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Antibacterial activity of titanium nitride coating: a mini review

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Abstract. Bacterial adhesion to the implant surface was the first step of peri-implant inflammation. Changes in the properties of the implant surface represent a way to reduce plaque colonization. The aim of this study was to evaluate the actual efficacy of titanium nitride (TiN) coated implants on antibacterial activity. Data were collected after identification of PICO. A search was performed in PubMed-Medline, Embase, Web of Knowledge, and Google Scholar using the following keywords: "Titanium nitride, dental implant coating, antibacterial activity, biofilm formation, plaque formation, modified implant surfaces, implant abutments". The original search included 107 articles. After title and abstract screening, the number was reduced to 12. These articles were read in full text, and finally 5 articles were included in the mini-review. TiN-coated titanium appears to reduce bacterial adhesion and growth and may represent a real possibility for preventing peri-implantitis and mucositis. However, further clinical studies need to be conducted.

Keywords: systematic review, titanium nitride, antibacterial activity, dental implant coating, peri-implantitis, bacterial adhesion.

INTRODUCTION

The long- term stability of dental implants depends on the integration of the biomaterial with the tissues surrounding the implants, i.e., bone and soft tissue, epithelium and fibrocollagenous connective tissue. Maintenance of a healthy connective tissue-implant interface is a critical issue for long-term implant survival. (Adell et al. 1981) Peri-implant inflammation, mucositis and peri-implantitis, represent the most common complications of dental implants (22%) and may be responsible for implant loss. (Derks and Tomasi 2015) The initial stage in the pathogenesis of peri-implant inflammation is caused by plaque colonization and bacterial adhesion to the implant surface. Therefore, it is essential to prevent bacterial adhesion to hard or soft tissue.(Abrahamsson et al. 1996) (Abrahamsson et al. 2002) Modifications of

implant surface characteristics could affect the biocompatibility and osteointegration of dental implants. TiN coating was introduced in dentistry in the 1980s. The aim of the coating is to achieve greater surface hardness, abrasion/wear resistance and corrosion resistance, lower friction, and better interaction with adjacent biological and material substrates. Physical vapor deposition (PVD) is the most common method for depositing TiN on orthopedic implants, and TiN is formed by the reaction of pure titanium and nitrogen gas in a vapor phase prior to deposition («Mezger, P.R.; Creugers, 1992) (Yeniyol et al. 2013).The aim of this study was to evaluate the antibacterial properties of TiN coating on dental implants on microbial biofilm adhesion and bacterial growth suppression.

MATERIAL AND METHODS

This review was performed in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-analyses) statement (Fig. 1).

A search was performed on PubMed-Medline, Embase, Web of Knowledge, Google Scholar including the following keywords: "Titanium nitride, dental implant coating, antibacterial activity, biofilm formation, plaque formation, modified implant surfaces, implant abutments".

The review included in vitro studies comparing the antibacterial activity of titanium nitride coatings with that of pure titanium, evaluating the percentage of titanium surface covered by bacteria.

In vitro studies were selected based on title and abstract. The participants, intervention, comparison, and outcomes (PICO) were determined to formulate a specific question: How effective is the antibacterial effect of TiN?

RESULTS

The initial search included 105 articles. It was reduced to 11 after title and abstract screening. These articles were full-text read and finally 5 articles were included in the mini review (Fig. 1).

All the studies included in this review were in vitro study (Table 1).

DISCUSSION

The main objective of this study was to determine the efficacy of the antibacterial activity of TiN used as a coating for implant abutments. The investigation was based on in vitro studies comparing TiN-coated titanium disks with uncoated pure titanium disks.

Großner-Schreiber et al. (2001) investigated the effect of titanium nitride coating on bacterial adhesion of S. sanguis and S. mutans compared to a pure titanium surface and concluded that "a significant reduction in the number of adherent bacteria was observed on inherently stable titanium hard materials such as TiN compared to polished titanium"," with a statistically significant difference (p=0.0036) (Größner-Schreiber et al. 2001).

Zhang et al. (2015) showed no difference in biofilm formation between TiN-coated disks and pure titanium disks (Zhang et al. 2015).

