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FLUID DYNAMICS AND SMEAR LAYER REMOVAL EVALUATION BETWEEN ENDOVAC, MODIFIED APICAL NEGATIVE PRESSURE AND POSITIVE PRESSURE IRRIGATION TECHNIQUES

WAN NUR FARHANA BINTI WAN ABDUL RAHMAN

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ABSTRACT

Negative pressure irrigation system can deliver irrigant to the most apical areas and eliminate vapour lock, resulting in an improved smear layer (SL) removal. However, the current negative pressure irrigation system EndoVac produces the lowest wall shear stress (WSS). WSS influences the detachment of SL and biofilms from the root canal wall. This study aimed to evaluate the fluid dynamics and SL removal between EndoVac, a novel system-modified apical negative pressure (mANP), and SV positive pressure techniques. (Phase 1): A simulated 3-dimensional (3D) root canal model and three types of needles (EndoVac, mANP, and SV-positive pressure) were simulated. Model parameters and computer solution were set to analyse the WSS, apical pressure, and streamlines using computational fluid dynamics (CFD). (Phase 2): SL removal was investigated, which consists of 60 single-rooted extracted permanent lower premolars. The root canal was prepared up to F4 ProTaper size before being randomly divided into three groups: Group 1 (EndoVac), Group 2 (mANP), and Group 3 (SV). The samples were vertically split into half and observed under a scanning electron microscope (SEM). In CFD analysis, the mANP showed the highest average WSS (11.06 Pa) compared to SV (10.72 Pa) and EndoVac (10.48 Pa). Conversely, the SV positive pressure method revealed limited streamlines beyond the needle tip and positive apical pressure. In SEM evaluation, the mANP demonstrated superior SL removal compared to the other groups. There were significant differences in irrigation dynamics pattern in CFD analysis and the SL removal between the three groups using Fisher's exact test. In conclusion, this study revealed that different irrigation systems and needle designs affect the fluid dynamics pattern and magnitude. The mANP revealed the highest average WSS magnitude and the cleanest SL removal compared to the EndoVac and SV positive pressure technique. Thus, this proves there is a direct correlation between average WSS magnitude and SL removal.

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CHAPTER ONE
INTRODUCTION

1.1 Introduction

This chapter provides an overview and framework of the study conducted. The discussion aims to introduce the modified apical negative pressure (mANP) as a novel negative pressure irrigation technique. This chapter will also briefly discuss the negative pressure irrigation technique and the conventional positive pressure irrigation technique.

1.2 Research Background

Root canal therapy aims to remove microbes from the contaminated root canal, avoid reinfections, and preserve the natural tooth. (Thakur, 2016). The inflamed or contaminated pulp is eliminated during the root canal procedure, and the canal is thoroughly cleaned and disinfected before being filled and sealed (Stefanac, 2017). Chemomechanical preparation using the appropriate selection of instruments and irrigation techniques is required to accomplish a successful endodontic treatment. Irrigants should be able to reach the working length and remove the smear layer and microorganisms from the root canal (Miller & Baumgartner, 2010). The complexities of the root canal anatomy, especially at the apical third of the root canal system, make cleaning and shaping a clinical challenge (Chen et al., 2014).

Conventional root canal irrigation is a syringe-based system that slowly delivers irrigation solutions into the root canal system (Adarsh et al., 2016). Irrigation with a positive-pressure irrigation system using a syringe and needle instrument is a common technique (Hulsmann et al., 2005). However, caution must be exercised to avoid extruding the irrigant beyond the apex (Trope, 2010). It is revealed that positive pressure irrigation is insufficient for reaching the apical third of the root canal (Munoz & Camacho-Cuadra, 2012) due to stagnation plane (Gulabivala et al., 2010) and vapour lock (Hülsmann & Hahn, 2000). Hence, new irrigants and irrigating devices have been developed to improve root canal disinfection in endodontic practise (Munoz & Camacho-Cuadra, 2012) such as apical negative pressure (EndoVac), sonic activation