# JIMMA UNIVERSITY
# INSTITUTE OF HEALTH
# FACULTY OF MEDICAL SCIENCE
# SCHOOL OF DENTISRY

***ASSESSMENT OF QUALITY OF ROOT CANAL FILLING THROUGH RADIOGRAPHIC IMAGE OBSERVATION AND ASSOCIATED FACTORS AT DENTAL CLINICS IN JIMMA TOWN, SOUTHWEST ETHIOPIA.***

**BY: SELAM FISEHA (DMD)**

***A THESIS SUBMITTED TO SCHOOL OF DENTISTRY, FACULTY OF MEDICAL SCIENCES, INSTITUTE OF HEALTH, JIMMA UNIVERSITY IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR SPECIALITY CERTIFICATE ON OPERATIVE AND ENDODONTICS***

**JUNE 21, 2024**

**JIMMA, ETHIOPIA**

# ASSESSMENT OF QUALITY OF ROOT CANAL FILLING THROUGH RADIOGRAPHIC IMAGE OBSERVATION AND ASSOCIATED FACTORS AT DENTAL CLINICS IN JIMMA TOWN, SOUTHWEST ETHIOPIA.

**By: SELAM FISEHA (DMD)**

**ADVISORS**

**MR. YOHANNES ZEWDU (BSC, MPH-EPIDEMIOLOGY)**

**AND**

**DR. BELAY YADETA (DMD, SPECIALITY IN OPERATIVE & ENDODONTICS, ASSISTANT PROFESSOR)**

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**JIMMA, ETHIOPIA**

# CERTIFICATE

This is to certify that the thesis entitles "Assessment of quality of root canal filling through radiographic image observation and associated factors at dental clinics in Jimma town, southwest Ethiopia", submitted to Jimma University for the award of the requirements for specialty certificate on operative and endodontic and is a record of bonafide research work carried out by **Dr. *Selam Fisseha*,** under our guidance and supervision.

*Therefore, we hereby declare that no part of this thesis has been submitted to any other university or institutions for the award of any degree or diploma.*

| *Main Adviser's Name* | *Date* | *Signature* |
|---|---|---|
| ______________________________ | ____________________ | _______________________ |
| *Co-Advisor's Name* | *Date* | *Signature* |
| ______________________________ | ____________________ | _______________________ |

# DECLARATION

I hereby declare that this thesis entitled “Assessment of quality of root canal filling through radiographic image observation and associated factors at dental clinics in Jimma town, southwest Ethiopia”, has been carried out by me under the guidance and supervision of MR. Yohannes Zewdu (BSC, MPH-Epidemiology) and Dr. Belay Yadeta (DMD, Specialty In Operative & Endodontic, Assistant Professor).

The thesis is original and has not been submitted for the award of any degree or diploma to any university or institutions.

| Researcher’s Name | Date | Signature |
|---|---|---|
| ______________________ | ________________ | ________________ |

# Abstract

**Background**: Root canal treatment is an essential component of comprehensive dental care, and it is crucial to ensure high technical quality in root fillings. Several factors can impact the technical quality of root fillings. Various procedural errors can compromise the quality of root canal treatment and influence the overall outcome of the procedure. Despite numerous global studies, there has been a lack of study into the prevalence and factors affecting the quality of root canal filling techniques in Ethiopia and specifically in our study setting, Jimma. This underscores the urgent need for further research and improvement in this critical area of dental care.

**Objective:** To analyse the prevalence quality of root canal filling radiographically and assess factors affecting root canal treatment at dental clinics in Jimma town, southwest Ethiopia.

**Methods**: In a multi-center facility-based cross-sectional study, the characteristics of subjects and radiographs of 228 root canals were assessed for the overall quality of RCT. The quality of the root fillings was evaluated based on the distance between the end of the filling and the radiographic apex, the density of the filling, and the taper of the root filling. Data was entered into EPI Data version 3.1 and then exported to SPSS version 20 for analysis. For analysis involved conducting Chi-square tests and binary logistic regression tests.

**Result**: The prevalence of roots with overall acceptable root filling was 48.7%. We observed significant differences in numerous aspects, including teeth type and positions (P.value=0.000), Obturiation level compared to CEJ (P.value=0.026), presence of missed canal (P.value=0.000), presence of fractured instrument (P.value=0.002), root canal anatomy (P.value=0.001), root canal location (P.value=0.000), root canal position (P.value=0.000), root canal curvature (P.value=0.000), operating professional education (P.value=0.004), and operating dentist work experience (P.value=0.000) observed. In multifactorial analysis, RCT was more likely to succeed in straight teeth (OR=0.003), unvoid teeth (OR=0.00), acceptable tapering (OR=106.25), initial treatment (OR=20.28) and acceptable length of root canal filling (OR=93136.38).

**Conclusion:** The overall quality of RCT performed was found to be low (less than 50%). Based on the findings, it is evident that various factors significantly impact the success of root canal treatment. Further research and consideration of these influencing factors can enhance the success rate of root canal treatments and contribute to improved overall dental care

***Keywords: Technical quality, root canal treatment, radiographic evaluation***

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# Table of Contents

**Abstract** ........ IV
Acknowledgements ........ V
**Table of Contents** ........ VI
List of Figures and tables ........ VIII
List of Tables ........ VIII
Abbreviations and Acronyms ........ IX
**CHAPTER ONE** ........ 10
INTRODUCTION ........ 10
1.1. Background ........ 10
1.2. Statement of the Problem ........ 12
**CHAPTER TWO** ........ 14
LITERATURE REVIEW ........ 14
2.1. **Root** Canal Morphology ........ 14
2.2. Root canal treatment (RCT) ........ 14
2.3. Quality Root Canal filling material ........ 17
2.4. Prevalence of Root Canal Filling ........ 18
2.5. Factors that affect RCT ........ 19
2.6. Significance of the study ........ 22
**CHAPTER THREE** ........ 24
OBJECTIVES ........ 24
3.1. General objective ........ 24
3.2. Specific objectives ........ 24
**CHAPTER FOUR** ........ 25
METHODS AND MATERIALS ........ 25
4.1. Study area and period ........ 25
4.2. Study design ........ 25
4.3. Population ........ 25
4.3.1. Source population ........ 25
4.3.2. Study population ........ 25
4.3.3. Inclusion and Exclusion Criteria ........ 25
4.4. Sample size Determination and sampling technique ........ 25
4.4.1. Sample size Determination ........ 25

4.4.2. Sampling techniques ..... 27
4.5. Study Variables ..... 28
4.5.1. Dependent variable ..... 28
4.5.2. Independent variables ..... 28
4.6. Operational definitions ..... 28
4.7. Data collection Tool ..... 29
4.8. Data collection Procedure ..... 29
4.9. Data quality Management ..... 29
4.10. Data processing and Analysis ..... 29
4.11. Ethical Consideration ..... 30
4.12. Dissemination plan ..... 30
**CHAPTER FIVE** ..... 31
5.1. RESULT ..... 31
**CHAPTER SIX** ..... 38
6.1. DISCUSSION ..... 38
**CHAPTER SEVEN** ..... 41
7.1. CONCLUSION AND RECOMMENDATION ..... 41
**REFERENCES** ..... 42
Annexes ..... 45

# List of Figures and tables

## List of Tables

Table 1. Characteristics of study participants ........ 32
Table 2. Length, density, and taper of the root canal treatment in association to teeth group (FDI classification) (n=228). ........ 33
Table 3. Table quality of root canal treatment in relation to root location, position, and curvature (root canal is the unit) (n=228). ........ 34
Table 4 . Length, density, and taper of root canal treatment in relation to canal curvature (n=228) ........ 34
Table 5. Characteristics of study participant and overall quality of root canal treatment (n=228) ........ 35
Table 6. Factors related to the overall success of root canal treatment (RCT) by means of logistic regression modeling (n=228) . 37

# Abbreviations and Acronyms

| | |
|---|---|
| **AAE** | American Association of Endodontists |
| **ADA** | American Dental Association |
| **AOR** | Adjusted Odd ratio |
| **CBCT** | Cone Beam Computed Tomography |
| **CEJ** | Cemento-enamel Junction |
| **CI** | Confidence interval |
| **COR** | Crude Odd ratio |
| **ESE** | European Society of Endodontology |
| **FDI** | Fédération Dentaire International |
| **MCT** | Micro-computed tomography |
| **MTA** | Mineral trioxide aggregate |
| **NGO** | Non govermental organization |
| **OR** | Odd ratio |
| **RCF** | Root canal filling |
| **RCT** | Root canal treatment |
| **RFT** | Root filling treatment |
| **RVG** | Radiovisiography |
| **SE** | Standard error |

# CHAPTER ONE

## INTRODUCTION

### 1.1. Background

Root canal treatment (RCT) is an important part of comprehensive quality dental car and aimed to prevent the reinfection of root canals that have been biomechanically instrumented, irrigated, disinfected, and obturated. Endodontics is the branch of dentistry that is concerned with the morphology, physiology and pathology of the human dental pulp and periradicular tissues. Its study and practice encompass the basic clinical sciences including biology of the normal pulp, and etiology, diagnosis, prevention and treatment of diseases and injuries of the pulp and associated periradicular tissues as defined by The American Dental Association (ADA) and American Association of Endodontists (AAE) (1).

When the pulp—the soft area of the tooth that houses the blood vessels, nerves, and live connective tissues—becomes infected or inflamed, root canal therapy, also known as endodontic therapy, is required. Rather than pulling a tooth that is severely damaged or infected, a root canal operation is used to save it. This process is carried out by an endodontic or a root canal specialist (1).

Root canal treatment or endodontic treatment is necessary when the soft spot of the tooth, known as the pulp, housing the blood vessels, nerves and living connective tissues, become infected or inflamed. The root canal procedure is performed to save a damaged or badly infected tooth, instead of extracting it. An endodontist or a root canal specialist performs this procedure (1).

