

UNIVERSITI TEKNOLOGI MARA

**A COMPARISON OF
CYTOTOXICITY LEVEL,
CHEMICAL AND
MORPHOLOGICAL CHANGES OF
FAKE AND CONVENTIONAL
BRACES**

MUHAMMAD FATHY BIN ZAINAL FIKRY

Dissertation submitted in partial fulfilment
of the requirements for the degree of
Dr In Orthodontics

Faculty of Dentistry

JUNE 2025

ACKNOWLEDGEMENT

Firstly, I wish to thank God for giving me the opportunity to embark on my PhD and for completing this long and challenging journey successfully. I would like to express my heartfelt gratitude to everyone who has supported me throughout the journey of this research and dissertation writing.

I extend my deepest thanks to my main supervisor, **Professor Dr Aida Nur Ashikin Abd Rahman**, whose expert guidance, insightful advice, and unwavering support have been invaluable from the inception of this project to its completion. Her commitment to academic excellence, patience and her generous sharing of knowledge have inspired me to strive for the highest standards.

I am also sincerely grateful to my co-supervisors, **Dr Nik Mukhriz Nik Mustapha** and **Dr Ayuni Binti Ahmad Shafiai**. Their combined expertise, critical feedback, and steadfast encouragement have enriched my research significantly.

A special thank you goes to my co-researcher, **Puan Fara Fariza Binti Zahar**, for her crucial assistance with the laboratory work, especially in cell culture. Her technical skill, dedication, and collaborative spirit were essential in ensuring the reliability of the experimental work, and her contributions have left an indelible mark on the success of this project.

I am deeply appreciative of my colleagues and friends whose emotional support and intellectual camaraderie have been a constant source of strength. The many discussions, shared challenges, and collective celebrations of small victories have made this journey not only productive but also enjoyable and enriching.

I would also like to acknowledge the financial support provided by **Universiti Sains Malaysia (USM)** and the **Ministry of Higher Education (MOHE)** through salaries and scholarship. Their commitment to supporting academic endeavours is truly commendable and has greatly contributed to the realization of this dissertation.

Finally, I dedicate this dissertation to my dear wife, **W Nur Arisya Shafiqah Binti Wan Anuar** and both my 2 daughters, whose unwavering love, patience, sacrifices and encouragement have been the cornerstone of my strength. Without my wife's support, this would never be possible. I am forever grateful to both my parents and my in-laws for their support and encouragement, which have enabled me to pursue my academic aspirations. Their belief in my potential and their enduring support have been my guiding light through every challenge.

Each of these contributions has been vital in shaping not only the outcome of this research but also my personal growth as a scholar. I am humbled and deeply thankful for the collective effort, support, and inspiration provided by my mentors, peers, and family. This dissertation stands as a testament to the collaborative spirit of academia and the power of shared determination.

Thank you all for being an essential part of this journey.

ABSTRACT

The rising trend of fake braces, particularly in Southeast Asia, has raised significant health concerns. Regarded as a fashion statement, fake braces are unregulated orthodontic appliances sold through social media and online marketplaces. Unlike conventional braces, fake braces are often installed by unqualified individuals or self-applied, lacking the oversight of licensed professionals. Teenagers and young adults are drawn to fake braces because of their perceived status symbol, affordability, and potential to be customized aesthetically. However, there are serious concerns to oral health, including periodontal damage, infection, allergic reactions, and unintentional ingestion due to their poor installation and inferior grade materials. The risks are further highlighted by reports of fatalities and medical issues. According to studies, fake braces exhibit irregular surface textures encouraging the growth of bacteria and the creation of biofilms, which exacerbates oral problems like caries. Despite these risks, research on the toxicity and clinical impacts of fake braces remains sparse. This research aim is to compare the implications of fake and conventional braces in term of morphological changes, level of toxic ion released, and its cytotoxicity. It specifically aims to firstly examine the surface roughness between fake and conventional braces under immersion of different pH values of artificial saliva. Secondly is to determine the level of toxic ions released by fake and conventional braces. Thirdly is to assess the level of cytotoxicity of fake and conventional braces towards HGF cells. For objective 1 and 2, samples of fake braces (bonded and removable type) bought from Shopee and conventional braces bought from MDA-certified company were prepared in triplicates. The bracket samples were immersed in artificial saliva at pH 4.9 and pH 7.8 and kept at 37°C. The bracket samples were then extracted at 1-day and 14-days and were analysed using scanning electron microscope and surface profilometer to determine the changes in its surface roughness (Ra), and using the Inductively Coupled Plasma Optical Emission Spectroscopy (ICP-OES) to determine the levels of chromium and nickel ions released. For Objective 3, samples of fake braces bought from Shopee and conventional braces bought from MDA-certified company were immersed in Dulbecco's Modified Eagle Medium (DMEM) solution. Extracts from the immersion were then taken at 14-days and 28-days and its cytotoxicity towards HGF cells were assessed using MTT assay. Fake braces, both the bonded and removable type shows significantly higher surface roughness compared to conventional braces at pH 4.9 at T3 $F(2,4) = 26.085$, $p = 0.005$ and $F(2,4) = 11.007$, $p = 0.024$, respectively. Both the bonded and removable type fake braces show significantly higher Chromium ions release at T2 as compared to conventional braces in pH 7.8 of artificial saliva at (95% CI, 76.01794 to 554.0853) $\mu\text{g/L}$, $p = 0.030$ and (95% CI, 159.137 to 1110.577) $\mu\text{g/L}$, $p = 0.029$, respectively. Nickel ions released were also higher at pH 7.8 in both the bonded and removable fake braces as compared to conventional braces with (95% CI, 5542.1077 to 5893.0789) $\mu\text{g/L}$, $p < 0.001$ and (95% CI, 5940.539 to 6354.768) $\mu\text{g/L}$, $p < 0.001$, respectively. In cytotoxicity testing, there were statistically significant differences between both types of fake braces and conventional braces at both T1 ($F(2, 6) = 5.206$, $p = 0.049$) and T2 ($F(2,6) = 11.844$, $p = 0.008$), with removable fake braces showing highest level of cytotoxicity. The research suggested that there were significant differences between fake and conventional braces in surface roughness, metal ions released and cytotoxicity. Both the bonded and removable type fake braces show higher surface roughness, higher levels of Chromium and Nickel ions released, and higher cytotoxicity towards HGF cells as compared to conventional braces in vitro. These may be interpreted as the low quality of alloy used in the manufacturing of fake braces and may suggests that it can pose some health risks.

