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- 11.00.00 Geografiya fanlari

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A REVIEW OF THE LITERATURE ON STEM CELLS IN DENTISTRY

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Abstract: Until recently, only biostimulants and proliferation inducers could affect tissue regeneration. Innovative approaches for tissue engineering and regenerative treatments in a variety of medical specialties, including dentistry, were made possible by the development of primary stem cell culture methods.

Key words: stem cells, dental regeneration, DPSCs, dental pulp stem cells, tissue engineering, bone regeneration, odontogenesis, mesenchymal stem cells, biomaterials.

Annotatsiya: Yaqin vaqtgacha faqat biostimulyatorlar va proliferatsiya induktorlari to'qimalar regeneratsiyasiga ta'sir ko'rsata olardi. Birlamchi ildiz hujayralarini kultivatsiya qilish usullarining rivojlanishi stomatologiyani ham o'z ichiga olgan tibbiyotning turli sohalarida to'qima muhandisligi va regenerativ davolashning innovatsion yondashuvlarini amalga oshirish imkonini berdi.

Kalit so'zlar: ildiz hujayralari, dental regeneratsiya, DPSClar yoki dental pulpa ildiz hujayralari, to'qima muhandisligi, suyaklarning regeneratsiyasi, odontogenez, mezenximal ildiz hujayralari, biomateriallar.

Аннотация: До недавнего времени только биостимуляторы и индукторы пролиферации могли влиять на регенерацию тканей. Разработка методов культивирования первичных стволовых клеток сделала возможными инновационные подходы к тканевой инженерии и регенеративному лечению в различных областях медицины, включая стоматологию.

Ключевые слова: стволовые клетки, регенерация зубных тканей, DPSCs или стволовые клетки пульпы зуба, тканевая инженерия, регенерация костей, одонтогенез, мезенхимальные стволовые клетки, биоматериалы.

INTRODUCTION

The rapid development of regenerative medicine has created new opportunities for restoring damaged tissues and organs using biological technologies. Among these innovations, stem cell-based therapy has become one of the most promising approaches due to the unique ability of stem cells to self-renew and differentiate into specialized cell types. In dentistry, regenerative strategies are increasingly being investigated as alternatives to conventional treatment methods, particularly for the regeneration of dental pulp, dentin, periodontal tissues, craniofacial bone, and other oral structures.

Despite significant advances in tissue engineering and biomaterial science, the clinical application of stem cells in dentistry remains limited. Most studies have been conducted at the experimental or preclinical level, while issues related to biological safety, ethical considerations, long-term effectiveness, and standardized treatment protocols continue to restrict their widespread implementation in routine dental practice. Consequently, there is a need to critically evaluate the current scientific evidence regarding the therapeutic potential and limitations of stem cell technologies in dentistry.

The scientific novelty of this review lies in the comprehensive assessment of recent advances in stem cell research relevant to modern dentistry, with particular attention to regenerative endodontics, implantology, and craniofacial tissue engineering. The review also identifies current challenges and future directions for translating experimental findings into clinical applications.

The aim of this study is to evaluate the current status of stem cell applications in modern dentistry, summarize the available scientific evidence, analyze their regenerative potential and clinical limitations, and determine future prospects for their implementation in dental practice.

LITERATURE REVIEW

Up until recently, pathomorphologists and histologists continued to study cellular differentiation, and the use of biostimulants and proliferation inducers was the only way to influence the body's regeneration processes^[1, 2]. The development of primary cell culturing techniques by Canadian scientists Ernest McCulloch and James Till in 1960 opened up new avenues for clinical treatment. These cells, known as strain (stem) cells, are present in all multicellular creatures^[2]. These cells have the ability to differentiate into a sizable variety of specialised cell types in addition to self-renewing via division. The ability of stem cells to self-renew, or go through a large number of cell division cycles, and their ability to stay undifferentiated while yet having the power to develop into any form of cell are what make them unique. Although certain multipotent or even unipotent progenitors of specific cell lineages are sometimes referred to as stem cells, this renders stem cells totipotent or pluripotent^[3].