The most common causes of tooth damage or infection are, cavities occurring due to plaque accumulation, cracked or broken tooth due to any accidents or trauma, gum diseases, and repeated dental treatment to a particular tooth. These issues can cause pulp inflammation, infection and damage the pulp irreversibly. The person will at times experience excruciating pain. The pain may subside when the pulp dies, but very often returns as the infection spreads. It is advisable to see a general dentist immediately if you experience a toothache or gum pain. One of the most important aims of a root canal filling is to prevent the reinfection of root canals that have been biomechanically instrumented, irrigated, disinfected, and obturiated (2).

According to the American Association of Endodontists (AAE), there are clinical and radiographic criteria for judging the technical success of a root canal filling(3). Clinically, for a case to be considered successful, routine tests such as palpation, percussion, periodontal probing, and visual inspection of the

final coronal restoration should reveal normal findings during periodical follow-up visits. The following three criteria should be radiographically assessed: length, shape, and density (3).

According to the guidelines of the European Society of Endodontology (ESE), the radiographic criteria of an adequate root canal treatment includes a prepared root canal with a consistent taper from the orifice to the apex and an obturated root canal that is completely without voids between the canal filling and canal walls. It is important that the root canal filling should be placed as close to the apical constriction as possible, i.e., within 0.5–2 mm of the radiographical apex (4).

## 1.2. Statement of the Problem

Understanding the anatomy of the root canal system is essential for a successful root canal treatment. Complexity of root canals depends on reasons such as ethnicity, gender, age, the existence of lateral/accessory canals, isthmuses, the location of the teeth at the jaws and anomalies of the teeth (dens invaginatus, dens evaginatus, fusion, gemination, dens in dente).

Besides all of these, some physiological alterations occur in enamel and dentin with age. Mineralization of dentin results in calcification of dentinal tubules; thus, dentin becomes sclerotic. Several difficulties occur during root canal treatment in such cases. The utilization of novel technologic equipments for magnification and lightning of the root canal system like dental microscope, loupe, radiographic visualization systems and cone beam computed tomography (CBCT) in dentistry enlightens endodontic treatment (5).

Root canal treatment is a commonly performed dental procedure aimed at eliminating infection and preserving the tooth structure. The success of root canal treatment depends heavily on the quality of the root canal filling, which ensures a hermetic seal and prevents reinfection. Radiographic evaluation plays a crucial role in assessing the quality of root canal fillings (6). However, despite its importance, there is a lack of comprehensive research evaluating the accuracy and reliability of radiographic observations in determining the quality of root canal fillings (7).

Several observational studies determined the frequency of (in-) adequately filled root canals in relation to healthy periapical areas, and epidemiological data have shown different treatment outcomes in various regions of the world, with prevalence of inadequate root canal fillings of up to 72.4%, and with 87.0% of these teeth showing apical periodontitis.

Despite advancements in root canal treatment techniques and materials, there is still a lack of standardized and objective methods for evaluating the quality of root canal fillings. Current evaluation methods primarily rely on clinical and subjective criteria, which can be influenced by operator experience and interpretation. As a result, there is a need for a more precise and reproducible assessment method that can provide accurate insights into the quality of root canal fillings (2, 7). Specifically, there is a lack of standardized criteria and objective measures to determine whether a root canal filling is adequately performed or requires further intervention (6-8). Without a reliable and validated method for radiographic

assessment, there is a risk of misdiagnosis, inadequate treatment, or unnecessary retreatment, leading to compromised patient outcomes and increased healthcare costs.

Furthermore, current literature on radiographic assessment of root canal fillings is limited and often conflicting, making it challenging for dental professionals to make informed clinical decisions. The lack of consensus regarding the interpretation of radiographic findings in relation to the quality of root canal fillings adds to the complexity of this problem.

Periodic assessments of the prevalence of apical pathosis in different populations may help to define treatment needs in a specific region and relate treatment outcome to various factors. With regard to Central European (German-speaking) populations, however, only limited information on quality and quantity of endodontic treatments has been published over the last decade (8, 9), and this in particular comes true for Austria (8). In addition, the qualities of root canal fillings as well as those regarding the respective post-endodontic coronal restorations were evaluated with regard to their impact on periapical health

By investigating these questions, this study aims to contribute to the development of evidence-based guidelines and protocols for the radiographic evaluation of root canal fillings. The findings will have significant implications for dental professionals, enabling them to make diagnoses that are more accurate, provide appropriate treatment plans, and improve patient outcomes in root canal therapy.

# CHAPTER TWO

## LITERATURE REVIEW

### 2.1. Root Canal Morphology

Morphological presentation of root canal system and its success depends on the proper application of all procedures of root canal treatment. Complexity of root canals depends on reasons such as ethnicity, gender, age, the existence of lateral/accessory canals, isthmuses, the location of the teeth at the jaws and teeth anomaly. The utilization of novel technologic equipment for magnification and lightning of the root canal system like dental microscope, loupe, radiographic visualization systems and cone beam computed tomography (CBCT) in dentistry enlightens endodontic treatment (10). Dental morphological anomalies accompany some growth and developmental abnormalities. Dens invaginatus, dens evaginatus, dens in dente, fusion and gemination are among the often seen dental anomalies. Dental anomalies could also be associated with syndromes, such as Down syndrome (11).

Focusing on the tooth morphology considering root canal complexity allows dentists to perform successful root canal treatment. Besides the dentists' knowledge and interest in root canal morphology and anatomy, proficiency on root canal treatment and the tendency to use novel technological devices enable prosperous endodontic treatment. The novel tooth morphology classification presented by Ahmed and Dummer, based on the simplicity and clarity respecting tooth number, number of roots and root canal configuration types, is the prominent leading literature for dentistry (12).

### 2.2. Root canal treatment (RCT)

Root canal treatment is a crucial procedure for preserving natural teeth, and the success of the treatment largely depends on the quality of root canal filling and subsequent coronal restoration.

Root canal treatment is a widely performed dental procedure that involves the removal of infected pulp tissue from the tooth's root canal system and subsequent sealing to prevent reinfection (9). The success of root canal treatment depends on various factors, including proper root canal filling and coronal restoration. While several assessment methods exist, the evaluation of radiographic images provides a valuable means to assess the quality of root canal treatment, allowing for the identification of potential defects and the determination of treatment success (8, 10-13).

Most of the studies on RCT and coronal restoration used radiographic assessments in which images from patients who underwent root canal treatment and coronal restoration in dental clinics are reviewed. The images are evaluated by calibrated observers, including experienced endodontists and prosthodontists, using standardized criteria. The assessment focuses on the quality of root canal filling, including length, density, taper, and absence of voids, as well as the quality of coronal restorations, such as marginal adaptation, integrity, and presence of recurrent caries (14).

Root canal treatment continues to be the treatment with which the majority of AP cases are treated and with which it is possible to keep the affected mature tooth functional in the patient's mouth (15). Considering the high prevalence of AP globally(16), the prevalence of RCT can be also expected to be very high. Some studies have investigated the frequency of RCT in different countries(17), finding a very wide range of percentages of RFT, from 0.7% (18) to 87% (19), as well as people with at least one RFT, from 19.9% (20) up to 97.3% (21).

In short, the data on the prevalence of RFT differs from one study to another, reflecting the differences in the needs and availability of RCT in different countries and populations (20, 22), as well as the different impact of the new diagnostic and therapeutic trends in the management of deep carious lesions pulpitis (9). Knowing the prevalence of RFT in the worldwide will allow dentists and policy makers to evaluate the impact that RCT has on the world population.

Taking into account that RCT is the most frequent treatment carried out by endodontists, determining the worldwide prevalence of RFT will also inform about the fraction of clinical activity of dentists dedicated to treat endodontic diseases, which will allow the frequency of RCT to be compared with that of other medical or dental therapies. Finally, the prevalence of RFT worldwide will also tell us how often dentists around the world continue to carry out RCT (23).

Root canal treatment, also known as endodontic treatment, is a dental procedure performed to treat a tooth that has become infected or severely damaged. The purpose of the treatment is to remove the infected or damaged pulp from the inside of the tooth, clean and disinfect the root canals, and seal them to prevent further infection (23).

The overall root canal treatment procedure include examination and X-rays by which the dentist examines the tooth and takes X-rays to evaluate the extent of infection and determine the shape of the root canals.

This is done under local anaesthesia to numb the area surrounding the tooth, ensuring the procedure is comfortable for the patient. The others are access opening, pulp removal, cleaning and shaping, irrigation, filling material, temporary or permanent restoration and subsequent follow up (16).

Here's a step-by-step overview of the root canal treatment process:

1. Examination and Diagnosis: The dentist examines the tooth and takes X-rays to assess the extent of the damage and determine if root canal treatment is necessary.
2. Local Anesthesia: The area around the affected tooth is numbed using a local anesthetic to ensure a painless procedure.
3. Access Opening: A small access hole is created in the tooth's crown to reach the pulp chamber and root canals.
4. Pulp Removal: Using specialized instruments called files, the dentist removes the infected or damaged pulp from the tooth's pulp chamber and root canals. The canals are shaped and cleaned to remove any debris.
5. Irrigation and Disinfection: The root canals are flushed with an antibacterial solution to eliminate any remaining bacteria and disinfect the area.
6. Filling: After the canals are thoroughly cleaned and dried, they are filled with a biocompatible material called gutta-percha. This material seals the canals to prevent re-infection.
7. Restoration: Since a significant amount of tooth structure may have been removed during the treatment, a dental crown or filling is placed to restore the tooth's strength, function, and appearance.
8. Follow-up Care: After the root canal treatment, it's important to follow the dentist's instructions for oral care and attend regular check-ups to monitor the tooth's healing process.

Root canal treatment is typically performed by an endodontist, a dentist specializing in treating the inner structures of teeth (24). It is a highly successful procedure that can save a tooth from extraction and relieve pain caused by infection or damage to the dental pulp.

2.3. Quality Root Canal filling material

A root canal filling refers to the material used to seal and fill the space inside a root canal after the infected or damaged pulp of a tooth has been removed. The goal of a root canal treatment is to remove the infection, alleviate pain, and preserve the tooth's structure (25).

