LSU Health NEW ORLEANS School of Dentistry

Comparisons of Antibacterial Properties of New Commercial MTA Products

Tran M., O'friel G., Wen Z., Roberts SM
Department of Pediatric Dentistry
Louisiana State University School of Dentistry, New Orleans, LA

INTRODUCTION

Untreated dental caries can rapidly advance to the dental pulp, requiring more invasive treatments like pulpotomies or root canal therapy. MTA has since gained widespread popularity in pediatric dentistry due to its favorable biocompatibility, excellent sealing properties, and antibacterial effects and it is endorsed by the American Academy of Pediatric Dentistry (AAPD). Limited research compares the antibacterial properties of newer MTA formulations to widely used products like ProRoot MTA and MTA Angelus. Despite their promise, comparative data on these formulations' antibacterial profiles remain limited, leaving clinicians without clear guidance for material selection in pediatric pulp therapy. these newer MTA products often differ in their ratios of tricalcium silicate to dicalcium silicate, which may influence the material's ability to form calcium hydroxide and, consequently, its antibacterial efficacy.

OBJECTIVES

This study aims to evaluate and compare the antibacterial properties of newer MTA formulations from NuSmile, Sprig, and Ultradent. The goal is to help clinicians identify the most effective MTA product for preventing caries progression in pediatric patients.

METHODS

Agar Diffusion Assay

Each MTA product will be placed in petri dishes containing agar inoculated with Streptococcus mutans, Enterococcus faecalis, Lactobacillus spp., and Candida albicans. After a 24-hour incubation period, zones of inhibition will be measured using a ruler with 0.5 mm precision. For enhanced accuracy, additional measurements will be conducted under a microscope.

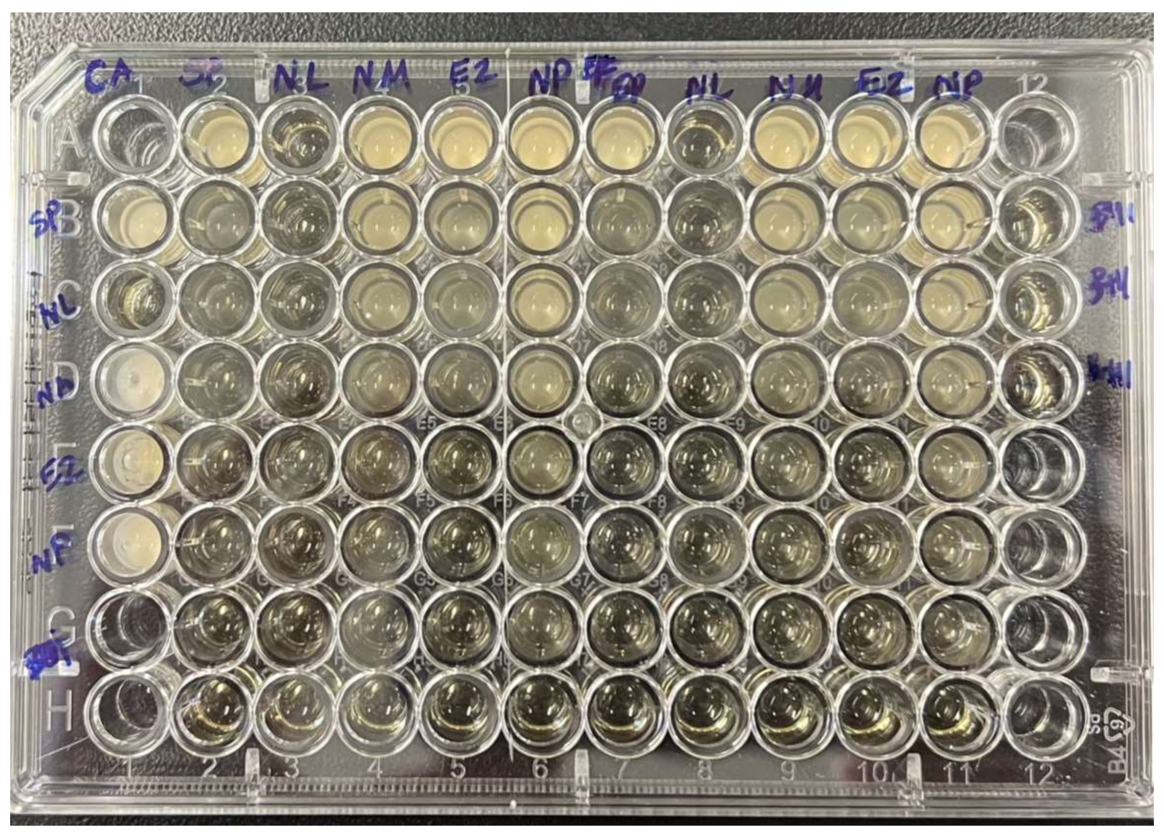
Broth Dilution Assay

In a second approach, each MTA product will be dissolved in selective media at a concentration of 50 mg/mL, following the method described by Kim et al.. A volume of 180 µL of the bacterial media will be dispensed into each well of a 96-well microtiter plate. The assay will be performed in triplicate to quantify the remaining colony-forming units (CFUs) for each bacteria–material combination. Both positive (MTA in assay media) and negative (sterile BHI broth) controls will be included for comparison.