Ji et al. (2015) showed that the number of S.mutans colonies on TiN significantly decreased ($p < 0.05$) compared to the control group (Ji et al. 2015).

Brunello et al. (2018) showed that the percentage of dead bacteria in the biofilms that grew on the TiN-coated disks was higher than in the pure titanium disks (Brunello et al. 2018).

Finally,Camargo et al. (2020) concluded their study by stating that biofilm coverage was lower on TiN (24.22%) compared to uncoated samples (85.2%). $p < 0.05$ (Camargo et al. 2020).

The results of this mini-review demonstrate that TiN-coated titanium can effectively reduce bacterial adhesion and the percentage of titanium surface covered by bacteria.

CONCLUSION

We were able to answer the PICO question "How effective is TiN in terms of antibacterial activity?" and confirm that TiN coating suppresses bacterial adhesion and growth on the titanium surface compared to pure titanium.

TiN-coated implants and abutments could be an effective way to reduce mucositis and peri-implantitis, thus improving the long-term stability of implants.

Furthermore, only in vitro studies were performed in this study; further clinical investigations need to be performed to confirm these results.

REFERENCES

Abrahamsson et al. "The mucosal attachment to titanium implants with different surface characteristics: an experimental study in dogs." *Journal of Clinical Periodontol*ogy 2002

