Review Article

Titanium implants coated with stem cells: A mini-review of the impact on osseointegration

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Abstract

Introduction: Dental implants deserve increasing attention because the number of completely and partially edentulous patients is growing due to the higher life expectancy in most populations. Osseointegration is a crucial factor in the success of dental implants. This study investigated the effect of coating titanium implants with stem cells on the osseointegration of dental implants.

Methods: Databases of PubMed, Scopus, and Web of Science were searched with defined MeSH and non-MeSH keywords of implant, osseointegration, and stem cell, in the title/abstract and MeSH fields. The related articles were first selected according to the content of the title and abstract, and then the full text was assessed.

Results: Bone marrow mesenchymal stem cells and stem cells from human exfoliated deciduous teeth were shown to be useful in achieving better and accelerated osseointegration.

Conclusion: Dental implants coated with different stem cells showed encouraging results in osseointegration. These findings will help in achieving better osseointegration of implants in patients with inadequate alveolar ridge volume, or healing impairments. The maxillofacial stem cell niches might be the focus of future research for improving osseointegration. *(J Dent Mater Tech 2023;12(1): 51-54)*

Keywords: *Dental implants, implant surface coating, osseointegration, stem cells*

Introduction

Dental implants are widely used to restore dentition in patients who have lost their teeth due to trauma, caries, periodontal disease, or congenital missing of dental follicles. Today, treatment plans that include dental implants have gained increasing popularity among patients and clinicians due to better social health conditions, the global aging trend, and increased life expectancy (1). However, lower healing potentials, and insufficient quality and quantity of bone in elderly individuals, could afflict proper osseointegration and implant stability under functional loads (2, 3).

Osseointegration is a critical term in implantology that could be defined as a functional and structural connection between the implant surface and bone (4). Proper osseointegration depends on various factors, such as the implant material, the macro and microscopic characteristics of the implant surface, as well as the bone morphology and quality at the insertion site. Furthermore, an appropriate healing phase is highly crucial for the secondary stability of the implant.

Surface coating is a way of implant surface modifications, which uses growth factors, peptides, extracellular matrix proteins, and messenger molecules to help the attachment of osteogenic cells to the implant surface and enhance bone deposition (5-8). Coating the implant surface with stem cells and their exosomes and products is a novel technique to improve osseointegration (9, 10). The present study reviewed the success of osseointegration by coating dental implant surfaces with stem cells.

Materials and methods

International databases of PubMed, Scopus, and Web of Science were searched comprehensively to find relevant articles with defined MeSH and non-MeSH keywords of implant*, osseointegration, and stem cell* in the title/abstract and MeSH fields. The title and abstract of the obtained articles were checked based on the eligibility criteria and the final selection of the article was based on the assessment of the full text. The inclusion criteria were

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studies investigating the coating or recruiting of the implant surface with stem cells. All of the procedures were independently conducted by the two authors, and in cases of lacking conformity, the authors selected the articles after consulting with each other.

Results

Three studies met the inclusion criteria of this study. The results of these studies were summarized as follows:

Cao et al. (11) investigated the effect of implants loaded with stem cells from human exfoliated deciduous teeth (SHEDs) on osseointegration around implants in an animal model (mandibles of Beagle dogs). The results showed that the interthread bone was denser and thicker, and bone-to-implant contact was greater in SHEDs-loaded implants than that in the control group. These results suggested that using SHEDs-loaded implants could help achieve better and earlier osseointegration.

Omori et al. (12) investigated bone regeneration and stability around dental implants after atmospheric pressure plasma (APP) pretreatment of the implant device followed by immobilization of stem cells derived from human exfoliated deciduous teeth-conditioned medium (SHED-CM) on the implant surface. The implants were placed in the femur of dogs and the results showed enhanced new bone formation around the implants. They suggested APP pretreatment of the implant device followed by SHED-CM immobilization as an effective method to stimulate bone formation. However, in contrast with Cao et al. (11), they did not insert the implant in the jaw bone.

Marei et al. (13) evaluated the formation of periodontal structures around titanium implants in an animal study. The implants were inserted immediately after the extraction of the canine teeth of 5 goats. The authors used implants with scaffolds on the control side, and the same scaffold seeded with bone marrow-derived mesenchymal stem cells (BMMSCs) on the experimental side. The results showed earlier and better periodontal tissue with newly formed bone near the fixtures in the experimental group, implying that stem cells are efficacious in achieving better osseointegration. They suggested that the use of bone marrow stem cells with scaffolds might also be effective in regenerating the periodontal tissues around natural teeth with poor prognosis.

Discussion

Various techniques were under research to obtain proper osseointegration for dental implants. One of the most efficient approaches is coating the implant surface using natural and synthetic materials, such as metal oxide, polyether ether ketone, apatite, and Ca^{2+} (14). Some studies suggested loading the surface of the implant with stem cells as a new approach to improve osseointegration. However, since little evidence is available, this review investigated related evidence to examine the probability of this approach for future applications.

The studies evaluated in this review investigated the impact of implant surface modification by bone marrow mesenchymal stem cells (BMMSCs) or stem cells from human exfoliated deciduous teeth (SHEDs). It is believed that BMMSCs are involved in bone formation and healing on the outer surface and the inner cylinder canal of the implants. Moreover, the implant body has fissures and cracks that could be filled with the bone formed by BMMSCs (15). Some signaling pathways also impact the function of BMMSCs and osseointegration.

Other studies indicated that loading the implants with engineered exosomes produced by BMMSCs improved the activity of alkaline phosphatase, mineralization, extracellular matrix deposition, osteogenesis-related gene expression, and cell proliferation (16-21). Loading implants with BMMSCs may foster earlier and better osseointegration, especially in patients with compromised healing potentials. Some studies investigated the effect of surface coating with some medications and cellular sheets of mesenchymal stem cells on the osseointegration of implants in diabetic rat models and revealed promising results (22, 23).

Other stem cells may also be applied for loading stem cells on the implant surface. Periodontal ligament stem cells (PLSCs) were used for bone morphogenetic protein 2 gene delivery in cases with periimplantitis for re-osseointegration of the implant (24). Calcium phosphate-coated implants were also proven to be effective in the differentiation of PLSCs to osteoblasts (25). These results show the possible potential for PLSCs to be loaded on titanium implants in combination with other surface modifications to improve osseointegration properties.

Adipocyte-derived stem cells (ASC) are fast and easy in isolatable sources. Nitinol nanoparticles were indicated to improve adherence of ASCs to the implant surface; therefore, they could increase ASCs near the implant site and induce better osseointegration (26). Nitinol nanoparticles might also be able to increase adherence to other stem cells. However, further research is required to investigate this subject and whether nitinol nanoparticles, alone or with various stem cells, could impact osseointegration.

We suggest that further research should investigate whether using stem cell niches related to the dental and alveolar structures is better than other sources of stem cells. It can be assumed that the niches which are related to hard tissue formation, such as SHED, dental follicle stem cells, and stem cells from the apical papilla, might have more potential for improving osseointegration. Further research should be conducted on implants coated with stem cells in elderly and medically compromised patients as well as in animal models that have lower healing potential and bone turnover impairment. It might be possible to regenerate periodontal attachment by using stem cells and scaffolding around the natural teeth with poor prognosis and bone defects. Future studies should also elucidate the proper period of osseointegration in coated and non-coated implants.

Conclusion

Coating dental implant surfaces with stem cells obtained from different tissues might be an efficient way to improve the quality and quantity of osseointegration. The studies in this field are limited and thus further clinical studies are needed to investigate this issue.

Conflicts of Interest

There are no conflicts of interest to be declared.

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