The Antimicrobial and Mechanical Effects of Zeolite Use in Dental Materials: A Systematic Review

Jessica Hao[1], Spencer Lang[2], Francis Mante[2], Kresimir Pavelic[3], Fusun Ozer[2]

Contact: haoje@sas.upenn.edu

Introduction

- Zeolite, an aluminosilicate, has a unique porous structure that allows for the controlled uptake and release of inorganic ions [1,2].
- Zeolite can take up antimicrobial silver and zinc ions (AgZ/ZnZ) to selectively inhibit the growth of pathogenic oral bacteria [3].
- Published dental materials literature on the antimicrobial effects and mechanical properties of zeolite was reviewed **to determine if adding silver (and/or zinc) zeolite to dental materials would increase the antimicrobial effectiveness without inhibiting the materials' strength and hardness.**

Methods

- **Databases:** PubMed, Ovid Medline, Scopus, Embase, and the Dentistry & Oral Sciences Source, ProQuest Dissertations & Theses Global and Trip Database
- No limits were set on the year or language of the publication.
- **Inclusion Criteria:** Full-text studies that pertained to the usage of zeolite in dental materials such as composite resin, bonding agents, cements, restorative root material, cavity base material, prosthesis, implants, and endodontics.
- **Exclusion Criteria**: Zeolite used in oral rinses, oral medicaments, or tissue conditioners. Literature reviews and abstracts.

Results

The database, grey literature, and reference search yielded 1534 studies. After exclusion of duplicates and application of inclusion and exclusion criteria, 35 full-text articles were eligible for review. Specifically, 17 studied antimicrobial effects, 12 studied mechanical properties, and 6 studied both properties.

Discussion

The 35 selected articles were grouped into four major categories based on the type of dental material tested: dental restorations, endodontics, prosthesis, and implants.

		Antimicrobial Properties	Mechanical Properties
Dental Restorations	Glass Ionomer Cements	Depending on AgZ or ZnZ concentration, GIC can have enhanced and sustained antimicrobial properties. Results may be affected by the use and type of GIC, and this should be a topic of further research.	▸**Shear Bond Strength**: change depended on the type and use of the GIC. ▸**Compressive Strength**: ↑ with 1% wt AgZ, ↓ with higher than 3% wt AgZ.
	Resin Cement	AgZ and ZnZ inhibited *S. mutans* and *S. mitis* but not *S. salivarius* and *S. sanguis* . Greater AgZ or ZnZ did not lead to greater antimicrobial activity.	**Compressive strength** and **flexural strength** either improved or stayed the same after zeolite was modified with active diazonium
	Bonding Agents	↑ exchange time between AgZ and environmental ions ↓ biofilm formation of *S. mutans, S. gordonii,* and *S. sanguinis.*	Pretreating dentin with ZnZ ↑ **shear bond strength** between dentin and alloys using dental adhesives.
Endodontics	Root Canal Irrigants	AgZ isn't as effective of a root canal irrigant as 5% Sodium hypochlorite, 2% Chlorhexidine, and 0.10% Octenidine (OCT)	Further studies are needed
	Calcium Hydroxide	When AgZ is added to $Ca(OH)_2$, antimicrobial properties against *E. faecalis* is enhanced compared to the control or when chlorhexidine is added.	Further studies are needed
	MTA	2% AgZ, the concentration with the greatest ion-release and antimicrobial effects, is effect against *E. faecalis, S. aureus, and C. albicans* but not against *P. intermedia* and *A. israelii* .	Negatively affected **setting time, water absorption, push-out bond strength** and **compressive strength**.
Prosthesis	Non-Acrylic Resin	Adding AgZ to soft liners improved its antimicrobial properties against *C. albicans* and gram-negative bacteria	Sodalite zeolite ↑ **bond strength, flexural strength, Vickers hardness, fracture toughness, and elastic modulus**
	Acrylic Resin	AgZ and Ag-Zn-Ze may be potentially viable options against *S. mutans, F. nucleatum,* and *C. albicans*	Adding >2.5% AgZ, depending on the type of acrylic resin, will significantly reduce the **impact, flexural, tensile, and bending strength.**
Implants		Coating titanium implants with AgZ inhibits methicillin-resistant S. aureus growth	Further studies are needed

Conclusions

- Silver and/or zinc incorporated zeolite can improve the antimicrobial properties of dental materials.
- **Non-acrylic prosthetic materials**: ↑ mechanical and antimicrobial properties
- **GIC**: greatest antimicrobial effectiveness with 2% zeolite wt while maintaining mechanical properties between 1-3% zeolite wt. *Therefore, use 2% zeolite wt to optimize both factors.*
- **MTA and acrylic prosthetic materials**: Since they showed the greatest ↓ in mechanical properties, lower concentrations such as 0.2-2% wt are recommended.

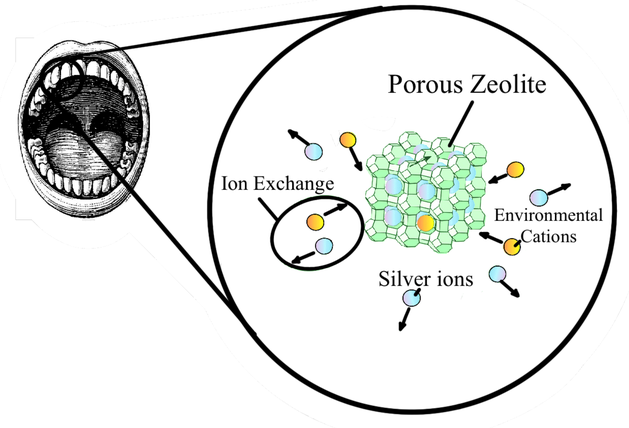

Figure 1: The release of silver ions by zeolite in exchange for environmental cations.

Works Cited

1. Pavelić S, et al. Critical review on zeolite clinoptilolite safety and medical applications in vivo. Frontiers in Pharmacology.
2. Derakhshankhah H, et al. Biomedical applications of zeolitic nanoparticles, with an emphasis on medical interventions. International Journal of Nanomedicine.
3. Sivakumar I, et al. Incorporation of antimicrobial macromolecules in acrylic denture base resins: a research composition and update. Journal of Prosthodontics.

[1] School of Arts and Sciences, University of Pennsylvania, Philadelphia, PA, USA
[2] University of Pennsylvania School of Dental Medicine, Philadelphia, PA, USA
[3] Juraj Dobrila University of Pula, Pula, Croatia