immunocompetent cells that act against bacterial infections caused by dental caries (8). The macrophages of the dental pulp are located in the central zone of the pulp. In light microscopy, they appear as large, oval or elongated cells with a dark-stained nucleus. Pulp macrophages, like all macrophages in the body, are derived from blood monocytes and are involved in phagocytosis of dead cells.

In the healthy dental pulp, a small number of T lymphocytes, B lymphocytes, plasma cells are also found. The number of lymphocytes and plasma cells increased in the inflammatory processes of pulp. There are also found some leukocytes, such as neutrophilic and eosinophilic granulocytes, whose numbers increase substantially during an infectious process of pulp.

Mast cells are important cells of the immune system (9) and are found in all connective tissue types of the oral cavity, including the dental pulp, the periodontal ligament, and the gingiva (10). The presence of mast cells in the dental pulp and their role in the inflammation of the dental pulp remained a controversial issue. Data from the literature revealed that mast cells are few or absent in healthy human dental pulp, but appeared as active cells in the inflammatory response (11). According to Miller et al., mast cells are occasionally found in inflammatory tissue of pulp (12). High concentrations of TNF- α have been detected in the inflamed human dental pulp. The source of TNF- α could be mast cell granules, which release TNF during degranulation (13). Some studies suggest that mast cells histamine, which is a strong vessel dilator and mediator of vascular permeability, may play a role in the initiation of dental pulp inflammation. Bacterial invasion of the pulp during caries formation can also cause the activation of mast cells. In 2009, Karapanou et al. launched hypothesis that mast cell activation may occur through neuropeptides that are released locally

into the pulp. Subsequently pro-inflammatory mediators released by mast cells granules may participate in the inflammatory process of the dental pulp and may serve as diagnostic markers for pulpal inflammatory diseases (14, 15).

Dendritic antigen-presenting cells are found inside and around the odontoblast layer in non-erupted teeth, and in erupted teeth beneath the odontoblast layer. They are at least 50 μm long and have three or more main branched dendritic processes. Their function is similar to that of Langerhans cells found in the epithelium where they capture and present the antigen to T lymphocytes. The number of these cells increases in carious teeth, where they infiltrate the layer of odontoblasts and can project their extensions into the dentinal tubules (16).

DENTAL PULP STEM CELLS

Mesenchymal stem cells have been isolated from the dental pulp of adult and deciduous teeth. These stem cells from postnatal dental pulp have a capacity for self-regulation and, under appropriate environmental conditions, can differentiate into odontoblasts, adipocytes, chondrocytes, but also into neurons. It has also been shown that these cells have the ability to differentiate into osteoblasts and can therefore be a promising tool for bone regeneration (17).

OTHER CELL TYPES

Perivascular cells are found in the dental pulp closely disposed to the vessels from the pulp. Pericytes are intimately associated with blood vessels in the pulp. These cells show cytoplasmic processes in contact with the basement membrane of blood vessels and are involved in pulp regeneration processes. Endothelial cell line the lumen of the pulpal blood vessels and involved in the synthesis of collagen IV in the basement membrane. It was demonstrated that these cells proliferate after pulp exposure trying to revascularize the wounded area during the process of wound healing (18).

CONCLUSION

The dental pulp contains both the resident cells of the pulp (fibroblasts - the main cells of the pulp, the stem cells), but also the cells migrated from the blood or hematogenous marrow, all these forming the cell population of the pulp. Altogether they provide the extracellular matrix proteins. Undifferentiated mesenchymal cells play an important role in pulpal regenerative processes. Macrophages, lymphocytes, antigen presenting cells (dendritic cells), mast cells and plasma cells are involved in phagocytosis and immune defence. All these cell types present in the dental pulp have a crucial role in maintaining healthy tooth functions.

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