INPLASY

Mapping Connections Between Abutment Surface Properties, Cellular Behavior and Peri-Implant Outcomes: A Systematic Review.

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ADMINISTRATIVE INFORMATION

Support - No support.

Review Stage at time of this submission - Formal screening of search results against eligibility criteria.

Conflicts of interest - None declared.

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Amendments - This protocol was registered with the International Platform of Registered Systematic Review and Meta-Analysis Protocols (INPLASY) on 10 September 2026 and was last updated on 10 September 2026.

INTRODUCTION

Review question / Objective In patients with dental implants, what is the effect of unmodified compared with modified titanium transmucosal abutment surfaces on surface properties, cellular and bacterial behaviour, peri-implant soft-tissue healing, and clinical, radiographic, histological, and aesthetic outcomes?.

Rationale The transmucosal portion of dental implants plays a critical role in the establishment and maintenance of peri-implant soft-tissue health. Titanium is widely used for transmucosal abutments because of its favourable mechanical properties and biocompatibility; however, the surface characteristics of these components may influence protein adsorption, cellular adhesion and behaviour, bacterial colonisation, and the formation of a stable soft-tissue seal.

Several surface modifications of titanium transmucosal abutments have been developed with the aim of improving their biological interaction with peri-implant tissues. These modifications can alter physicochemical surface properties, such as roughness, wettability, surface energy, and chemical composition, which may subsequently affect cellular and bacterial responses. However, the available evidence is heterogeneous in terms of surface treatments, experimental models, evaluated outcomes, and clinical applicability.

Previous reviews have primarily focused on specific aspects of titanium abutment surface modification or on individual biological outcomes. A comprehensive synthesis integrating physicochemical surface characteristics with cellular and bacterial behaviour, preclinical tissue responses, and clinical and radiographic outcomes is currently lacking. Therefore, a systematic review is warranted to map and critically evaluate the available evidence regarding the effects of

modified compared with unmodified titanium transmucosal abutment surfaces.

This review aims to provide an integrated overview of the relationship between transmucosal abutment surface characteristics and biological and clinical responses, identify areas of consistency and uncertainty in the current evidence, and highlight gaps that may guide future laboratory and clinical research.

Condition being studied Peri-implant soft-tissue health is a key determinant of the long-term stability and maintenance of dental implants. Following implant placement and prosthetic loading, the transmucosal abutment establishes a direct interface with the surrounding peri-implant soft tissues. The formation of a stable soft-tissue seal around this interface is essential for maintaining tissue homeostasis and limiting the penetration of microorganisms and inflammatory stimuli towards the underlying peri-implant tissues.

The biological response at the transmucosal interface is influenced by the characteristics of the abutment surface. Surface properties may affect protein adsorption, cellular adhesion, proliferation and differentiation, collagen deposition, bacterial adhesion and biofilm formation, and consequently the quality and stability of the peri-implant soft-tissue seal. An unfavourable biological response may contribute to soft-tissue inflammation and, potentially, to the progression of peri-implant disease and marginal tissue or bone alterations.

Titanium is the most commonly used material for transmucosal abutments, and different surface modifications have been investigated to improve their interaction with peri-implant tissues. However, the biological and clinical relevance of these modifications remains uncertain, with findings varying according to the type of surface treatment, experimental model, and outcome assessed.

This review therefore focuses on peri-implant soft-tissue health and healing in relation to the surface characteristics of titanium transmucosal abutments, considering evidence from in vitro, preclinical, and clinical studies.

METHODS

Search strategy A systematic literature search was conducted in PubMed/MEDLINE, Embase, and Web of Science. The search strategy was developed to identify studies investigating the influence of titanium transmucosal abutment surface characteristics or modifications on biological, microbiological, preclinical, and clinical outcomes.

The search strategy was adapted to the specific indexing systems and search syntax of each database. In PubMed/MEDLINE, Medical Subject Headings (MeSH) and free-text terms were used. In Embase, Emtree terms and free-text terms were applied. In Web of Science, topic searches using relevant free-text terms were performed. The search strategies combined terms related to dental implants and transmucosal abutments with terms related to titanium, surface characteristics, and surface modification.