There are several materials commonly used for root canal fillings, and the choice depends on various factors such as the tooth's location, the extent of damage, and the dentist's preference. The commonly used root canal filling materials include Gutta-percha, which is the most commonly used material for root canal fillings. Similarly, Resin-based sealers are also those materials providing an excellent seal, have good adhesive properties, and are more resistant to bacterial leakage compared to traditional sealers. The others are endodontic cements which uses calcium hydroxide-based cements. But, bioceramic sealers and silver points are rarely used today due to their tendency to corrode, discolor the tooth, and cause potential harm to the surrounding tissues (19-21).

The quality of a root canal filling depends on several factors, including the skill and expertise of the dentist, the choice of materials, and the thoroughness of the procedure. A well-done root canal filling should effectively seal the root canal system, prevent reinfection, and provide long-term stability for the treated tooth (21). It is essential to consult with a qualified dentist who can evaluate your specific dental condition and recommend the most suitable root canal filling material for your case.

A study conducted on Technical quality of root canal treatment in Taiwan; a total of 1085 RCT cases were evaluated by eight endodontic specialists. The qualitative evaluation of RCT cases was based on two variables: length of the root filling and density of the Obturiation. Approximately 70% of the teeth receiving RCT in Taiwan were either inadequately filled or incompletely obturated. These findings suggest that the technical standard of RCT is not satisfactory in Taiwan (26).

Similarly, a conducted study on the quality of root canals performed by the Inaugural Class of Dental Students at Libyan International Medical University and evaluated the technical quality of root canal fillings performed by dental undergraduates at Libyan International Medical University in Libya. The study found that the overall quality of endodontic treatment performed by undergraduate dental students was adequate in 53.9% of the cases. The study suggests that there is a significant opportunity to improve the quality of root canals provided by dental students, particularly in treating molars. The authors recommend adapting educational plans to bolster student knowledge and confidence, and testing the effect

of new models and education improvement initiatives to improve actual clinical performance of subsequent groups of dental students (21).

The other study conducted on Radiographic evaluation of the technical quality of root canal fillings performed by dental students by Reisha N. Rafeek focused the technical quality of root canal fillings performed by dental students at the School of Dentistry, University of the West Indies. The study found that only 10.9% of the root canals examined had an overall acceptability of root fillings having adequate length and taper, absence of voids and no fractured instruments. The percentage acceptability of root fillings for length and taper was 31.5%. The study concludes that improvements are required to increase the number of radiographically acceptable root canal fillings (22).

A study conducted on the quality of root canal treatment performed by undergraduate dental students by Gul Celik Una and others showed that the quality of root canal fillings in anterior teeth performed by undergraduate students in Isparta Turkey was satisfactory. This study recommended that to improve the success with molar teeth, education about newer techniques and instruments must be incorporated into the preclinical and clinical curriculum. Root canal treatment is a highly successful procedure that allows a tooth to be saved instead of extracted. It relieves pain, eliminates infection, and restores functionality, enabling the patient to maintain their natural tooth (17). It is important to note that root canal therapy is typically performed by endodontists, who are dental specialists trained in treating diseases of the dental pulp and root canals.

2.4. Prevalence of Root Canal Filling

Many previous studies reported root canal treatment performed by dental students showed success rates of 68% for teeth with pre-existing periapical radiolucencies and 91% for teeth with no pre-existing radiolucencies (27). Another study reported a success rate of 70% among teeth treated by undergraduate dental students (28). These rates are similar to our rates, whereas one study reported a higher success rate of 84% of teeth that had root filling placed by postgraduate students and staff in dental hospitals (11).

The factor which has no effect on the outcomes of root canal treatment are various, and many, and they included age, sex, location of teeth, signs and symptoms, pulp vitality, caries, visit, shaping, radiolucency, sealer leakage, fracture, final restoration, hypertension, diabetes mellitus, teeth group, adjacent and antagonist teeth. Some factors are also reported in one study to have no impact on the outcomes of treatment, as homogeneity, taper, and quality of filling (13); however, these factors are reported to affect

the outcomes of treatment in another study in some of the study analysis. Also, it was reported that the absence of voids within the root filling was associated with the success of treatment in one study in our analysis (10). On the other hand, another study reported that void had no impact on the treatment outcomes (29). One study in our analysis reported that success of treatment was associated with females (30), whereas the other two studies reported no influence of gender (11, 20).

## 2.5. Factors that affect RCT

The rates of root canal treatment success are based on adequate removal of the microorganism from the canal system and the prevention of re-growth and recolonization of residual microorganisms by the placement of root filling that obturates the entire space, combined with a restoration that results in a satisfactory coronal seal (9). Endodontic treatment isn't always successful (9, 22, 31). Root canal treatment is subject to enormous variation in the way it is performed depending on interpretation and execution of any given protocol by an operator, not to mention the variations imposed by the environment and patient requirements. Root canal treatment is a multi-step procedure, where each sequential step is dependent on the adequacy of the previous for its cumulative efficacy (31). Some of these factors have a profound impact on periapical healing, whilst others show a negligible effect or had not accrued sufficient evidence.

The factors that may potentially influence periapical status (healing, or maintenance of periapical health) after root canal treatment may be classified into three groups:

- **Patient and tooth factors** (age, sex, general health or immune status, tooth anatomy, pre-operative pulpal and periapical status);
- **Treatment factors** (operator characteristics, tooth management and isolation, canal system access, working length control at all stages, canal shaping/enlargement, irrigation, medication, culture test outcome and obturation);
- **Post root canal treatment factors** (amount, distribution and quality of remaining tooth structure and its integrity, type of restorative material, full or partial coverage, timing of permanent restoration, quality and maintenance of marginal adaptation, abutment or nonabutment, and occlusal dynamics).

### 2.5.1. Patient and tooth factors

Patient and tooth factors characterizing the nature of disease consistently show the most potent effect (periapical status), whilst most of the treatment factors, individually, exert only a weak effect, except for

the apical extent of root canal filling (treatment) relative to the root apex (root canal terminus), the quality of root-filling, and the quality of the postoperative restorative care, which show profound influences on periapical health (32).

#### 2.5.2. Effect of age, sex, and health

The routinely collected demographic data on factors such as the patient's age and sex, show no significant influence on root canal treatment outcome, even though youth and old age may be anticipated to produce some effect through immune responsiveness. A proportion of the variation in periapical healing outcomes may be attributed to differences between individual patients' host responses (32). Although, the notion is further supported by the weak influence of "general health" of the patient on periapical healing, specific health conditions, such as diabetes and "compromised innate immune response" (33), may have a significant influence, although with limited evidence for the mechanistic pathway and strength of effect. Emerging evidence suggests that polymorphisms of various genes involved in periapical healing may have an effect on outcomes (34).

The factors that were reported to have no significant impact on outcome included age, sex (35), location of teeth, signs and symptoms, radiolucency, pulp vitality, caries, fracture, visit, shaping, sealer leakage, void, final restoration, hypertension, diabetes mellitus, cardiovascular disease (36), preoperative periapical lesion (37), teeth group (single or two-rooted), adjacent tooth, antagonist tooth, filling quality parameters (apical extension, homogeneity, taper, quality of filling), coronal restoration parameters (occurrence, quality of restoration, type, number of surfaces, extension, intra-radicular post, the void between post and gutta-percha, remaining gutta percha) (24, 38).

#### 2.5.3. Effect of tooth type

The commonly accepted perception that single-rooted teeth must exhibit a higher rate of periapical healing than multi-rooted teeth, is shown to be untrue by the collective data, as well as the majority of individual studies. This entirely plausible preconception is driven by the simpler canal anatomy, easier access, and comfort of dentists to complete root canal treatment in such teeth. In sharp contrast, posterior teeth harbour more difficult access, unpredictable canal numbers and location, complicated canal negotiation and enlargement due to severe and multiple canal curvatures, as well as the perception of difficulty and likelihood of failure (38).

### 2.5.4. Effect of operator skill and knowledge (competence)

The general theme of the previous section is continued along a specific line in this section. The impact of operator insight and skill (using the surrogate measure of training qualification and experience) has been investigated to a limited extent. Clinicians with higher educational or training backgrounds (amongst undergraduate students, general dental practitioners, postgraduate students and specialists) display outcome rates commensurate with their training and experience level (23). It is difficult to segregate the complex constellation of cognitive, technical and clinical skills expressed by the dentist in completing the treatment. It is not just the refined and insightful technical execution that matters, but also how the overall understanding of the biological problem influences the operators' intra-operative decision-making, especially, the motivation and integrity with which the procedure is performed (elements difficult to measure) (39).

It's important to note that the success of a root canal filling depends on the dentist's expertise, the patient's oral health, and various individual factors (40). Regular follow-up visits and proper oral hygiene practices are essential to ensure the long-term success of root canal treatment.

### 2.5.5. Effect of use of magnification and illumination

Having accessed the pulp chamber, optimal visualization of its floor to identify all canal orifices and negotiate (or "thread") them with instruments for enlargement, benefits from good illumination, and if possible, magnification. Indeed, some operators even use magnification and illumination for preliminary stages such as anaesthesia and access cavity preparation, which makes little sense, since these elements require broader 3D perspective for correct orientation, which may be lost under certain types of magnification. The virtues of magnification and illumination during the root canal location and negotiation phase and indeed for most of the root canal treatment procedure are almost universally extolled by Endodontists because of the "feeling" of control over the process (41).

### 2.5.6. Effect of root filling material and technique

Notwithstanding the observations on residual microbial presence in the root canal system and its relationship with obturation or root-fillings, investigation of the individual effects of obturation technique and root-filling material on treatment outcome is complicated by the inter-action between core root-filling material, sealer and placement technique. The most commonly used core root-filling material in the majority of outcomes studies was gutta-percha with various types of sealer or gutta-percha softened in

chloroform (chloropercha) (41). The healing rate of teeth obturated with Resilon® (Resilon Research LLC) and Epiphany sealer (Pentron Clinical Technologies) was reportedly comparable with conventional gutta-percha/ sealer in 1–2-year follow-ups (42).