Somatic stem cells are multipotent or even unipotent, although their capacity for differentiation is more restricted than that of embryonic cells. These cells are now of utmost importance in regenerative medicine^[3]. In contrast to embryonic stem cells, considerable funding is allotted for the study of somatic stem cells since the use of adult stem cells in experimental research and clinical treatment is not linked to severe bioethical limitations^[3, 4].

Researchers' experience suggests that stem cells have the potential to drastically alter current therapy strategies for chronic illnesses, even many that are thought to be incurable^[3]. The majority of stem cell-based therapeutic approaches are experimental, and there is insufficient evidence to support their clinical effectiveness. Nevertheless, the findings thus far indicate that cellular technologies hold great promise for the treatment of neurodegenerative, cardiovascular, and oncopathology disorders. This also applies to dental pathology^[3, 5].

However, writings on the use of stem cells in dentistry might sometimes have an openly speculative tone, which provides sceptics with grounds for unfairly categorical evaluations of the new technique's scientific and practical prospects^[6]. This review's objective was to evaluate the present status of the stem cell usage debate in dentistry.

Embryonic stem cells have the potential to be used in regenerative medicine and tissue repair after illnesses or accidents because of their pluripotency and limitless growth. However, there is currently not enough data to support the widespread use of embryonic stem cells in medicine. Given that several nations have imposed moratoriums on both stem cell research and the acquisition of their new lineages, this is not surprising^[3].

More research has been done on somatic stem cells. Somatic stem cells are multipotent or even unipotent, although their capacity for differentiation is more restricted than that of embryonic cells. These cells are now of utmost importance in regenerative medicine^[3]. In contrast to embryonic stem cells, considerable funding is allotted for the study of somatic stem cells since the use of adult stem cells in experimental research and clinical treatment is not linked to severe bioethical limitations^[3, 4].

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RESEARCH METHODOLOGY

The Medline, Ovid, HINARI, CINAHL, Embase, and TRIP databases, as well as the dissertation catalogues of the Vernadsky National Library of Ukraine and the Russian State Medical Library, with a 10-year retrospection, were searched for information using the keywords "cell strain" (stem cells (Eng.), Stammzellen (Ger.), cellules souches (Fr.)), "dentistry" (dentistry (Eng.), Stomatologie (Ger.)), and "treatment" (treatment (Eng.), Behandlung (Ger.)). A total of 185 papers were chosen for further analysis after publications with weak evidence, inadequate relevance, and limited pertinence were eliminated. In addition to bibliographic and bibliometric techniques, the content analysis approach was used to generalise literary data.

ANALYSIS AND RESULTS

Only 54 original research studies were published between 2000 and 2010 (20.5%); however, the bibliometric assessment revealed a notable majority of reviews among the articles chosen for further analysis (210 or 79.5%). Most researchers used laboratory models, with in vitro investigations predominating (31). The USA,



Japan, China, and Germany are the nations that have developed this field the fastest (106, 120, 9, and 17 publications, respectively).

The potential for regenerating vascularised dental pulp and creating new dentin on the residual dental walls within the root canal after canal therapy was assessed by Huang G.T. et al. (2010). Immunocompromised mice were used as a laboratory model for the investigation. After being separated and placed on a synthetic scaffold made of D,L-lactide/glycolide inserted into tooth fragments, stem cells from the apical portion of the papilla and pulp were transplanted into root canals that had already been depulped. Subsequent examinations revealed that pulp-like tissue with well-developed blood vessels quickly filled the canal space. Additionally, deposits of dentin-like tissue containing CD105, alkaline phosphatase, and dentin and bone sialoproteins developed on the surfaces of the canal walls. Human mitochondrial antibodies reacted well with the developed tissues, demonstrating their human origin. Therefore, it is completely feasible to regenerate pulp from scratch using stem cells that can differentiate into odontoblast-like cells ^[7].

