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Modern View on the Factors of Inflammation in Peri-Implant Tissues and Methods for Its Prevention

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Abstract: This article presents a review of current studies devoted to the factors influencing the development of inflammatory processes in peri-implant tissues, as well as methods for their prevention. The key etiological factors considered include bacterial colonization, characteristics of the immune response, bone tissue quality, and the influence of systemic diseases. Particular attention is paid to the role of the quality of the implant treatment protocol, the materials and design of implants, as well as the condition of the surrounding soft tissues. Modern preventive strategies are analyzed, including improvement of oral hygiene, the use of antimicrobial coatings, correction of systemic risk factors, and refinement of surgical techniques. The paper emphasizes the need for a comprehensive approach to preventing inflammatory complications, which is an important prerequisite for successful osseointegration and the long-term durability of dental implants.

Keywords: Peri-implant tissues, inflammation, dental implants, prevention, bacterial colonization, osseointegration.

Introduction

Reducing the frequency of complications following dental implantation remains one of the pressing tasks of modern dentistry. Risk factors can be classified into general ones, which include smoking, systemic diseases, the state after radiation therapy, and others, and local ones, including unsatisfactory oral hygiene, periodontal pathologies, iatrogenic factors, as well as design features and processing of the transgingival part of the implant. Studying the inflammatory-destructive processes occurring in peri-implant tissue after implant placement contributes to the improvement of existing conservative and surgical approaches to treating such conditions. Additionally, attention is being increased to the prevention of this pathology and the factors influencing its development. The development of new surgical techniques, the improvement of prosthetics, and the creation of innovative implantation systems will contribute to increasing the service life of dental prostheses on implants, as well as improving patients' quality of life.

Over the last decade and a half, dental implantation has become a key method for treating partial and complete adentia, gaining a firm position in orthopedic dentistry. Every year, more than 2 million implants are installed worldwide, confirming the growing interest in this technology in dental practice.

Most scientific research in this field focuses on various aspects of the surgical and prosthetic stages of implantation. Methods for implantation into bone tissue have been developed and optimized. The shape of root-shaped implants from well-known manufacturers was created using computer modeling, and various types of threads are offered for different types of bone tissue.

Despite high success rates in the early postoperative period, long-term complications associated with tissue inflammation around osteointegrated implants remain a pressing issue in dentistry.

An effective solution to the problem requires a clear understanding of the nature of inflammatory processes occurring in peri-implant tissue. In modern dentistry, two main types of lesions are distinguished: peri-implantation mucositis and peri-implantitis. Peri-implantation mucositis is characterized by the inflammation of soft tissues around the implant without disrupting the

osteointegration process. In contrast, periimplantitis is an inflammatory reaction accompanied by the destruction of bone tissue around an osteointegrated implant. According to various studies, the incidence of mucositis ranges from 32-54% depending on the timing of implantation, while periimplantitis ranges from 14% to 30%. These pathologies have common etiological factors and a similar developmental mechanism, being in the same relationship as gingivitis and periodontitis, representing sequential stages of a single inflammatory-destructive process [1,2,3].

The primary cause of periimplantitis development is likely the penetration of infection from the oral cavity into the area where the implant comes into contact with bone tissue [4,5,6]. The microbial profile in this disease is well-studied and includes a wide range of aerobic and anaerobic microorganisms similar to those involved in periodontal inflammatory processes such as gingivitis and periodontitis. Among them, Prevotella intermedia, Porphyromonas gingivalis, Treponema denticola, Veillonella spp., and Branhamella catarrhalis are most frequently identified. Specific pathogens responsible for the development of periimplantitis have not yet been identified. Most of the detected microorganisms belong to conditionally pathogenic species, and some are saprophytes. The high proportion of anaerobic bacteria and their diversity complicate the determination of the leading pathogenic microorganism capable of acting as the primary factor of infection. It is likely that the nature of the inflammatory process in the peri-implant area is determined by the combined impact of several most frequently encountered pathogens and the characteristics of their interaction in the anaerobic microflora. According to several studies, in the absence of adequate treatment, peri-implantation mucositis transforms into peri-implantitis in 43% of cases within five years, while maintaining therapy reduces this figure to 18% [7,8].

Thus, studying the inflammatory-destructive processes occurring in peri-implant tissue after implant placement, as well as the body's reactions to the implant as a foreign body, contributes to the improvement of existing conservative and surgical treatment methods. This also increases attention to the prevention of this pathology and the analysis of risk factors for its occurrence.

Risk factors are divided into general and local. Common ones include smoking, systemic diseases (diabetes mellitus, cardiovascular pathologies, immunodeficiency states), and according to some researchers, the state after radiation therapy. Local factors include unsatisfactory oral hygiene, the presence of periodontal diseases in the anamnesis, iatrogenic injuries, as well as design features and quality of treatment for the transgingival part of the implant [9,10].