#### 2.5.7. Effect of quality and type of restoration

The prominent impact of restorative factors on periapical healing is highly suggestive of the importance of tooth integrity as well as the restoration/ margin integrity. The quality and type of coronal restoration after root filling has a major impact on the probability of periapical healing. Teeth with "satisfactory" coronal restorations exhibit three-fold better periapical healing rates compared with those with "unsatisfactory" restorations (23). This is another one of the startling observations as it seems to compete with the presence of apical pathosis as a major influence, suggesting a connection with microbiota ingress or their reactivation. Definition of the term "satisfactory" restoration varies in detail from study to study, for example: (1) no evidence of marginal discrepancy; (2) no evidence of marginal discoloration; (3) no evidence of recurrent caries; and (4) absence of a history of restoration decementation (43).

The factors associated with failure included the presence of a periapical lesion on the postoperative radiograph (COR=3.35) (31), inadequate quality of the root failing, inadequate homogeneity and taper, the short length of filling (>2mm) (32), and apical periodontitis (P<0.001) (44). One study revealed that carious lesions (P=0.017), gingival bleeding (P=0.043), and tooth motility (P=0.022) were significantly associated with the occurrence of periapical lesions (45).

Another study conducted on Factors Affecting Root Canal Treatment Outcomes showed many factors that affect the failure of root canal treatment, such as necrotic pulp of periradicular infection, under filling of the root canal, missed or unfilled canals, periodontal disease, broken instruments, root fractures, and mechanical perforation (30).

## 2.6. Significance of the study

The significance of this study lies in its pioneering nature within the Ethiopia context, particularly in the research setting of southwest Ethiopia. By evaluating RVG results at dental clinics in Jimma town, the study assesses the prevalence of the root canal filling. This radiographic image evaluation provides valuable insights into the procedures' quality, contributing to the development of guidelines and protocols for optimizing root canal treatment procedures. The findings will lead to improved clinical practice, enhanced patient satisfaction, and enable clinicians to identify areas of improvement, guide treatment

planning, and enhance patient outcomes. Additionally, the study aims to assess factors that impact success rate of RCT services. Thereby, the findings will be a valuable contribution to healthcare planners and health policy makers, aiding in the establishment of a strategy on root canal treatment.

# CHAPTER THREE
## OBJECTIVES

### 3.1. General objective

- To assess the quality of root canal filling through observation of RVG result at Dental Clinics in Jimma town, Southwest Ethiopia.

### 3.2. Specific objectives

- To analyse prevalence of the quality of root canal filling at Dental Clinics in Jimma town, southwest Ethiopia.
- To assess the factors that affect quality of root canal filling at Dental Clinics in Jimma town, southwest Ethiopia.

# CHAPTER FOUR

## METHODS AND MATERIALS

### 4.1. Study area and period

The study was conducted in dental clinics of Jimma town, 340 KM away from the capital city, Addis Ababa. The town has nine private dental clinics, three private hospitals and 2 government hospitals. For the study, purposefully three private dental clinics were selected due to the presence of Radiovisiography (RVG). The study took place from January to February 2024.

### 4.2. Study design

A facility based cross-sectional study was conducted at selected dental clinics in Jimma town.

### 4.3. Population

#### 4.3.1. Source population

The source population was endodontically treated patients that visit purposefully selected three dental clinics was the source population.

#### 4.3.2. Study population

The study population was all patients seeking root canal therapy at selected clinics were the study population.

#### 4.3.3. Inclusion and Exclusion Criteria

All patients visiting selected dental clinics for root canal treatment were considered for inclusion in the study. Patients with periodontal issues, limited mouth opening, complex tooth anatomy, severely damaged roots, open apex, calcifications, or X-rays of low quality or with additional artefacts' were carefully excluded from the study.

### 4.4. Sample size Determination and sampling technique

#### 4.4.1. Sample size Determination

The sample size was meticulously determined using a single population proportion. Specifically, the 44% proportion of acceptable quality root canal filling from a previous study conducted at Valencia University medical and Dental School, Spain served as the basis for this determination (11).

By using the following formula: $n = \frac{(Z\alpha/2)^2 P(1-P)}{d^2} = \frac{(1.96)^2 \times 0.44 \times 0.56}{(0.05)^2} = 379$

By considering 95% of confidence interval (z = 1.96) and 5% of marginal error (d= 0.05), p (0.44) the sample size is 379. Since the study population is 570 (88 for Dental clinic one, 197 for Dental clinic two, and 285 for dental clinic three) in reference to our study period, which is less than 10,000. Then correction factor was calculated as follow;

$$\mathbf{Cf} = \frac{n}{1+\frac{n}{N}} = \frac{379}{1+\frac{379}{570}} = \mathbf{228}$$

Then, the final maximum sample size for specific objective one = **228**

4.4.1.1. Sample size for specific objective two

To conduct a thorough assessment of the factors influencing the quality of RCT at selected clinics in Jimma town, Southwest Ethiopia, we selected some variables to determine the sample size for specific objective two using Epi-info7.2.5.0 Software. Our assumptions, including 95% confidence interval, 80% power of the study, 5% margin of error, and 10% non-response rate, ensure the robustness of our research. With careful consideration of independent variables such as age, gender, and tooth types from relevant literature, we have calculated sample sizes tailored for each variable. After careful consideration, we have chosen a maximum sample size of 228 for this study based on the first objective (Table 1). Since, the sample size calculated for the specific objective two using predictor factors are smaller than the sample size calculated using the main outcome (prevalence of quality of RCF). Therefore, it will make statistically sound to consider the sample size which is large. Hence, the final sample size for this study was **228.**

**Table 1: Sample size calculation using factors associated with root canal filling based on the previous studies.**

| No. | Factor | Proportion of non-exposed | AOR | Power | Confidence interval(CI) | Sample size | Ref. |
|---|---|---|---|---|---|---|---|
| 1 | Age | 44.4 | 3.18 | 80% | 95% | 104 | (46) |
| 2 | Gender | 48.2 | 2.90 | 80% | 95% | 124 | (11) |
| 3 | Type of tooth | 53.1 | 2.53 | 80% | 95% | 166 | (10) |

4.4.2. Sampling techniques

In Jimma town, there are a total of ten dental clinics and four hospitals offering a variety of dental health services during the study. To ensure a comprehensive representation, three dental clinics equipped with RVG technology were purposefully selected for the study. The participants have the opportunity to visit various dental clinics as per their preference. The participants were recruited using a convenient sampling approach, which allowed all eligible individuals included, regardless of the limited number of participants during the study period. This method ensured that the participants had the opportunities to visit various dental clinics as per their choice, resulting in a diverse representation of dental health services. Accordingly during the study period, participants' recruitment varied within the selected health facilities. For this study, we use a purposive sampling technique to identify sample units from selected Dental clinics sampling frame 570 (88 for Dental clinic one, 197 for Dental clinic two, and 285 for dental clinic three). Thus, for this study, those 228 sample respondents were stratified to Dental clinic one (35 study participants), Dental clinic two (79 participants), and Dental clinic three (114 participants). Study participants were collected from each respective clinic till the study sample size reached enrolled participants in each clinic. Thereby the study aimed to provide a comprehensive assessment of the quality of root canal fillings across different dental clinics in Jimma, southwest Ethiopia.

## 4.5. Study Variables

### 4.5.1. Dependent variable

- overall quality of root canal filling

### 4.5.2. Independent variables

- Socio-demographic factors(Age, sex, residency, and occupation of clients)
- Type of treatment
- peri-apical lesion
- Obturiation level compared to CEJ
- Density of root filling
- Length of root filling
- Tapering
- Missed canal
- Fractured instrument
- Perforation
- Root canal location
- Root canal position
- Root canal curvature
- Material use
- Technique used
- Operating professional education
- Dentist work experience on RCT

## 4.6. Operational definitions

**Overall acceptable quality of RCT**: overall acceptable root canal treatment should have a root filling with a uniform density and no voids; with the canal space not visible on X-rays. The root filling should end 0-2mm from the radiographic apex. Additionally, there should be a consistent taper from the coronal to the apical part of filling, with a clear reflection of the canal shape (22, 31, 41).

**Overall unadequate quality of RCT**: means not consistent taper from the coronal to the apical part of the filling(taper), root filling extending beyond the radiographic apex(overfilled) or greater than 2mm away from the apex(underfilled), and presence of voids in the root filling or between the root filling and root canal wall (22, 31, 41).

## 4.7. Data collection Tool

After doing a thorough review of the literature, we used a semi-structured questionnaire to gather data and checked the quality of RCT-filled tooth using X-rays. The questionnaire helped us gather information about study participants socio-demographic, their clinical characteristics, and other factors that might affect the quality of root canal filling (see Annex section for questionnaires).

## 4.8. Data collection Procedure

All eligible patients visiting the endodontic unit for root canal treatment were asked for consent to participate in the study. X-ray radiography and interviews were conducted to collect socio-demographic and clinical information. Dentist expertise, specialty, and treatment details were also documented. Well-trained endodontists were evaluated the quality of root canal fillings using X-ray radiographs. The evaluation included measuring the length, density, and taper of the fillings. Clinical data extraction tools were used to collect patient information.

## 4.9. Data quality Management

In order to ensure the quality of the data in our study, we implemented stringent data management measures. Each set of data has undergone quality checks, with a strong emphasis on proper data handling procedures. Furthermore, the questionnaire has been prepared in English, translated into local languages (oromiffa and Amharic), and then translated into English to ensure accuracy and consistency. To maintain high data quality during data collection, three professional nurses from respective selected dental clinics and a supervisor underwent training. Daily evaluations of data completeness were conducted by principal investigator to thoroughly review all collected data for completeness and consistency during data collection, entry, and analysis phases.

## 4.10. Data processing and Analysis

The descriptive analysis was conducted to assess the frequency of distribution to understand the success rate of root canal treatment. We used the chi-square test to identify potential associations between the overall success rate of root canal treatment and various factors such as gender, age, treatment modality,

presence of peri-apical lesion, teeth type and position, obturation level compared to CEJ, presence of missed canal, fractured instruments, perforation, root canal anatomy, location, position, curvature, operating professional education, and dentist work experience. Furthermore, we conducted binary logistic regression to determine the association between independent variables and the radiographic evaluation of success rate of RCT-treated teeth. The results were indicated by an odds ratio (OR) with a 95% confidence interval (CI). All statistical analyses were performed using SPSS version 20.0 for Windows (IBM Corp., Armonk, NY, USA) after importing Epi-Data 3.1 version entered data. P. value <0.05 were considered statistically significant.

