UNIVERSITI TEKNOLOGI MARA

THE EFFECT OF PRE-TREATED NANO SILVER FLUORIDE (NSF) ON THE MICROTENSILE BONDING STRENGTH (MTBS) OF COMPOSITE RESIN TO PRIMARY MOLARS' DENTIN: AN IN-VITRO STUDY

NADHIRAH SAKINAH BINTI ROSMAN

Dissertation submitted in partial fulfilment
of the requirements for the degree of
Doctor in Paediatric Dentistry

Faculty of Dentistry

June 2025

ACKNOWLEDGEMENT

Firstly, I wish to thank God for allowing me to embark on my program, Doctor in Paeditaric Dentistry, and for completing this long and challenging journey successfully. My gratitude and thanks go to my supervisor, whom I have worked with for the past four years, Associate Professor Dr. Annapurny Venkiteswaran for her dedication and guidance towards me and keep helping me until I have completed my research and thesis. My thanks also go to my co-supervisor Associate Professor Dr. Alaa Sabah Hussein, for her ideas, helping me to finish my research and checking my dissertation.

I would like to express my sincere appreciation to the Ministry of Higher Education Malaysia and Universiti Sains Islam Malaysia (USIM) for sponsoring my postgraduate journey. My gratitude also extends to the Faculty of Dentistry, Universiti Teknologi MARA (UiTM) for providing the facilities for sampling and access to laboratory equipment essential for this research. Special thanks to the staff, DSA Nurshafina and DSA Normalinah who help me collect the samples for this study. I am also thankful to the laboratory staff from the Faculty of Dentistry UiTM and the Faculty of Dentistry, Universiti Malaya (UM), for providing knowledge and teaching me laboratory methods. I would like to express my gratitude to Dr. Tengku Fazrina Tengku Mohd Ariff (TFT) for her guidance in the Scanning Electron Microscopy analysis and to Dr. Mohd Yusof bin Hamzah (MYH) for his contribution to the NSF experimental study. Special thanks to my batchmates: Nurfarhana and Noorfarahain. The sharing discussions, as well as editing advice, were all greatly appreciated. To my friends and colleagues, thank you for listening, offering advice, and supporting me through this process.

None of this would have been possible without the steadfast love and support of my family. My deepest appreciation goes to my devoted parents,
whose lifelong dedication to my education laid the foundation for this achievement. Their wisdom and sacrifices continue to illuminate my path. I am eternally grateful to my loving husband, Anas Basri bin Musthafa, whose unwavering emotional support and patience sustained me through every challenge. Equal recognition goes to my cherished parents-in-law,
and whose steadfast moral support and loving care for my children created the ideal environment for me to complete this journey. The collective encouragement from beloved siblings, dear in-laws, and extended family members formed an unshakable pillar of strength throughout this process. Their constant prayers, thoughtful gestures, and quiet confidence in my abilities often carried me through difficult moments. May this accomplishment inspire my precious children, Anis Nabihah and Aqilah, to pursue excellence with both worldly knowledge and spiritual wisdom. This milestone truly belongs to the entire family whose unconditional love and support made it possible. Alhamdulillah for these countless blessings.

ABSTRACT

Nanosilver fluoride (NSF) is an emerging anti-caries material that has garnered considerable attention in the field of dentistry due to its potent antimicrobial properties and its capacity to prevent dental caries—capabilities that have been significantly enhanced through advancements in nanotechnology. One of the notable advantages of NSF is its ability to remineralize dentinal carious lesions without causing the undesirable dark staining commonly associated with silver diamine fluoride. Despite its promising antimicrobial and remineralizing effects, there remains a paucity of comprehensive research investigating its influence on the mechanical properties and structural integrity of dentin, particularly in the context of adhesive restorative procedures. The present study aims to compare the physicochemical characteristics of NSF synthesized via a chemical method with those of a commercially available NSF formulation, and to evaluate the effect of NSF pre-treatment on the microtensile bond strength (mTBS) of composite resin to primary tooth dentin. In the chemical synthesis method, silver nitrate was combined with chitosan, followed by titration with sodium borohydride, and subsequently mixed with sodium fluoride. In contrast, the commercial preparation involved mixing colloidal silver with sodium fluoride and stirring until a homogeneous solution was obtained. Both formulations were stored in light-proof brown bottles to prevent photodegradation. For microtensile bond strength testing, forty-six extracted primary molars were sectioned buccolingually, with each half assigned to either the control group (without NSF pre-treatment) or the experimental group (with NSF pre-treatment). Following standard composite resin application protocols, the specimens were subjected to microtensile testing using a universal testing machine (UTM). The peak force at fracture was recorded, and the mTBS values were analyzed using a paired samples t-test to determine statistical significance. Additionally, the surface morphology and failure modes were examined using scanning electron microscopy (SEM). The results demonstrated that chemically-synthesizer NSF exhibited superior optical and structural properties, including a distinct surface plasmon resonance (SPR) peak at 410 nm and well-dispersed nanoparticles. Conversely, the commercial NSF lacked a defined SPR peak and predominantly existed in ionic form. The mTBS results indicated that the NSF-treated group (62.74 ± 22.03 MPa) exhibited a statistically significant increase in bond strength compared to the control group (54.87 ± 19.06 MPa) ($p < 0.05$). SEM analysis revealed a higher incidence of mixed failure patterns in the NSF-treated samples. However, the Chi-square test showed no significant difference in the distribution of fracture modes between the control and experimental groups, suggesting that NSF pre-treatment did not adversely affect the integrity of the dentin–adhesive interface. Although the findings underscore NSF's potential as an anti-caries agent that enhances adhesive bond strength, the limitations of an in vitro study must be acknowledged, as such conditions do not fully replicate the complexities of the oral environment. Therefore, further research is warranted to explore the long-term effects of NSF application, including its impact on bond durability and material degradation under simulated clinical conditions.

TABLE OF CONTENTS

CHAPTER 1
INTRODUCTION

1.1 Introduction

Chapter 1 introduces the study by providing an in-depth background on dental caries, a significant non-communicable disease that affects a substantial proportion of children worldwide. This chapter sets the stage for the research by outlining its objectives, research questions, and hypotheses. Additionally, it emphasizes the significance of the study and highlights its potential contributions to the field.

1.2 Research Background

Dental caries is a preventable bacterial disease affecting both primary and permanent teeth. However, the multifactorial nature of dental caries has contributed to a perception that dental caries is a complex and unmanageable disease. A well-known clinical finding of carious lesions in primary teeth is diagnosed in children as Early Childhood Caries (ECC). American Academy of Paediatric Dentistry (AAPD, 2021) has specifically defined ECC as “the presence of one or more decayed (non-cavitated or cavitated lesions), missing (due to caries), or filled tooth surfaces in any primary tooth in a preschool-age child between birth and 71 months of age”.

A systematic review and meta-analysis done by Kazeminia et al., (2020), the overall prevalence of dental caries in primary dentition worldwide was 46.2% among children. In Malaysia, several authors had reported the prevalence of caries in primary teeth varying from 44.6% (Kaur et al., 2015; Lee et al., 2020) to 98.1% (Ruhaya et al., 2012) of children which was found to be high. The National Oral Health Survey of Preschool Children (NOHPS 2015) highlights the significant burden of dental caries among Malaysian preschoolers, reporting that nearly two-thirds required restorative care and over 12% needed tooth extractions (Che Salleh & Vengadasalam, 2017). Appropriate measures and strategies should be implemented to combat and tackle this issue since the consequences of untreated dental caries could jeopardize children’s quality of life (AAPD, 2021).