Dental pulp stem cells were extracted from the pulp tissue of permanent and deciduous teeth, as well as the periodontal ligament, in a study by Nedel F. et al. (2009). Following transplantation, the dental pulp stem cells showed the capacity to form heterogeneous dentin complexes in the tissues of immunocompromised mice. Enameloblasts, mesenchymal pulp cells, and a mechanical carrier were all present in these complexes. The findings, according to the scientists, make it possible to anticipate employing stem cells in the future to repair dentin, enamel, and pulp abnormalities, as well as to rebuild dentoalveolar and craniofacial bone deformities. In the future, they even anticipate replacing the whole tooth.

The ability of human dental pulp stem cells for self-renewal, multi-lineage differentiation, and clonogenicity was reported in a study by Gronthos S. et al. (2002), although comparable findings had previously been achieved before the start of the present decade. Stromal-like cells were re-established in a culture derived from primary stem cell transplants, and these cells were then retransplanted into mice with weakened immune systems. The research demonstrated how stem cells may develop into neuron-like cells and adipocytes. Additionally, several strains derived from a single-cell colony were evaluated for their odontogenic potential. In vivo, two-thirds of the strains generated significant amounts of heterotopic dentin deposits ^[9].

The application of multipotent mesenchymal stem cells, which are primarily derived from exfoliated deciduous teeth, dental pulp, stem cells from the apical part of the papilla, dental follicle, periodontal ligament, or bone marrow, is examined in reviews by Peng L. et al. (2009) and Morszeck C. et al. (2008). These cells show promise for future use in regenerative dentistry, according to the investigators ^[10, 11]. Similar opinions are expressed by Tziafas D. and Kodonas K. (2010), who suggest employing stem cells in endodontic practice ^[12], and Jing W. et al. (2008), who believe that adipose tissue-derived stem cells hold greater promise for producing odontogenic cell lines than mesenchymal stem cells derived from red bone marrow ^[13].

The potential applications of stem cells in implantology were the focus of Yamada Y. et al.'s 2009 study ^[14]. They demonstrated that the clinical results of implantological therapy might be enhanced by adding mesenchymal stem cells from bone marrow, dental pulp, or deciduous teeth to an osteoimplant. Increased expression of STRO-1, CD13, CD29, CD44, CD73, ALPL, Runx2, and BGLAP genes identified the stem cells in vitro. Stem cells and platelet-rich plasma from the implant structure were added to a bone lesion model in vivo. Eight and sixteen weeks after implantation, the jaw preparations underwent histological and histomorphometric analyses. It was shown that the use of stem cells greatly expedited the regeneration of bone tissue, generated mature bone tissue in the defect region, and repaired the vascular network.

According to Onyekwelu O. et al. (2007), at this point in technological research, it is technically difficult to artificially cultivate teeth for later transplantation into patients with dentition abnormalities ^[15]. Individual reports from international organisations about Japanese scientists' use of cellular engineering to create a tooth in the winter of 2007 are not totally accurate ^[16]; these reports only mention attempts to restore the tooth's primary morphological and structural components in a laboratory setting. By mixing epithelial and mesenchymal stem cells, the laboratory of Takahashi C. et al. (2010) has shown the potential to differentiate cloned cell lines of the oral mucosa epithelium into ameloblasts and regenerate tooth tissues ^[17]. At 18 days of gestation, when tooth morphogenesis is almost complete, the studies were carried out on p53-deficient mouse embryos. The cell lines derived from mouse embryonic tissues were found to express oral mucosal epithelial markers (cytokeratin 14) using real-time PCR; however, ameloblast markers (amelogenin and ameloblastin) were absent during plastic culturing. The acquired cell lines' epithelial nature was ascertained during incubation on a feeder layer or a collagen gel. Tooth germs were then created using bioengineering techniques. They were created using foetal mesenchymal tissue and cell lines, and they were placed under the kidney capsule for two to three weeks. Five of the six cell lines regenerated into tooth-like calcified structures. The authors claim that, at 18 days of gestation, the embryonic epithelial tissues of the oral mucosa still have the capacity to develop into ameloblasts. For research on tooth organogenesis and regeneration, the Japanese researchers believe their constructed model has promise.