## 4.11. Ethical Consideration

Ethical clearance and a supportive letter were obtained from the Ethical Review Board of the Institute of Health at Jimma University. Official permission was obtained from each dental clinic before data collection. Patients' data will be kept confidential using codes, and verbal informed consent was obtained from each participant before data collection.

## 4.12. Dissemination plan

The finding of the study will be disseminated to Jimma University, College of health sciences dentistry department, Faculty of Public Health, Department of Epidemiology. Additionally, the finding of this study will be presented on Seminars and review meeting. Finally, maximum efforts will be done to publish the finding of this study on Public Journals for further utilization.

# CHAPTER FIVE

## 5.1. RESULT

The study data were entered into Epi-data version 3.1 and exported into SPSS version 20 to analyze the result. Our study participants' mean age was 32 years (standard deviation 11.424). Over half of the treated individuals were male 131 (57.5%). Most of participants livelihood was on private sector 85(37.3%), governmental employees 60(26.3%), and student 45(19.7%), followed by housewife 20(8.8%), employees of NGO 10(4.4%), and farmers 8(3.5%). Of 228 respondents', 208(91.2%) were on initial RCT, and 20 (8.8%) were on retreatment. Concerning Obturiation level compared to CEJ, the majority 107(46.9%) and 96(42.1%) possess at CEJ and coronal to CEJ level respectively, followed by below to CEJ level 25(11%) (See table 1).

Of 228 RCT-operated teeth, 10(4.4%) led to the fracture of the instrument, and the types of fracture were 9(3.6%) from the apical $3^{rd}$ and 1(0.4%) of them were from the middle $3^{rd}$. Similarly, of RCT-operated teeth, 4(1.8%) of them showed teeth perforation, and all of them belong to the group of furcation type of perforation. Furthermore, 25(11%) of presented teeth possess missed canals, and those missed canals grouped under; 3(1.3%) miso distal canals, 6(2.6%) miso buccal canals, 2(0.9%) buccal canals, 13(5.7%) lingual canals, and 1(0.4%) into disto buccal canals. (See table 1).

3% of those RCT-operated individuals took both amoxicillin 500mg/PO/TID and metronidazole 5400mg/PO/TID for 7 days, while only 25(11%) of them did not take any type of antibiotic. Of the 228 patients who completed the RCT treatment, just over 86% of them took analgesics (see table 1).

Of RCT operated working length of 222(97.4%) roots was determined using the radiographic method and the rest 6 (2.6%) of them were determined using an apex locator, while all 228 roots root filling material used was Gutta-percha.

Table 1. Characteristics of study participants

| characteristics | Number of roots (%) | characteristics | Number of roots (%) |
|---|---|---|---|
| **gender** | | **Antibiotic taken** | |
| female | 97(42.5%) | Amoxicillin 500mg/PO/TID for 7 days | 72(31.6%) |
| male | 131(57.5%) | Amoxicillin 250 mg/PO/TID for 7 days | 4(1.8%) |
| **Occupation** | | Metronidazole 500mg/PO/TID for 7 days | 1(0.4%) |
| Government employees | 60(26.3%) | Azithromycin 500mg/PO/QD for 3 days | 14(6.1%) |
| NGO | 10(4.4%) | Augmentin 625mg/PO/TID for 7 days | 6(2.6%) |
| Private sector | 85(37.3%) | Augmentin 1000mg/PO/BID for 7 days | 7(3.1%) |
| student | 45(19.7%) | Both Amoxicillin & Metronidazole 500mg/PO/TID for 7 days | 98(43%) |
| farmers | 8(3.5%) | Antibiotic not taken and taken analgesic | 25(11%) |
| House wife | 20(8.8%) | **Analgesic** | |
| **Type of treatment** | | Ibuprofen 400mg/PO/ PRN | 197(86.4%) |
| Initial RCT | 208(91.2%) | Diclofenac 500 mg/PO/ PRN | 10(4.4%) |
| retreatment | 20(8.8%) | Paracetamol 500 mg/PO/ PRN | 21(9.2%) |
| ***Obturiation level compared to CEJ*** | | **Presence of missed canal** | |
| At CEJ | 107(46.9%) | yes | 25(11%) |
| Below CEJ | 25(11%) | No | 203(89%) |
| Coronal to CEJ | 96(42.1%) | **Type of missed canal** | |
| **Fractured instrument** | | Miso distal canal | 3(1.3%) |
| Yes | 10(4.4%) | Miso bucal canal | 6(2.6%) |
| No | 218(95.6%) | Bucal canal | 2(0.9%) |
| **Type of fractured instrument** | | Lingual canal | 13(5.7%) |
| Apical 3rd | 9(3.9%) | Disto bucal canal | 1(0.4%) |
| Middle 3rd | 1(0.4%) | **Working length determination** | |
| **Perforation** | | Apex locator | 6(2.6%) |
| yes | 4(1.8%) | Radiographic method | 222(97.4%) |
| No | 224(98.2%) | **Materials used for filling** | |
| **Type of perforation** | | Gutta percha | 226(99.1%) |
| Furcation | 4(1.8%) | resilon | 2(0.9%) |
| Strip | 0(0%) | **Endodonitic instrument for cleaning & shaping** | |
| Coronal | 0(0%) | Group 1: hand operated endodonitic reamers and files | 180(78.9%) |
| **Mean age of RCT filled client** | 32 yrs, SD 11.424 | Group 1: hand operated endodonitic K –types reamers & files | 48(21.1%) |
| **Operating dentist educational type** | | **Operating dentist work experience on RCT** | |
| Doctor of dental medicine | 186(81.6%) | 1 to 2 years | 95(41.7%) |
| Bachelor of dental science | 1(0.4%) | 2 to 4 years | 50(21.9%) |
| Operative &endodontic specialist | 16(7%) | 5 to 6 years | 82(36%) |
| Orthodontics specialist | 1(0.4%) | Greater than 6 years | 1(0.4%) |
| Maxillofacial specialty(Resident,yr3) | 24(10.5%) | | |

Table 2. Length, density, and taper of the root canal treatment in association to teeth group (FDI classification) (n=228).

| Teeth group | Number of root canal | **Length** | | | **Density** | | **Taper** | |
|---|---|---|---|---|---|---|---|---|
| | | accept | over | under | accept | poor | accept | poor |
| **Maxilla** | | | | | | | | |
| Molars | 45(19.7%) | 22(48.9%) | 3(6.7%) | 20(44,4%) | 26(57.8) | 19(42.2%) | 30(66.7%) | 15(33.3%) |
| premolars | 19(8.3%) | 13(68.4%) | 0(0%) | 6(31.6%) | 12(63.2%) | 7(36.8%) | 10(62.6%) | 9(47.4%) |
| Anterior | 54(23.7%) | 47(87%) | 5(9.3%) | 2(3.7%) | 47(87%) | 7(13%) | 47(87%) | 7(13%) |
| **Mandible** | | | | | | | | |
| Molars | 76(33.3%) | 31(41%) | 13(17.1%) | 32(42.1%) | 50(66%) | 26(34.2%) | 45(59.2%) | 31(41%) |
| premolars | 19(8.3%) | 12(63.2%) | 1(5.3%) | 6(32%) | 13(68.4%) | 6(32.%) | 14(74%) | 5(26.3%) |
| Anterior | 15(6.6%) | 13(87%) | 0(0%) | 2(13.3%) | 14(93.3%) | 1(7%) | 13(87%) | 2(13.3%) |

The adequacy of root canal treatment in relation to the teeth group is presented in Table 2. Most adequate teeth in relation to length were observed in the maxillary anterior (87%), mandibular molar (41%), and maxillary molar (48.9%). Most adequate teeth in relation to density parameter were observed in mandible molar, maxillary anterior, and maxillary molar (66%, 87%, and 57.8% respectively), while in relation to taper most adequately fulfilled teeth groups were maxillary anterior(87%), mandible molar (59.2%), and maxillary molar (66.7%).

Table 3. Table quality of root canal treatment in relation to root location, position, and curvature (root canal is the unit) (n=228).

| **Quality** | **Number of root canals** | **Root canal location** | | **Root canal position** | | **Root canal curvature** | |
|---|---|---|---|---|---|---|---|
| | | Maxillary | mandibular | Anterior | posterior | straight | curved |
| **Adequate** | 111(48.7%) | 69(56.6%) | 42(39.6%) | 58(79.5%) | 53(34.2%) | 99(55%) | 12(25%) |
| **Not-adequate** | 117(51.3%) | 53(43.4%) | 64(60.4%) | 15(20.5%) | 102(65.8%) | 81(45%) | 36(75%) |
| **Total** | 228(100%) | 122 | 106 | 73 | 155 | 180 | 48 |

The distribution of the 228 teeth in relation to adequacy in overall quality of RCT compared to root canal location, root canal position, and root canal curvature is presented in Table 3 above. The prevalence of overall technical quality of RCT was achieved in 48.7% of all roots treated; 56.6% of maxillary root locations, 39.6% of mandibular root locations, 79.5% of anterior teeth, 34.2% of posterior teeth, 55% of straight teeth, and 25% of curved teeth.

Table 4 . Length, density, and taper of root canal treatment in relation to canal curvature (n=228)

| **Root canal anatomy** | **Total**[a] | **Length**[b] | | | **Density**[b] | | **Taper**[b] | |
|---|---|---|---|---|---|---|---|---|
| | | acceptable | over | under | acceptable | poor | acceptable | poor |
| **straight** | 180(78.9%) | 124(54.4%) | 16(7%) | 40(17.5%) | 48(21%) | 132(57.9%) | 134(58.8%) | 46(20.2%) |
| **curved** | 48(21.1%) | 14(6.1%) | 6(2.6%) | 28(12.3%) | 18(7.9%) | 30(13.2%) | 25(11%) | 23(10.1%) |
| **Total**[a] | 228(100%) | 138(60.5%) | 22(9.6%) | 68(30%) | 66(29%) | 162(71.1%) | 159(69.7%) | 69(30.3%) |

[a] percentage distribution within the total number of root canals.