The complete search strategy for each database, including the specific search terms and Boolean operators, was documented separately. In addition, the reference lists of the included studies and relevant reviews were screened manually to identify potentially eligible studies not retrieved through the electronic database searches.

Participant or population The review will include in vitro, preclinical animal, and clinical studies.

For in vitro studies, eligible models will include cell lines representative of peri-implant soft tissues, such as gingival fibroblasts and keratinocytes, exposed to unmodified or surface-modified titanium substrates representative of transmucosal abutment surfaces. Studies using relevant microbiological models to evaluate bacterial responses to these titanium surfaces will also be considered.

For preclinical studies, eligible animal models will be those evaluating peri-implant tissues in relation to titanium transmucosal abutments or their surface characteristics.

For clinical studies, the population will comprise adults aged ≥18 years with dental implants restored with unmodified or surface-modified titanium transmucosal abutments. Studies involving participants younger than 18 years will be excluded. No restrictions will be applied regarding sex, implant location, or follow-up period.

Intervention The intervention of interest is the use of surface-modified titanium transmucosal abutments or titanium surfaces intended to represent transmucosal abutment surfaces. Eligible surface modifications may include, but are not limited to, anodization, coatings, chemical or physicochemical treatments, surface functionalization, and other modifications designed

to alter the physicochemical or biological properties of the titanium surface.

The intervention will be evaluated in comparison with unmodified titanium transmucosal abutments or unmodified titanium surfaces representative of transmucosal abutments. Studies will be eligible when the surface modification is the primary difference between the intervention and comparison groups and its potential influence on surface properties, cellular or bacterial behaviour, peri-implant soft-tissue responses, or clinical and radiographic outcomes is assessed.

Comparator The comparator will be unmodified titanium transmucosal abutments or unmodified titanium surfaces representative of transmucosal abutment surfaces. Studies will be eligible when the comparator represents the conventional or untreated titanium surface and is directly compared with a surface-modified titanium intervention.

No specific type of unmodified titanium surface will be required, provided that it is comparable to the modified titanium surface in terms of its intended use or experimental representation of a transmucosal abutment.

Study designs to be included The review will include in vitro studies, animal studies, and clinical studies, including randomized trials and prospective or retrospective observational studies.

Eligibility criteria Studies will be considered eligible when they directly investigate or compare unmodified and surface-modified titanium transmucosal abutments, or experimental titanium surfaces representative of transmucosal abutments, and report at least one relevant physicochemical, cellular, bacterial, histological, clinical, radiographic, or aesthetic outcome.

Eligible study designs will include in vitro studies, animal studies, randomized clinical trials, and prospective or retrospective observational clinical studies. No restrictions will be applied based on publication language.

Studies will be excluded when none of the comparative groups involves titanium, when the study does not evaluate the influence or characteristics of the abutment surface, or when the full text is unavailable. Case reports, case series, letters to the editor, narrative reviews, systematic reviews, meta-analyses, opinion articles, conference abstracts without sufficient data, and studies with duplicated populations will also be excluded. When multiple publications report data from the same study population, the most complete or relevant report will be retained.

Information sources The literature search was conducted using three electronic bibliographic databases: PubMed/MEDLINE, Embase, and Web of Science. These databases were selected to provide broad coverage of the biomedical, dental, and multidisciplinary literature relevant to dental implant abutments and peri-implant tissues.

The search strategies were adapted to the specific indexing systems and search interfaces of each database and included both controlled vocabulary and free-text terms, as applicable. The reference lists of all studies considered eligible for inclusion were manually screened to identify additional relevant publications. The reference lists of relevant systematic and narrative reviews were also screened to identify potentially eligible studies that may not have been retrieved through the electronic database searches.

No restrictions based on publication language were applied.

Main outcome(s) This review will assess the effects of modified, compared with unmodified, titanium transmucosal abutment surfaces on peri-implant soft-tissue responses and related biological outcomes.

In vitro outcomes will include physicochemical surface properties, cellular behaviour and biological responses, such as cell adhesion, viability, proliferation, collagen production, gene and protein expression, and inflammatory responses. Bacterial outcomes will include bacterial adhesion, biofilm formation, and bacterial viability.