Research dedicated to the influence of individual factors on the condition of peri-implant tissue has shown that tobacco smoking is one of the most significant risk factors for the development of peri-implantitis [11]. According to Clementini, the annual loss of bone mass around the implant in smokers is 0.16 mm. Smoking also negatively affects the speed and quality of implant osteointegration. According to Wallowy, tobacco smoking, as well as having a history of periodontitis, increases the risk of developing periimplantitis by 4.7 times [12].

When considering systemic pathologies, special attention should be paid to the presence of diabetes mellitus. This disease is traditionally included in the list of risk factors and relative contraindications for any surgical and periodontal interventions [4, 8]. However, a number of studies do not unequivocally confirm a higher frequency of periimplantitis development in patients with diabetes mellitus. Elevated glucose levels in the blood may affect the regenerative abilities of tissues, but there is no data in scientific literature confirming a direct link between these diseases. According to M. V. Shcherbakov, the development of periimplantitis and periimplantation mukozitis may be associated with minimal thyroid insufficiency syndrome, accompanied by a decrease in the level of active thyroid hormones [13]. The author notes that women prone to hypothyroid conditions should be included in the risk group for developing these pathologies. Additionally, it is important to consider the condition of the teeth surrounding the implant [14]. The absence of proper oral sanitation can serve as a constant source of bacterial infection. Microbiological studies of patients with periodontitis showed that after antibacterial therapy, microorganisms such as Aggregatibacter actinomycetemcomitans and Porphyromonas gingivalis recover quickly, while Prevotella intermedia is constantly detected, demonstrating resistance to antibiotics. Thus, the nosological form - partial or complete adentia - can influence the composition and level of microbial contamination of tissues in the peri-implantation zone.

Methodology

This study is based on a narrative literature review of contemporary scientific publications addressing peri-implant tissue inflammation and its prevention. Relevant articles were selected from peer-reviewed journals indexed in international databases, focusing on studies published between 2011 and 2025. Inclusion criteria comprised clinical, experimental, and systematic review studies investigating etiological factors, microbiological profiles, and preventive strategies in peri-implantitis. Data extraction included analysis of bacterial colonization, host immune response, implant design, and systemic risk factors. Special attention was given to studies evaluating preventive measures such as oral hygiene protocols, antimicrobial coatings, and surgical techniques. Comparative synthesis was performed to identify consistent findings and clinically relevant patterns. The methodological approach emphasizes qualitative analysis and thematic categorization rather than statistical pooling, enabling an integrated understanding of inflammation mechanisms and preventive approaches in peri-implant tissues.

Results and discussion

According to Willson, in 81% of patients with clinical or radiological signs of inflammation, residues of cement used for fixing orthopedic structures were identified in the area of the peri-implant groove. After their removal, clinical indicators normalized in 74% of cases. Similar studies conducted by Korsh showed that removing cement residues helped reduce the inflammatory reaction in 60% of cases. Maintaining oral hygiene implies not only performing sanitation in the preparatory stages before implantation but also systematic monitoring during the postoperative period. This includes regular professional cleaning of the teeth and implant areas during scheduled examinations, the frequency of which should be determined individually and range from 2 to 4 times per year [15]. Insufficient prevention of oral diseases in patients with orthopedic structures on dental implants can lead to the accumulation of bacterial deposits, plaques, and dental stones in the neck area of the implant and the gingival part of the prosthesis. Failure to remove these deposits in a timely manner may disrupt the epithelial adherence to the implant, contributing to the formation of a pathological pocket. This, in turn, increases the risk of bone loss, the development of peri-implantitis, and subsequent loss of the prosthesis. One of the effective preventive measures is independent "mechanical control" of the coat, carried out by the patient using hand or mechanical toothbrushes.

When using two-component dental implants, a gap inevitably forms between the implant and the abatment. This area is prone to colonization by bacteria and their metabolites, which can cause inflammation of the surrounding soft tissues. To reduce the risk of developing peri-implantitis, certain measures are required from both implant system manufacturers and dentists. The quality and structural features of the implant's connection with the abatment are of paramount importance. Placing the implant connection platform at the subcristal level contributes to a significant reduction in the probability of inflammatory reactions. Additionally, applying a higher torque (25–35 N·cm) when fixing the abatment to the implant can play a preventive role if provided by the manufacturer of the specific system. To prevent microorganisms from penetrating the inner part of the implant and migrating back into the peri-implant tissues, special sealants can be used [4,9]. Research confirms the presence of bacterial leakage through the internal interface of the implant. However, the question of which specific type of connection minimizes or completely eliminates this process remains open and requires further research.

Conclusions

Thus, the problem of searching for optimal implantation technologies, as well as methods for the prevention and treatment of peri-implantitis, remains relevant to this day and includes not only the development of new surgical techniques and the use of additional measures during prosthetics, but also the creation of new implant systems that fully meet the requirements for preventing inflammatory diseases in the peri-implant zone. There is no doubt that new achievements in this direction will contribute to reducing the number of complications after implantation in dental patients and improving their quality of life.

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