[b] percentage distribution within each root canal type.

The present study assessed the overall quality effectiveness of root canal procedures based on three measures: length, density, and taper. Adequacy of RCT is more prevalent in straight teeth (54.4%) compared to curved teeth (27.1%) (P.value=0.000) see Table 5. In terms of parameters of length (54.4%), density (21%), and taper (58.8%) straight teeth types fulfilled technical requirements compared to curved teeth (see Table 4 above).

Table 5. Characteristics of study participant and overall quality of root canal treatment (n=228)

| Characteristics n (%) | Overall quality of root canal treatment | | Total n (%) | *P.value* |
|---|---|---|---|---|
| | **Acceptable n (%)** | **Unacceptable n (%)** | | |
| **Gender** | | | | ***0.122*** |
| Male | 58(44.3) | 73(55.7) | 131 | |
| Female | 53(54.6) | 44(45.4) | 97 | |
| ***Treatment modality*** | | | | ***0.554*** |
| Initial RCT | 100(48.1) | 108(51.9) | 208 | |
| Retreatment | 11(55) | 9(45) | 20 | |
| ***Presence of peri-apical lesion*** | | | | ***0.153*** |
| yes | 36(56.2) | 28(43.8) | 64 | |
| No | 75(45.7) | 89(54.3) | 164 | |
| ***Teeth type and position*** | | | | ***0.000*** |
| Maxilla, molar | 15(33.3) | 30(66.7) | 45 | |
| Maxilla, premolar | 8(42.1) | 11(57.9) | 19 | |
| Maxilla, anterior | 44(81.5) | 10(18.5) | 54 | |
| Mandible, molar | 22(28.9) | 54(71.1) | 76 | |
| Mandible, premolar | 11(57.9) | 8(42.1) | 19 | |
| Mandible, anterior | 11(73.3) | 4(26.7) | 15 | |
| ***Obturiation level compared to CEJ*** | | | | ***0.026*** |
| At CEJ | 53(49.5) | 54(50.5) | 107 | |
| Below CEJ | 6(24) | 19(76) | 25 | |
| Coronal to CEJ | 52(54.2) | 44(45.8) | 96 | |
| ***Presence of missed canal*** | | | | ***0.000*** |
| Yes | 0(0.00) | 25(100) | 25 | |
| No | 111(54.7) | 92(45.3) | 203 | |
| ***Fractured instrument*** | | | | ***0.002*** |
| yes | 0(0.00) | 10(100) | 10 | |
| No | 111(50.9) | 107(49.1) | 218 | |
| ***Presence of perforation*** | | | | ***0.068*** |
| yes | 0(0.00) | 4(100) | 4 | |
| No | 111(49) | 113(50.4) | 224 | |
| ***Root canal type(anatomy)*** | | | | ***0.001*** |
| Straight | 98(54.4) | 82(45.6) | 180 | |
| Curved | 13(27.1) | 35(72.9) | 48 | |
| ***Root canal location*** | | | | ***0.000*** |

| | | | | |
|---|---|---|---|---|
| Maxillary adequate | 68(97.1) | 2(2.9) | 70 | |
| Maxillary not adequate | 1(1.9) | 51(98.1) | 52 | |
| Mandibular adequate | 42(95.5) | 2(4.5) | 44 | |
| Mandibular not adequate | 0(0.00) | 62(100) | 62 | |
| ***Root canal position*** | | | | ***0.000*** |
| Anterior adequate | 58(96.7) | 2(3.3) | 60 | |
| Anterior not adequate | 0(0.00) | 13(100) | 13 | |
| Posterior adequate | 52(98.1) | 1(1.9) | 53 | |
| Posterior not adequate | 1(1) | 101(99) | 102 | |
| ***Root canal curvature*** | | | | ***0.000*** |
| Straight adequate | 99(97.1) | 3(2.9) | 102 | |
| Straight not adequate | 0(0.00) | 78(100) | 78 | |
| Curved adequate | 11(84) | 2(15.4) | 13 | |
| Curved not adequate | 1(2.9) | 117(51.3) | 35 | |
| ***Operating professional education*** | | | | ***0.004*** |
| Doctor of dental medicine | 85(45.7) | 101(54.3) | 186 | |
| Bachelor of dental medicine | 0(0.00) | 1(100) | 1 | |
| operative &endodontic specialist | 15(93.8) | 1(6.2) | 16 | |
| Orthodontic specialist | 0(0.00) | 1(100) | 1 | |
| Maxillofacial specialist | 11(45.8) | 13(54.2) | 24 | |
| ***Operating dentist work experience*** | | | | ***0.005*** |
| 1 to 2 years | 37(38.9) | 58(61.1) | 95 | |
| 2 to 4 years | 21(42) | 29(58) | 50 | |
| 5 to 6 years | 52(63.4) | 30(36.6) | 82 | |
| Greater than 6 years | 1(100) | 0(0.00) | 1 | |
| Statistical evaluation: chi square tests CEJ: | | | | |

The chi-square results presented in Table 5 above indicated a significant association between the dependant variable(overall technical adequacy of root canal treatment) and the following factors: teeth type and position (P.value =0.000), Obturiation level compared to CE (P.value=0.026), Presence of missed canal (P.value=0.000), Fractured instrument (P.value=0.002), Root canal type (P.value=0.001), Root canal location(P.value=0.000), Root canal position(P.value=0.000), Root canal curvature (P.value=0.000), Operating professional education (P.value=0.004), and Operating dentist work experience (P.value=0.005) association. At the same time, characteristics

like Gender, Treatment modality, Presence of periapical lesion, and Presence of perforation do not show association (p. value >0.05).

Table 6. Factors related to the overall success of root canal treatment (RCT) by means of logistic regression modeling (n=228)

| | estimate | SE | OR | 95% CI | P.value |
|---|---|---|---|---|---|
| **Root canal anatomy** (Straight vs curved) | -5.782 | 2.55 | 0.003 | 0.00-0.401 | **0.024*** |
| **Obturiation density** (unvoid vs void) | -8.08 | 1.845 | 0.00 | 0.00-0.012 | **0.000*** |
| **Taper of root canal filling** (Acceptable vs poor) | 4.666 | 1.132 | 106.25 | 11.56-976.56 | **0.000*** |
| **Length of root canal filling** (Acceptable vs unacceptable) | 11.44 | 2.781 | 93136.38 | 400-21680969 | **0.000*** |
| **Treatment type** (initial RCT vs retreatment) | 3.010 | 1.438 | 20.281 | 1.211-339.657 | **0.036*** |
| **Presence of Lesion** (yes vs no) | 1.858 | 1.533 | 6.411 | 0.318-129.438 | 0.226 |
| **Study Participants residency** (Urban vs rural) | -0.230 | 0.935 | 0.795 | 0.127-4.963 | 0.806 |
| **Study participants sex** (male vs female) | -1.156 | 1.491 | 0.315 | 0.017-5.847 | 0.438 |
| **Sealant as root canal filling material** (yes vs no) | -2.978 | 18.732 | 0.051 | 0.00-4,479 | 0.874 |
| SE: standard error OR: odds ratio CI: confidence interval<br>Nagelkerke R square =0.939 | | | | | |

The results provided in Table 6 above are related to factors affecting the overall success of root canal treatment based on logistic regression modeling. It appears that factors such as Obturiation density (OR=0.000, P. value =0.000), the taper of root canal filling (OR=106.25, P. value=0.000), root canal type (OR=0.003, P. value=0.024), and length of root canal filling (OR=93136, P.value=0.000) have a significant impact on the success of root canal treatment. Study participants' residency, sex, usage of a sealant as root canal filling material, treatment type, and presence of lesion did not show significant impacts on RCT success (P.value >0.05). Using these explanatory variables, the logistic regression model had a predictive value of 93.9%.

# CHAPTER SIX

## 6.1. DISCUSSION

An initial objective of the project was to determine the prevalence of the quality of root canal filling, accordingly, our study found that 48.7% of roots operated showed overall acceptance of root canal treatment, which is lower than the study conducted in England (84.29%) (9), in Finland (67.4%) (38), and study conducted in India (47). However it is higher than the study conducted in Saudi Arabia (36%) (48), France (21%) (6), Jordan (47.4%) (49), Brazil (41.6%) (20), Sudan (32.5%) (50), and the United States of America (40.4%) (19). Based on our findings, it is evident that there is a significant variation in the prevalence of overall quality root canal filling across different regions. This discrepancy in acceptance rates may be attributed to variations in operational skill and knowledge, study design, and sample sizes across different studies. It is important for future researches to investigate into these factors to gain deeper understanding of the disparities observed in the overall quality of root canal treatments and to identify opportunities for improvement.

Another important finding of this study was that root canal type (straight or curved) was associated with the overall quality of root canal treatment (P.value=0.024). This study mirrors a study conducted elsewhere where the impact of the anatomy of the teeth is associated with accurate determination of the working length of the teeth in the preparation phase of the teeth thereby determining the quality of root filling (37, 38, 51). Supporting this, a study conducted in Sudan also concluded that curved root canals are more likely to result in poor root filling compared to straight root filling (52). These findings underscore the need for careful consideration of the anatomy of the teeth when undertaking root canal treatment, particularly in relation to achieving effective root filling.

The current investigation found that the Obturiation of the root canal system is associated with the overall quality of root canal treatment (P.value =0.000). The findings provide strong evidence that achieving uniform density of root filling without voids and canal space is crucial for the overall quality of root canal treatment. This findings complements earlier studies into this brain area that relate the idea that inadequate density of root canal is one challenging issue in root canal treatment (47, 48). Based on the findings, it is clear that the quality of root canal treatment

is closely linked to the Obturiation of the root canal system. The study provides strong evidence that achieving uniform density of root filling without voids and canal space is essential for successful root canal treatment. This aligns with previous research highlighting the importance of proper root canal filling density. The analyses confirm that Obturiation of the root canal is a critical factor in assessing the overall quality of root canal treatment and is often found to be inadequately performed.

