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REVIEW ARTICLE

Fixed dental prostheses with controlled therapeutic drug release

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ABSTRACT

Introduction: fixed dental prostheses have improved oral rehabilitation, but peri-implant infections remain a challenge that compromises the health and longevity of implants.
Objective: to evaluate the effectiveness of controlled drug release systems in fixed prostheses to reduce infections and prolong implant durability.
Methods: a systematic review of the scientific literature was conducted across different databases, using an algorithm with keywords and Boolean operators to identify relevant sources. The selected studies, after applying rigorous inclusion and exclusion criteria, were critically assessed in terms of timeliness, methodological quality, and thematic relevance, and coherently integrated into the final synthesis of the review.
Development: the reviewed studies show that implants with controlled release reduce the incidence of infections by 35 % to 50 % compared to conventional ones. They also increase success and osseointegration rates, thanks to localized release of antibiotics and bioactive biomaterials. A combined relative risk of 0,39 was reported, confirming preventive efficacy. The integration of nanomaterials, hydroxyapatite, and supramolecular systems enhances bone regeneration and immune response, consolidating this innovation as a promising strategy in restorative dentistry.
Conclusions: controlled drug release in fixed prostheses significantly decreases peri-implant infections and improves implant longevity. These findings support its incorporation into clinical practice as a relevant advance in oral health and prosthetic rehabilitation.

Keywords: Dental Implants; Drug Liberation; Oral Health.

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INTRODUCTION

Modern dentistry has advanced significantly in recent decades, with innovations that have improved patients' quality of life. One critical area of development is fixed prosthetics, used to restore the function and aesthetics of missing teeth.[1] The incorporation of advanced technologies, such as controlled drug release systems, offers additional benefits, including infection prevention and reduced inflammation.[2] Integrating these systems into fixed prostheses not only increases treatment efficiency but also reduces systemic side effects, as drug exposure is limited to the affected areas. Research shows that controlled drug release decreases postoperative infection rates by 35 % to 50 %.[3]

Despite advances in the manufacture of fixed prostheses, the incidence of peri-implant infections is a significant challenge, affecting approximately 10–20 % of patients with dental implants.[4] Current solutions are not always effective in preventing these complications, which can lead to implant loss and the need for further treatment. Currently, one of the most important challenges in medicine is the proper management of drug administration.[5] Inaccurate dosage delivery and poor control of drug release are persistent problems that demand innovative solutions to optimize clinical outcomes and increase patient satisfaction. Implementing advanced technologies in this area can significantly transform the effectiveness of medical treatments.[6]

The integration of controlled drug delivery systems into fixed prostheses can significantly reduce infections, improving implant longevity and patients' oral health.[2] To date, few studies have explored this integration, underscoring the novelty and relevance of the project. These systems are expected to increase the success rate of dental implants by 15-25 %.[3] Furthermore, they offer a durable and less invasive solution for managing peri-implant infections, representing a significant advance in clinical practice.[7]

In relation to the above, the need arises to carry out the present review, which aimed to evaluate the effectiveness of controlled drug release systems in fixed prostheses to reduce infections and prolong the durability of implants.

METHODS

This work was conducted as a systematic literature review, following the PRISMA guidelines to ensure transparency and reproducibility. The search period was defined as between January 2018 and December 2023, with the aim of including recent studies on fixed dental prostheses with controlled drug release systems.

The databases consulted were PubMed, Scopus, Web of Science, SciELO, and Google Scholar, in addition to secondary references obtained from key articles. Grey literature was considered only in the form of conference proceedings and technical documents, provided they met quality and full access criteria.

The search strategy was designed using MeSH terms and Boolean operators: "controlled drug release" AND "fixed prosthesis" OR "peri-implant infections" OR "implant longevity". Studies in English and Spanish were included in order to encompass the most relevant literature in the field of dentistry.

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The inclusion criteria were: articles published within the defined time frame, clinical studies, systematic reviews, and meta-analyses that specifically addressed fixed prostheses with controlled drug release. Duplicates, articles without full access, opinion polls, and irrelevant publications were excluded.

The selection process was conducted in three stages: title screening, abstract review, and full-text analysis. An initial 145 records were identified, of which 35 duplicates and 82 that did not meet the inclusion criteria were excluded. Finally, 23 articles were included in the review, of which three clinical studies fully met the inclusion criteria and were analyzed in detail. Taken together, these studies provide strong evidence on the efficacy of controlled-release drug delivery systems in fixed dental prostheses.

Data extraction included variables such as author, year, methodological design, sample size, type of intervention, and main outcomes. The analysis was performed using qualitative synthesis, and where possible, meta-analysis techniques were applied to calculate effect measures such as relative risk and confidence intervals. This strategy allowed for the integration of evidence on the efficacy of controlled-release systems in preventing peri-implant infections and improving implant longevity.

DEVELOPMENT

All three studies agree in pointing to a significant reduction in infections in the groups receiving controlled-release antibiotics compared to conventional controls. Freischmidt H et al.,[8] reported an incidence of 10 % in the intervention group versus 30% in the control group; Gulati et al.,[9] observed 8 % versus 22 %; and Sbricoli L et al.,[10] reported 12 % versus 25 %. These results are reflected in relative risks (RR) ranging from 0,33 to 0,48, all with 95 % confidence intervals that confirm preventive efficacy. The random-effects meta-analysis consolidated these findings, showing a pooled RR of 0,39 (95 % CI: 0,28–0,54; $p<0,001$), indicating a reduction of nearly 60 % in the risk of infection.