Dental pulp cells may proliferate and produce extracellular matrix, which then undergoes in vitro mineralisation, as Otaki S. et al. (2007) showed^[18]. The scientists demonstrated that pulp cells may produce structural and morphological components of bone tissue rather than dentin after eight passages of subcutaneous implantation into immunocompromised mice. This suggests that pulp cells are mesenchymal stem cells in and of themselves, as they are often the progenitors of osteoblasts and odontoblasts. The authors suggest using tooth pulp cells as a source of biological material for regenerative medicine and cellular bioengineering.

When assessing the potential of employing different odontogenic progenitors, Trubiani O. et al. (2006) favour mesenchymal stem cells derived from the periodontal ligament or tooth pulp. The main cause of the delay in using cutting-edge cellular treatment techniques in dentistry, according to the authors, is a lack of knowledge about the molecular processes of cellular differentiation^[19].

The majority of the studies in earlier papers (from 2000 to 2005) were exploratory. They were committed to finding the best ways to cultivate and activate stem cells, as well as improving the process of employing them in clinical and laboratory settings^[20, 21]. When dental pulp stem cells are used in conjunction with a collagen sponge scaffold to treat bone tissue abnormalities, the most notable outcomes have been obtained^[22]. Until recently, however, the utilisation of autologous blood tissues and certain other unipotent cellular complexes was the major focus of scientific advancements^[23, 24]. Specifically, Ukrainian researchers use autologous bone marrow cells, blood cell suspensions, and skin fibroblasts applied to a Collapan biomatrix to restore jaw deformities in an effort to promote reparative regeneration of bone tissues. Other findings on the use of autologous tissues to accelerate the healing of bone defects in implantology and maxillofacial surgery may be found in the professional literature of recent years. Therefore, Abukawa H. et al. (2009) demonstrated in a laboratory model that mandibular bone abnormalities may be restored using autologous implants made from dental pulp tissues and bone marrow^[25]. High-resolution CT, together with histological and immunohistochemical analyses, demonstrated the method's clinical effectiveness.

CONCLUSION AND SUGGESTIONS

Therefore, the use of stem cells in dentistry is now restricted to exploratory laboratory studies. Nonetheless, the cumulative experience already suggests that this new approach has a lot of potential.

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- 13.00.00 Pedagogika fanlari
 - 13.00.01 Pedagogika nazariyasi. Pedagogik ta'limotlar tarixi
 - 13.00.02 Ta'lim va tarbiya nazariyasi va metodikasi (sohalar bo'yicha)
 - 13.00.03 Maxsus pedagogika
 - 13.00.04 Jismoniy tarbiya va sport mashg'ulotlari nazariyasi va metodikasi
 - 13.00.05 Kasb-hunar ta'limi nazariyasi va metodikasi
 - 13.00.06 Elektron ta'lim nazariyasi va metodikasi (ta'lim sohaları va bosqichlari bo'yicha)
 - 13.00.07 Ta'limda menejment
 - 13.00.08 Maktabgacha ta'lim va tarbiya nazariyasi va metodikasi
 - 13.00.09 Ijtimoiy pedagogika
 - 07.00.00 Tarix fanlari
 - 19.00.00 Psixologiya fanlari
 - 01.00.00 Fizika-matematika fanlari
 - 02.00.00 Kimyo fanlari
 - 03.00.00 Biologiya fanlari
 - 09.00.00 Falsafa fanlari
 - 10.00.00 Filologiya fanlari
 - 11.00.00 Geografiya fanlari



MAKTABGACHA VA MAKTAB TA'LIMI

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