Another finding is that the length of root canal filling is associated with the overall quality of root canal treatment (P.value=0.000). It was fascinating to find that the percentages of the length of root canal filling were distributed as follows: 60.5% adequately filled, 9.6% overfilled, and 29.8% under filled. Adequate length of root canals in terms of location 30.7% and 18.86% found in maxillary and mandibular teeth respectively (P.value=0.000). In some studies, a consistent pattern is observed, while variation in results is observed (49, 53). This variation makes it challenging to compare these results with the majority of research in the literature, where the assessment is typically made by general practitioners. The results might suggest the impact of the length of root canal filling on the success rate of root canal treatment (48). However, based on the findings of studies, a more plausible explanation is a suggestion of insufficient endodontic training, and experience (53). The data contribute a clearer understanding of the percentages of adequately filled, overfilled, and underfilled root canals indicate the need for precision in this aspect of treatment. The distribution of adequate root canal length by location further emphasizes the significance of proper training and experience in endodontic. Overall, these findings stress the need for further research and improvement of endodontic training to enhance the success rate of root canal treatment.

About 69.7% of the evaluated root canals had acceptable taper and taper of root canal filling were found to cause success in quality of root canal treatment (P. value =0.000). Further taper of root canal filling were found to be significantly associated with maxillary anterior and mandibular posterior teeth (P.value=0.000). This result is lower in prevalence with studies conducted in different regions of the world (48, 50, 54). This result build on existing evidence of impact of teeth location and position on acceptable quality of tapering thereby compromising on the overall success rate of root canal treatment (51).

Another important element that affect overall quality of root canal filling is treatment type (P.value=0.036). This also accords with our earlier observations, which showed that impact of treatment type on overall success rate of root canal filling (18). The result of these studies show that impact of treatment type on success rate of root canal treatment.

Contrary to expectations, this study did not find a significant difference between study participants residency, with gender of RCT treated individuals, usage of sealant as root canal filling material, and presence of lesion impacts on RCT success (P.value >0.05).

The current study is not free of limitations: First, the fact that it focused exclusively on private dental clinics located in Jimma Southwest Ethiopia may decrease confidence in the generalizability of the findings. It would be beneficial for future research to examine differences in the quality of root canal filling among Dentists in various healthcare institutions across Ethiopia. Second, another limitation of our study is that it utilized a cross-sectional study design, which limited our ability to establish cause-and-effect relationships as well as to evaluate long term success of root fillings. To address this limitation, we recommend employing a longitudinal study technique in future research. Third, our study uncovered an important issue in line with the assessment of radiographic images by independent evaluators to assess inter-examiners and intra-examiners reliability. Consequently, the inter-observer agreements weren't measured. These are an important issue for the future studies.

# CHAPTER SEVEN

## 7.1. CONCLUSION AND RECOMMENDATION

The result of this study showed that low prevalence of root canal treatment success rate at three selected dental clinic in Jimma town. Based on the results, it is clear that there are several factors that significantly influence the success of root canal treatment (RCT). These include the type and position of the tooth, Obturiation level compared to CEJ, presence of missed canal, presence of fractured instrument, root canal anatomy, location, position, and curvature, as well as the education and work experience of the operating dentist. In multifactorial analysis, RCT was found to be more likely to succeed in straight teeth, unvoid teeth, those with acceptable tapering, and with acceptable length of root canal filling. These findings emphasize the importance of considering these factors in order to achieve successful RCT outcomes. Further research and attention to these influencing factors can help improve the success rate of root canal treatments and contribute to better overall dental care.

# REFERENCES


1. Ray H, Trope M. Periapical status of endodontically treated teeth in relation to the technical quality of the root filling and the coronal restoration. International endodontic journal. 1995;28(1):12-8.
2. Endodontology ESo. Quality guidelines for endodontic treatment: consensus report of the European Society of Endodontology. International endodontic journal. 2006;39(12):921-30.
3. Ørstavik D, Kerekes K, Eriksen HM. The periapical index: a scoring system for radiographic assessment of apical periodontitis. Dental Traumatology. 1986;2(1):20-34.
4. Eriksen HM, Brstavik D, Kerekes K. Healing of apical periodontitis after endodontic treatment using three different root canal sealers. Dental Traumatology. 1988;4(3):114-7.
5. Habib AA, Doumani MD, Nassani MZ, Shamsy E, Jto BS, Arwadi HA, et al. Radiographic assessment of the quality of root canal fillings performed by senior dental students. Eur Endod J. 2018;3(2):101-6.
6. Boucher Y, Matossian L, Rilliard F, Machtou P. Radiographic evaluation of the prevalence and technical quality of root canal treatment in a French subpopulation. International endodontic journal. 2002;35(3):229-38.
7. Chen C-Y, Hasselgren G, Serman N, Elkind MS, Desvarieux M, Engebretson SP. Prevalence and quality of endodontic treatment in the Northern Manhattan elderly. Journal of endodontics. 2007;33(3):230-4.
8. Kabak Y, Abbott P. Prevalence of apical periodontitis and the quality of endodontic treatment in an adult Belarusian population. International endodontic journal. 2005;38(4):238-45.
9. Smith C, Setchell D, Harty F. Factors influencing the success of conventional root canal therapy—a five-year retrospective study. International endodontic journal. 1993;26(6):321-33.
10. Chueh LH, Chen SC, Lee CM, Hsu YY, Pai SF, Kuo ML, et al. Technical quality of root canal treatment in Taiwan. International Endodontic Journal. 2003;36(6):416-22.
11. Román-Richon S, Faus-Matoses V, Alegre-Domingo T, Faus-Llácer VJ. Radiographic technical quality of root canal treatment performed ex vivo by dental students at Valencia University Medical and Dental School, Spain. Medicina Oral, Patología Oral Y Cirugía Bucal. 2014;19(1):e93.
12. Bierenkrant D, Parashos P, Messer H. The technical quality of nonsurgical root canal treatment performed by a selected cohort of Australian endodontists. International endodontic journal. 2008;41(7):561-70.
13. Ridell K, Petersson A, Matsson L, Mejàre I. Periapical status and technical quality of root-filled teeth in Swedish adolescents and young adults. A retrospective study. Acta Odontologica Scandinavica. 2006;64(2):104-10.
14. Peters OA, Laib A, Göhring TN, Barbakow F. Changes in root canal geometry after preparation assessed by high-resolution computed tomography. Journal of endodontics. 2001;27(1):1-6.
15. Al-Omari MA, Hazaa A, Haddad F. Frequency and distribution of root filled teeth and apical periodontitis in a Jordanian subpopulation. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology. 2011;111(1):e59-e65.
16. Stoll R, Betke K, Stachniss V. The influence of different factors on the survival of root canal fillings: a 10-year retrospective study. Journal of endodontics. 2005;31(11):783-90.
17. Peršić R, Kqiku L, Brumini G, Husetić M, Pezelj-Ribarić S, Brekalo Pršo I, et al. Difference in the periapical status of endodontically treated teeth between the samples of Croatian and Austrian adult patients. Croatian medical journal. 2011;52(6):672-8.
18. Laukkanen E, Vehkalahti MM, Kotiranta AK. Impact of type of tooth on outcome of non-surgical root canal treatment. Clinical Oral Investigations. 2019;23:4011-8.

19. Polyzos NK, Sarris KG, Pita AI, Mikrogeorgis GV, Lyroudia KM. Quality of root canal fillings performed by undergraduate students and the related factors on the treatment outcome: A 2-to 5-year follow-up. European endodontic journal. 2018;3(3):179.
20. Costa GM, Santos Soares SM, Pelli Paiva PC, Verli FD, Gonçalves PF, Pereira SMdS, et al. Factors Affecting the Periapical Status of Root-Filled Canals: A Cross-Sectional Study at the Undergraduate Level. International Journal of Dentistry. 2017;2017(1):7413204.
21. Molven O, Halse A. Success rates for gutta-percha and Kloroperka N-Ø root fillings made by undergraduate students: radiographic findings after 10/17 years. International endodontic journal. 1988;21(4).
22. Heling B, Tamshe A. Evaluation of the success of endodontically treated teeth. Oral Surgery, Oral Medicine, Oral Pathology. 1970;30(4):533-6.
23. Ng YL, Mann V, Gulabivala K. Outcome of secondary root canal treatment: a systematic review of the literature. International endodontic journal. 2008;41(12):1026-46.
24. Alogaly JA, Ashour MS. Factors affecting the success of endodontic treatment (surgical or nonsurgical): a brief review. International Journal of Medicine in Developing Countries. 2020;3(9):730-.
25. Adriano L, Barasuol J, Cardoso M, Bolan M. In vitro comparison between apex locators, direct and radiographic techniques for determining the root canal length in primary teeth. European Archives of Paediatric Dentistry. 2019;20:403-8.
26. Adorno CG, Solaeche SM, Ferreira IE, Pedrozo A, Escobar PM, Fretes VR. The influence of periapical lesions on the repeatability of two electronic apex locators in vivo. Clinical Oral Investigations. 2021:1-7.
27. Hickel R, Peschke A, Tyas M, Mjör I, Bayne S, Peters M, et al. FDI World Dental Federation: clinical criteria for the evaluation of direct and indirect restorations—update and clinical examples. Clinical oral investigations. 2010;14:349-66.
28. Cakici E, Yildirim E, Cakici F, Erdogan A. Assessment of periapical health, quality of root canal filling, and coronal restoration by using cone-beam computed tomography. Nigerian Journal of Clinical Practice. 2016;19(5):673-7.
29. Elemam RF, Abdul Majid ZS, Groesbeck M, Azevedo ÁF. Quality of root canals performed by the inaugural class of dental students at Libyan International Medical University. International Journal of Dentistry. 2015;2015(1):135120.
30. Rafeek RN, Smith WA, Mankee MS, Coldero LG. Radiographic evaluation of the technical quality of root canal fillings performed by dental students. Australian Endodontic Journal. 2012;38(2):64-9.
31. Gulabivala K, Ng YL. Factors that affect the outcomes of root canal treatment and retreatment—A reframing of the principles. International Endodontic Journal. 2023;56:82-115.
32. Ng YL, Mann V, Gulabivala K. A prospective study of the factors affecting outcomes of non-surgical root canal treatment: part 2: tooth survival. International endodontic journal. 2011;44(7):610-25.
33. Doyle SL, Hodges JS, Pesun IJ, Law AS, Bowles WR. Retrospective cross sectional comparison of initial nonsurgical endodontic treatment and single-tooth implants. Journal of endodontics. 2006;32(9):822-7.
34. Mazzi-Chaves JF, Petean IBF, Soares IMV, Salles AG, Antunes LAA, Segato RAB, et al. Influence of genetic polymorphisms in genes of bone remodeling and angiogenesis process in the apical periodontitis. Brazilian Dental Journal. 2018;29:179-83.
35. Feiz A, Nazeri R, Karimi K, Tayaran S, Mosleh H, Mojtahedi N. The effects of surface treatments on root dentin analyzing microleakage of endodontically treated teeth restored with fiber posts. Annals of Dental Specialty. 2017;5(4):151-5.