The survival rate and clinical success were consistently higher in the controlled-release groups. Freischmidt H et al.,[8] reported 95 % success versus 80 % in the controls; Gulati et al.,[9] reported 90 % versus 75 %; and Sbricoli L et al.,[10] reported 92 % versus 78 %. Although the definitions of "success" varied among studies, the overall trend points to a substantial improvement in osseointegration and implant durability.

The integration of the results suggests that controlled-release systems not only reduce the incidence of peri-implant infections but also promote bone regeneration and the immune response, thanks to the use of nanomaterials, hydroxyapatite, and supramolecular designs. These findings position controlled drug release as a promising strategy for optimizing clinical outcomes in restorative dentistry.

The main findings of this study indicate that integrating controlled drug delivery systems into fixed prostheses can significantly reduce the incidence of peri-implant infections and, at the same time, improve the longevity of dental implants.[8] The evidence gathered shows that the reviewed studies report a consistent reduction in infection rates, with an average decrease of nearly 50 % compared to traditional implants.[3] This finding not only has direct clinical implications but also opens the door to new lines of research in restorative dentistry, where the prevention of infectious complications is one of the main challenges. The implementation of these

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emerging technologies promises a substantial advance in dental practice, benefiting both patients, by ensuring safer and longer-lasting treatments, and professionals, who have innovative tools to optimize therapeutic outcomes and reduce the need for additional interventions.[11]

These results suggest that controlled drug delivery systems offer highly effective prevention against peri-implant infections by providing sustained and localized release of therapeutic agents.[12] This mechanism of action represents an advantage over conventional systemic administration, as it allows the drug to be concentrated at the site of risk, decreasing the exposure of the rest of the body and, therefore, the associated side effects.[13]

In this respect, treatment efficiency is significantly increased, as more precise dose control and prolonged action are achieved. Within the context of the proposed hypothesis, the results confirm that incorporating these technologies into fixed prostheses not only increases implant longevity but also significantly reduces postoperative infectious complications, resulting in improved quality of life for patients and greater clinical predictability for professionals.[14]

The effectiveness of hydroxyapatite as a drug delivery system in dental implantology is reported in the literature, demonstrating that this biomaterial acts as an effective vehicle for the controlled release of drugs, improving osseointegration and reducing peri-implant infections.[15] In a study developed Shayeb MA et al.,[16] the implementation of bioactive materials in dental implants is discussed, highlighting the ability of hydroxyapatite to promote bone regeneration and serve as a matrix for drug release, which increases the durability and functionality of the implants.

In addition, Anil S et al.,[17] investigated the modification of implant surfaces using layer-by-layer electrostatic self-assembly techniques, finding that these modifications significantly improve osseointegration and reduce infection rates. Taken together, these studies reinforce the idea that combining advanced biomaterials and surface engineering techniques is a promising strategy for enhancing the effectiveness of dental implants.

Szwed-Georgiou A et al,[18] discussed the use of biomimetic supramolecular designs for the controlled release of growth factors in bone regeneration, providing evidence that this approach improves implant integration and accelerates tissue repair processes. Their findings align with the objectives of this study, demonstrating that controlled drug release can be applied not only to antibiotics but also to bioactive molecules that promote osseointegration.

A study by Wang S et al.,[19] analyzes how controlled-release growth factor systems positively influence bone regeneration and osseointegration, confirming the relevance of this approach in modern implantology. The agreement between both studies underscores the importance of controlled release as a cross-cutting tool in restorative dentistry, capable of addressing both infection prevention and the stimulation of bone regeneration.

For their part, Alshimaysawee S et al.,[20] detail in their article the recent advances in drug-eluting metallic implants, highlighting the importance of these devices in preventing infections and promoting osseointegration. This study supports previous findings on the effectiveness of controlled-release systems in improving the longevity of dental implants. This, in turn, is supported by Freischmidt H, et al.[8]

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Complementarily, the article "Drug release systems in implantology: Current developments and future perspectives" highlights the integration of drug release systems in metallic implants as an effective strategy to optimize osseointegration and prevent infectious complications, thus reinforcing the previous conclusions.[21] The convergence of these results confirms that the application of controlled release technologies in metallic implants constitutes an innovation with high potential for clinical impact.

In another relevant study, Moon KS et al.,[22] highlighted how the release of biomaterials and growth factors could modulate the immune response and promote osteoconduction, providing evidence that controlled-release systems not only act on infection prevention but also on the interaction of the implant with the host's immune system. These results are consistent with the hypothesis of our study, which posits that controlled release can improve the host body's response and promote implant integration.[9]

Oirschot BAJA et al.,[23] analyze the importance of biomaterials with immunomodulatory capabilities in promoting osteoconduction and implant integration, highlighting that the combination of bioactive and immunomodulatory properties is a key factor for the success of dental implants. The similarity between both studies emphasizes the relevance of bioactive materials and controlled release as fundamental pillars for ensuring the efficacy and safety of implant treatments.

CONCLUSIONS

This study confirms that controlled-release drug delivery systems in fixed dental prostheses reduce peri-implant infections by an average of 50 % compared to traditional implants, while simultaneously improving their longevity and functionality. The sustained and localized release of therapeutic agents increases treatment efficacy and decreases systemic side effects, reinforcing their value as an innovation in restorative dentistry. Taken together, the findings support the incorporation of these technologies as a strategy capable of optimizing clinical outcomes, extending implant lifespan, and transforming dental practice for the benefit of patients.

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