TABLE OF CONTENTS

CONFIRMATION BY PANEL OF EXAMINERS	2
AUTHOR'S DECLARATION.....	3
ABSTRACT	4
ACKNOWLEDGEMENT	5
LIST OF TABLES	8
LIST OF FIGURES	10
CHAPTER 1.....	11
INTRODUCTION	11
1.1 Background of the study	11
1.2 Problem statement	13
1.3 Research questions	14
1.4 Research objectives	15
1.5 Significance and rationale of the study	15
1.6 Hypothesis	16
1.7 Ethics exemption	17
CHAPTER 2.....	18
LITERATURE REVIEW	19
2.1 Orthodontic treatment modalities	19
2.2 Removable orthodontic appliances.....	19
2.3 Fixed orthodontic appliance	24
2.4 The potential risks of orthodontic treatment	25
2.5 Comparison between conventional and fake braces.....	29
2.6 Issues on fake braces.....	32
2.7 Cytotoxicity	36
2.8 Elemental composition of orthodontic alloys	38
2.9 Corrosion of orthodontic alloys	40
2.10 Plaque retention and caries	49
2.11 Type of incubation medium and the duration of immersion	51
CHAPTER 3.....	54
3.1 Flowchart of study	55
MATERIALS AND METHODS.....	56
3.2 Surface morphology and surface roughness analysis.....	56
3.3 Level of Chromium and Nickel ion present.....	60
3.3.1 Materials	61

CHAPTER 1

INTRODUCTION

1.1 Background of the study

There is a growing demand among communities around the world for orthodontic treatment. The desire to have a better dental appearance (65%) and to obtain straight teeth (48%) is the most significant factor affecting patients in Malaysia when pursuing orthodontic treatment. (Abdullah A.A.A., Yassin Z., 2001)

Many studies have shown that one out of the many reasons why patient seek fixed orthodontic treatment is the perception of dental beauty or aesthetics (Mandall et al., 2000; Yao et al., 2016). Age, gender, ethnicity, education level, severity of malocclusion, and the societal norms of dental aesthetics are some of the factors that this perception is influenced by (Flores-Mir et al., 2004). Thus, orthodontic treatment is seen by the public as a method to enhance personal appearance, enhancing oral health, and to improve self-confidence. As several studies have been conducted that link malocclusion to the quality of life, this pleasing advantage has been proven to be true (Sardenberg et al., 2013; Scapini et al., 2013). The reasons mentioned above is believed to be one of the factors which causes high demand in orthodontic treatment in the population. Plus, the long waiting list in Malaysian government clinics is making these issues difficult to cater.

When a patient is referred to an orthodontist, the orthodontist orders for radiographs (OPG) and occasionally lateral cephalograms in addition to cone-beam computed tomography (CBCT) to evaluate the patient's prognosis and tooth position. In addition to this, the patient's dental impression is required by the orthodontist to create study models. The downside of