MATERIALS & COMPOSITION

Ingredients	NuSmile NeoPutty	NuSmile NeoMTA2 Powder	NuSmile NeoLiner	Sprig SmartMTA Capsule	Ultradent EndoEze MTAFLOW Powder
Tricalcium Silicate	<25%	<50%	Not reported	61%	<50%
Dicalcium Silicate	<10%	<20%	Not reported		<20%
Tricalcium Aluminate	<1%	<5%	Not reported		
Silicone Dioxide			Not reported	11.7%	
Aluminum Dioxide			Not reported	2.3%	
Zirconium Oxide			Not reported	25%	
Silica			Not reported		<0.1%
Bismuth Trioxide			Not reported		<30%
Distilled Water			Not reported	.14 cc	

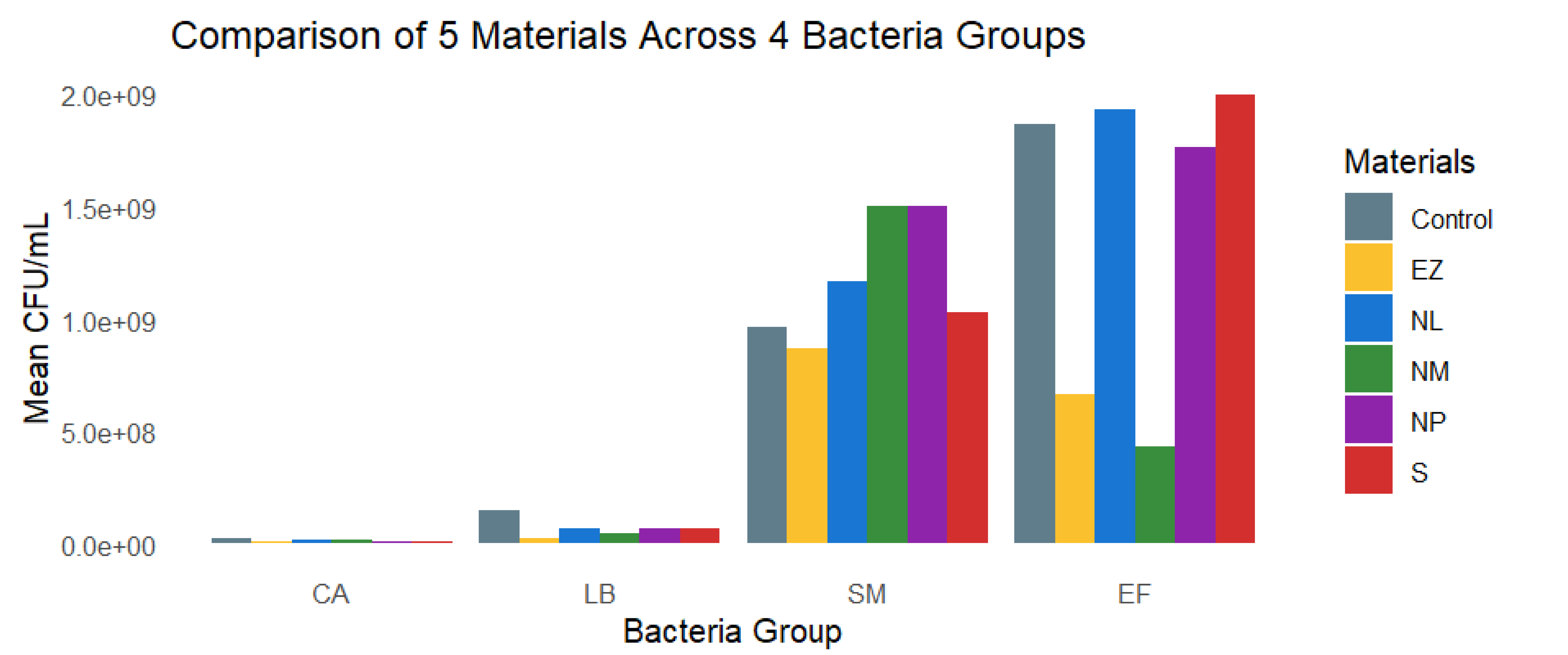
Figure 1. 96-well plate



96-well plate dilution for *C. albicans* and *E. faecalis.* MTA products listed respectively at the top. 1:1 serial dilution performed from well A-G.