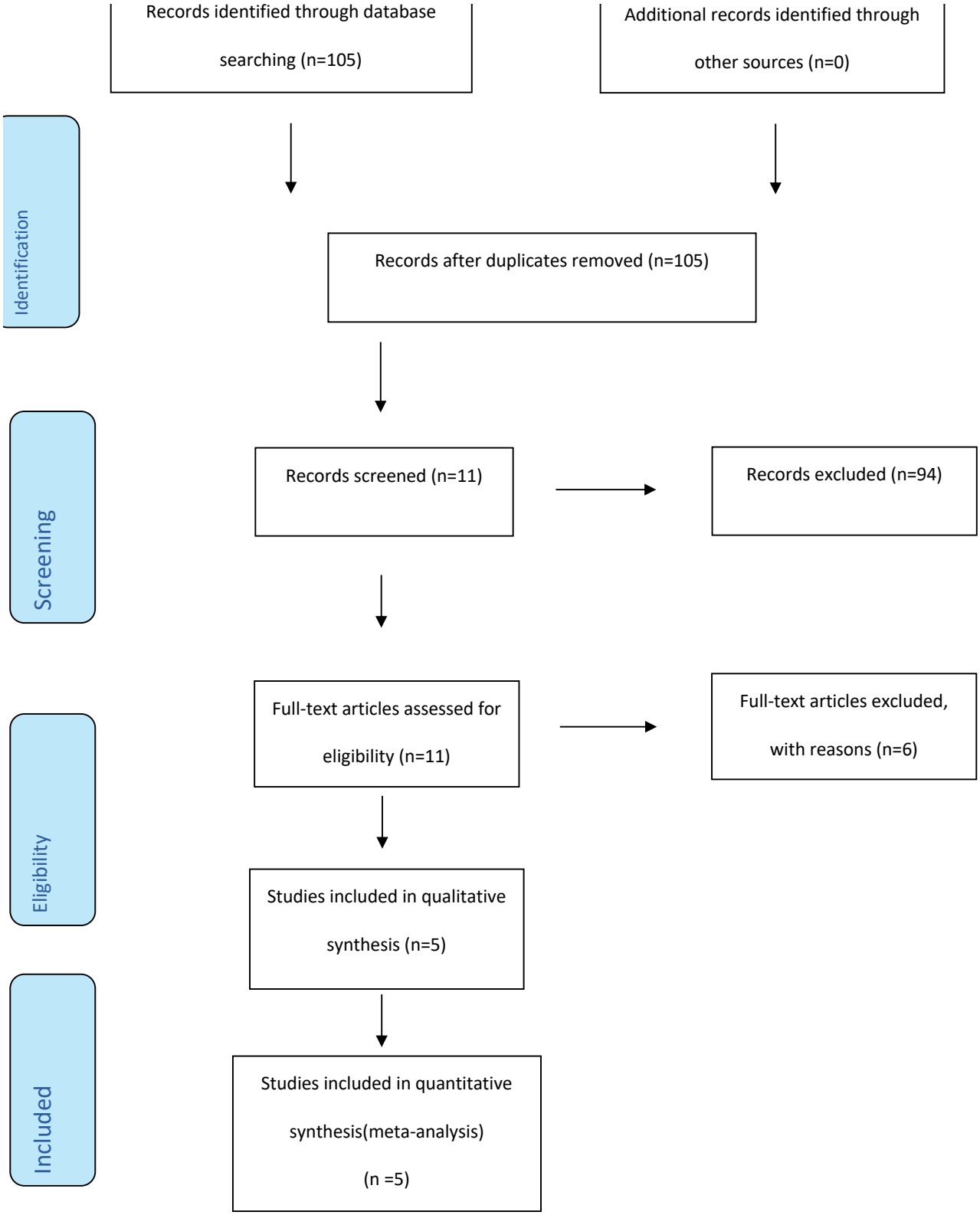

Figure 1. PRISMA Flow Diagram.

Table 1.

Author (Year)	Study design	Coating	Control group	Bacteria used	Influence of coating on bacteria
Großner-Schreiber et al. (2000)	In vitro	TiN	Pure titanium discs grade 2	*S. sanguis* *S. mutans*	Significantly lower number of bacteria on TiN coated discs (p=0.0036)
Zhang et al. (2015)	In vitro	TiN	Commercial pure titanium grade 2	*S. mutans* *A. viscosus* *P. gingivalis*	No difference in biofilm formation
Ji et al. (2015)	In vitro	TiN	Commercially pure titanium grade 2	*S. mutans* *P. gingivalis*	Number of S.mutans colonies on TiN decreased significantly (p<0.05)
Brunello et al. (2018)	In vitro	TiN	TiAl6V4, grade 5, disks	*S. sanguis* *S. salivarius* *S. mutans* *S. sobrinus* *S. oralis*	Percentage of dead bacteria was higher in the biofilms grown on the TiN coated disks
Camargo et al. (2020)	In vitro	TiN	High pure titanium	*P. gingivalis*	Biofilm coverage was lower in TiN (24.22%) compared to uncoated samples (85.2%) p<0.05

Abrahamsson et al. "The peri-implant hard and soft tissues at different implant systems. A comparative study in the dog." *Clin Oral Implants Res*. 1996

Adell et al." A 15-year study of osseointegrated implants in the treatment of the edentulous jaw." *Int J Oral Surg*. 1981

Brunello et al. "Biocompatibility and antibacterial properties of zirconium nitride coating on titanium abutments: An invitro study" *Plos One 2018*

Camargo et al. "Novel Coatings to Minimize Bacterial Adhesion and Promote Osteoblast Activity for Titanium Implants" *Materials 2021, 14, 342*.

Derks J.; Tomasi C. "Peri-implant health and disease. A systematic review of current epidemiology." *Journal of Clinical Periodontology 2014*

Großner-Schreiber et al. "Plaque formation on surface modified dental implants: An in vitro study" *Clinical Oral Implants Research* 2001

Ji et al. "Evaluation of antibacterial activity and osteoblast-like cell viability of TiN, ZrN and (Ti1-xZrx)N coating on titanium" *J Adv Prosthodont 2015;7:166-71*

Mezger, P.R.; Creugers, N.H. "Titanium nitride coatings in clinical dentistry." *J. Dent. 1992*

Yeniol et al. "Relative Contributions of Surface Roughness and Crystalline Structure to the Biocompatibility of Titanium Nitride and Titanium Oxide Coatings Deposited by PVD and TPS Coatings" *ISRN Biomaterials 2013*

Zhang et al. "Tantalum Nitride-Decorated Titanium with Enhanced Resistance to Microbiologically Induced Corrosion and Mechanical Property for Dental Application" *Plos One 2015*