In animal and clinical studies, the main outcomes will include peri-implant soft-tissue healing and health, histological and morphological parameters, inflammatory responses, marginal bone changes, clinical peri-implant parameters, aesthetic outcomes, and patient-reported outcomes when available.

Outcomes will be assessed at the time points reported in the individual studies. Because of the expected heterogeneity in study designs and outcome measurements, results will be reported using the effect measures derived from the original data, including mean differences or standardized mean differences for continuous outcomes and

risk ratios or odds ratios for dichotomous outcomes, where applicable.

Additional outcome(s) Additional outcomes will include adverse events and complications, prosthetic outcomes, and other treatment-related outcomes reported by the included studies.

The timing of outcome assessment will correspond to the experimental time points or clinical follow-up periods reported in each individual study.

Data management Records retrieved from the electronic database searches were imported into Zotero for reference management and organisation. Duplicate records were identified and removed before the study selection process. The resulting records were then imported into Rayyan to facilitate the organisation and management of the screening process.

Titles and abstracts were screened manually, followed by manual assessment of the full texts of potentially eligible studies. No automated screening or machine-learning tools were used.

Data from the included studies were extracted manually using a predefined data extraction process. Relevant information was recorded systematically, including study characteristics, study design, population or experimental model, characteristics of the titanium abutment surfaces, intervention and comparator characteristics, outcome measures, assessment time points, and main findings.

The records and extracted data were managed and stored by the review team throughout the review process.

Quality assessment / Risk of bias analysis The methodological quality and risk of bias of the included studies will be assessed independently by two reviewers using validated assessment tools appropriate to the design of each study.

Different tools will be applied according to study design, including appropriate instruments for in vitro studies, animal studies, randomized clinical trials, and observational clinical studies. The domains assessed will include, where applicable, study design and methodology, selection of participants or experimental models, intervention and comparator characteristics, outcome assessment, completeness of data, and potential sources of bias.

Any disagreements between the reviewers will be resolved through discussion and consensus. If consensus cannot be reached, a third reviewer will be consulted.

The results of the quality and risk-of-bias assessments will be presented separately according to study design and will be considered when interpreting the findings of the review.

Strategy of data synthesis The findings of the included studies will be synthesised according to study design, type of titanium surface modification, experimental or clinical setting, and outcome domain.

A narrative synthesis will be performed to summarise and compare the available evidence across in vitro, animal, and clinical studies. Study characteristics, intervention and comparator characteristics, outcome measures, assessment time points, and main findings will be presented in structured tables and summarised descriptively.

If a sufficient degree of clinical, methodological, and outcome homogeneity is identified among studies, a quantitative synthesis may be performed. Where quantitative synthesis is considered inappropriate because of substantial heterogeneity or differences in study characteristics or outcome assessment, the findings will be synthesised narratively.

The results will be interpreted considering the methodological quality and risk of bias of the included studies.

Subgroup analysis Where sufficient data are available, subgroup analyses may be performed according to study design, type of surface modification, experimental or clinical setting, and outcome domain.

Subgroup analyses will only be undertaken where sufficient methodological and clinical homogeneity exists to allow meaningful comparisons between groups.

Sensitivity analysis Where quantitative synthesis is performed, sensitivity analyses may be conducted to assess the robustness of the findings. These analyses may include excluding studies considered to have a high risk of bias or studies with substantially different methodological characteristics.

Sensitivity analyses will only be performed where sufficient data are available and their application is considered appropriate.

Language restriction No language restrictions will be applied. Studies published in any language will be considered for inclusion if they meet the predefined eligibility criteria.

Country(ies) involved Spain.

Keywords titanium transmucosal abutments; surface modification; anodization; peri-implant soft tissue; soft tissue integration; biological response.

Dissemination plans The findings of this systematic review will be disseminated through publication in a peer-reviewed scientific journal and through presentations at relevant scientific meetings and academic conferences.

Contributions of each author

Author 1 - Claudia Salavert Martínez - The author conceived and designed the review, conducted the data analysis, and drafted and revised the manuscript.
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