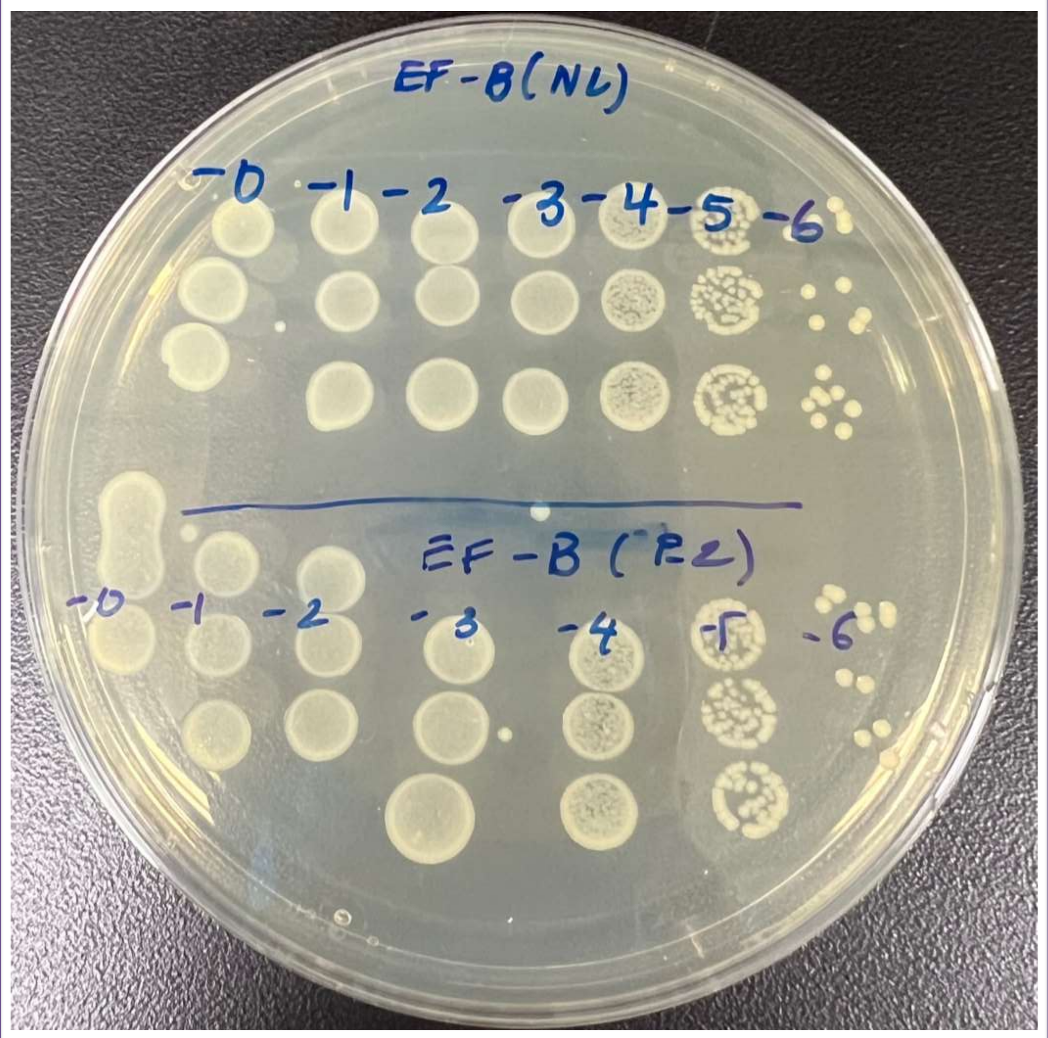
RESULTS

Figure 2. Five Materials against Four Bacteria



Bar chart Comparing CFU Values Across MTA Materials and Control for Each Bacterial Strain

Figure 3. Triplicate Assay



Triplicate assay example with each MTA extract and respective dilutions. 5 uL of each well spotted three times. CFU counted. In image, CFU counted at 6th dilution.

CONCLUSIONS

- No measurable inhibition zones were observed for any MTA product against any microbial strain.
- A Kruskal-Wallis test was conducted for each bacterial species across all MTA products:
  - Candida albicans (CA): No significant difference in CFU values ($p = 0.2491$).
  - Enterococcus faecalis (EF): Significant difference observed ($p = 0.002$), indicating variation in antibacterial efficacy.
  - Lactobacillus spp. (LB): Significant difference found ($p = 0.044$).
  - Streptococcus mutans (SM): No significant difference ($p = 0.339$).
- Ultradent EndoEZE showed the highest efficacy against E. faecalis.
  - Overall, none of the tested MTA products demonstrated consistent antibacterial activity against S. mutans, Lactobacillus spp., or C. albicans, as confirmed by the absence of inhibition zones and non-significant CFU reductions..

REFERENCES

1. Aas JA, Griffen AL, Dardis SR, Lee AM, Olsen I, Dewhirst FE, Leys EJ, Paster BJ. Bacteria of dental caries in primary and permanent teeth in children and young adults. J Clin Microbiol. 2008 Apr;46(4):1407-17. Epub 2008 Jan 23. PMID: 18216213; PMCID: PMC2292933.
2. Alsubait, S. A., Hashem, Q., AlHargan, N., Alfawaz, H., AlSougi, S., & Alqurashi, M. (2014). Comparative evaluation of antimicrobial effect of different MTA products against oral bacteria. *International Journal of Dentistry*, 2014.
3. Balouiri M, Sadiki M, Ibnsouda SK. Methods for *in vitro* evaluating antimicrobial activity: A review. J Pharm Anal. 2016 Apr;6(2):71-79. Epub 2015 Dec 2. PMID: 29403965; PMCID: PMC5762448.
4. Bogen G, Kim JS, Bakland LK. Direct pulp capping with mineral trioxide aggregate: an observational study. J Am Dent Assoc. 2008 Mar;139(3):305-15; quiz 305-15. doi: 10.14219/jada.archive.2008.0160. Erratum in: J Am Dent Assoc. 2008 May;139(5):541. PMID: 18310735.
5. Camilleri J. The chemical composition of mineral trioxide aggregate. J Conserv Dent. 2008 Oct;11(4):141-3. PMID: 20351970; PMCID: PMC2843533.
6. Estrela C, Cintra LTA, Duarte MAH, Rossi-Fedele G, Gavini G, Sousa-Neto MD. Mechanism of action of Bioactive Endodontic Materials. Braz Dent J. 2023 Jan-Feb;34(1):1-11. PMID: 36888836; PMCID: PMC10027099.
7. Guelmann, M., McEachern, M., & Turner, C. (2011). Mineral trioxide aggregate and calcium hydroxide for pulpotomies in primary molars: A systematic review. *Pediatric Dentistry*, 33(7), 498-505.
8. Kim RJ, Kim MO, Lee KS, Lee DY, Shin JH. An in vitro evaluation of the antibacterial properties of three mineral trioxide aggregate (MTA) against five oral bacteria. Arch Oral Biol. 2015 Oct;60(10):1497-502. Epub 2015 Jul 22. PMID: 26263538.
9. Lim M, Yoo S. The antibacterial activity of mineral trioxide aggregate containing calcium fluoride. J Dent Sci. 2022 Apr;17(2):836-841. Epub 2021 Oct 9. PMID: 35756781; PMCID: PMC9201925.
10. Moreira, M. S., Anacleto, C. A., Yamasaki, M. C., Hamata, M. M., Sakai, V. T., & Machado, M. A. (2022). Use of MTA in primary teeth pulp therapy: A systematic review. *Journal of Clinical Pediatric Dentistry*, 46(3), 157-163.
11. Parirokh, M., & Torabinejad, M. (2010). Mineral Trioxide Aggregate: A comprehensive literature review – Part I: Chemical, physical, and antibacterial properties. *Journal of Endodontics*, 36(1), 16-27.
12. Seow WK. Early Childhood Caries. Pediatr Clin North Am. 2018 Oct;65(5):941-954. PMID: 30213355.
13. Shirin, H., & Khosravi, M. (2017). In vitro antibacterial activity of MTA-based materials. *International Journal of Endodontics*, 12(5), 240-247.
14. Struzycka I. The oral microbiome in dental caries. Pol J Microbiol. 2014;63(2):127-35. PMID: 25115106.
15. Stuart, C. H., & Schwartz, S. A. (2009). Enterococcus faecalis: A review of its role in root canal therapy. *Journal of Endodontics*, 35(6), 710-716.
16. Tanomaru-Filho M, Tanomaru JM, Barros DB, Watanabe E, Ito IY. In vitro antimicrobial activity of endodontic sealers, MTA-based cements and Portland cement. J Oral Sci. 2007 Mar;49(1):41-5. PMID: 17429181.
17. Tawil, Peter Z, et al. "Mineral Trioxide Aggregate (MTA): Its History, Composition, and Clinical Applications." *Compendium of Continuing Education in Dentistry (Jamesburg, N.J. : 1995)*, U.S. National Library of Medicine, 27 July 2016, pubmed.ncbi.nlm.nih.gov/25821936/.
18. Use of Vital Pulp Therapies in Primary Teeth with Deep Caries Lesions. Pediatr Dent. 2018 Oct 15;40(6):179-192. PMID: 32074887.
19. Williams, D. L., & Pashley, D. H. (2008). Mineral Trioxide Aggregate and its use in root-end surgery. *Journal of Endodontics*, 34(9), 1113-1122.