36. Liberati A, Altman DG, Tetzlaff J, Mulrow C, Gøtzsche PC, Ioannidis JP, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. Annals of internal medicine. 2009;151(4):W-65-W-94.
37. RIBEIRO DM, HENCKEL MD, MELLO FW, FELIPPE MCS, FELIPPE WT. Radiographic analysis the obturation's quality in root canal treatment performed by a South Brazilian sample of undergraduate students. RGO-Revista Gaúcha de Odontologia. 2019;67:e20190040.
38. Laukkanen E, Vehkalahti MM, Kotiranta AK. Radiographic outcome of root canal treatment in general dental practice: tooth type and quality of root filling as prognostic factors. Acta Odontologica Scandinavica. 2021;79(1):37-42.
39. Ericsson KA. Development of professional expertise: Toward measurement of expert performance and design of optimal learning environments: Cambridge University Press; 2009.
40. Pratten DH, McDonald N. Comparison of radiographic and electronic working lengths. Journal of Endodontics. 1996;22(4):173-6.
41. Ng YL, Mann V, Rahbaran S, Lewsey J, Gulabivala K. Outcome of primary root canal treatment: systematic review of the literature–part 1. Effects of study characteristics on probability of success. International endodontic journal. 2007;40(12):921-39.
42. Cotton TP, Schindler WG, Schwartz SA, Watson WR, Hargreaves KM. A retrospective study comparing clinical outcomes after obturation with Resilon/Epiphany or Gutta-Percha/Kerr sealer. Journal of Endodontics. 2008;34(7):789-97.
43. Hoskinson SE, Ng Y-L, Hoskinson AE, Moles DR, Gulabivala K. A retrospective comparison of outcome of root canal treatment using two different protocols. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology. 2002;93(6):705-15.
44. Bender I, Seltzer S, Soltanoff W. Endodontic success—A reappraisal of criteria: Part I. Oral Surgery, Oral Medicine, Oral Pathology. 1966;22(6):780-9.
45. Briggs P, Scott B. Evidence-based dentistry: endodontic failure--how should it be managed? British dental journal. 1997;183(5):159-64.
46. Tomić M, Kolak V. Frequency of different indications for endodontic treatment among patients from Pancevo, Serbia. Medicinski podmladak. 2021;72(1):12-7.
47. Moradi S, Gharechahi M. Quality of root canal obturation performed by senior undergraduate dental students. Iranian endodontic journal. 2014;9(1):66.
48. AbuMostafa A, Ahmad IA, Alenezy G, AlZoman A. Quality of root canal filling performed by undergraduate students in a Saudi Dental College. Journal of Dentistry and Oral Hygiene. 2015;7(5):64-70.
49. Barrieshi-Nusair K, Al-Omari M, Al-Hiyasat A. Radiographic technical quality of root canal treatment performed by dental students at the Dental Teaching Center in Jordan. Journal of dentistry. 2004;32(4):301-7.
50. Awooda EM, Siddig RI, Alturki RS, Sanhouri NM. Radiographic technical quality of root canal treatment performed by undergraduate dental students at the Academy Dental Teaching Hospital, UMST, Sudan. Journal of International Society of Preventive and Community Dentistry. 2016;6(6):554-8.
51. Tang L, Sun Tq, Gao Xj, Zhou Xd, Huang Dm. Tooth anatomy risk factors influencing root canal working length accessibility. International Journal of Oral Science. 2011;3(3):135-40.
52. Dadresanfar B, Akhlaghi NM, Vatanpour M, Yekta HA, Mohajeri LB. Technical quality of root canal treatment performed by undergraduate dental students. Iranian Endodontic Journal. 2008;3(3):73.
53. Elsayed RO, Abu-bakr NH, Ibrahim YE. Quality of root canal treatment performed by undergraduate dental students at the University of Khartoum, Sudan. Australian Endodontic Journal. 2011;37(2):56-60.
54. Fong W, Heidarifar O, Killough S, Lappin M, El Karim I. An audit on technical quality of root fillings performed by undergraduate students. International endodontic journal. 2018;51:e197-e203.

# Annexes

## Annex-1: Information Sheet

**Project title:** Assessment of quality of root canal filling through observation of radiographic image at Dental Clinics in Jimma town, Southwest Ethiopia

**Principal investigator (PI)**: Selam Fiseha (DMD, Resident in Endodontic)

**Sponsoring organization:** Jimma University

**Study Code/ID No___________________ Mob No______________ Date_______________**

**Introduction:** Dear participant, I am________________ from Jimma University, Ethiopia. I am hereby cordially inviting you to participate in a research project "***Assessment of quality of root canal filling through observation of radiographic image at Dental Clinics in Jimma town, Southwest Ethiopia*"** that will be conducted at Dental Clinics of Jimma town. We would like to request your careful attention to explain the study goal and content of the study in short and precise way within 3-5 minutes, and respond freely and voluntarily.

**Purpose of the study**: This study is aimed to assess the quality of root canal filling and coronal restoration through observation of radiographic image at Dental Clinics in Jimma town, Southwest Ethiopia. The study will also pinpoint the skill of dental professionals and helps to improve their knowledge and skill towards root canal filling .This will improve patients' treatment outcomes after root canal treatment.

**Study procedures:** If you are voluntary to participate in this study, we will make maximum of 15 minutes interview with you to collect some sociodemographic and clinical data. Moreover, if you are voluntary radiography will performed to assess the quality of your root canal filling and coronal restoration.

**Voluntary participation:** Your decision to participate or not to the study is entirely based on your interest. Even after your decision to participate, you have full right to leave at any time during data collection. This will not affect your treatment.

**Discomforts and Risks**: No discomfort or risk could happen because of your participation in this study. The study is entirely based on a face-to-face interview and all the information that will be collected will be kept confidential and used only for research purposes.

**Benefits and incentive:** There will be no direct benefit to you, but your cooperation will help us to improve root canal filling and coronal restoration.

**Confidentiality:** All the information gathered from you will be kept in strict secret. All information that will be collected from you for this research project will be kept private. We will not be sharing information about you to anyone outside of the research team.

**Right to Refuse or Withdraw:** You have full right to withdraw from participating in this study at any time before and after consent even without explaining the reasons.

**Whom to contact:** If you have any questions you may ask to now or for later, even after the study has started, you are kindly requested to contact the following individuals:

1. Dr. Selam Fiseha (DMD, Resident in Endodentics) : **selamfiseha2@gmail.com**
   Mob No +251988442121

## Annex-2: Informed Consent form (English Version)

**Project title:** Assessment of quality of root canal filling through observation of radiographic image at Dental Clinics in Jimma town, Southwest Ethiopia

Study Code/ID No____________________ Mob No______________ Date_______________

**Introduction:** Good morning/ afternoon; my name is ____________. I am here inviting you to a research sponsored by Jimma University for postgraduate study. To accomplish this research, your voluntary participation is very crucial.

**Consent process:** The objectives and purpose of the research project have clearly been explained to me and I understood that the data obtained from me will help improve the treatment success of dental patients. Moreover, I have also been well informed of my right to keep hold of information, decline to cooperate, and make myself withdraw from the study. Therefore, with full understanding of the importance of the study, I agreed voluntarily to participate in the study. I confirm my consent to participate in the study with my signature below.

If you have any questions at any time during the study, you may contact [Dr. Selam Fiseha] at [Email: **selamfiseha2@gmail.com**, or Mob No: +251988442121)

Specific questions about your rights as a research subject can be directed to the Chair of the Jimma University's Institutional Review Board at irb@ju.edu. et

□ Please click here to indicate that you understand the above and freely give your consent to participate in this research project.

I understand the above and freely give my consent to participate in this research project.

Name of participant ________________________________Signature __________Date_____________

Name of data collector ______________________________Signature __________Date_____________

Name of witness ___________________________________Signature __________Date_____________

**Annex-3: Informed Consent form (Amharic Version)**

**<u>ተረድቶ መስማሚያ (Informed Consent)</u>**

**የጥናቱ ርእስ፡** Assessment of quality of root canal filling through observation of radiographic image at Dental Clinics in Jimma town, Southwest Ethiopia

**መለያ ቁጥር_____________________________ስልክ ቁጥር_________________ቀን_______________**

**የዋና ተማራማሪዉ ስም (PI) ፡** ዶ/ር ሰላም ፍስሃ

**<u>መግቢያ</u>፡** ዉድ ተሳታፊያችን፡ ስሜ ________________ሲሆን፣ በጅማ ዩኒቨርሲቲ የኢንዶዴንቲክስ ድህረ-ምረቃ ተማሪ ነኝ። የዚህ ጥናት ዋና ዕቅድ የጥርስ ታማሚዎች ህክምና ከተደረገላቸዉ በኋላ ያለዉን የህክምና ሂደት መከታተል ነዉ። ለዚህ ደግሞ ከእያንዳንዱ የጥርስ ታካሚ መረጃ እንሰበስባለን። እርስዎ ደግሞ መረጃ በመስጠት እንዲተባበሩን በትህትና እንጠይቃለን።

**ጥቅም**፡ ይህ ጥናት የጥርስ ታማሚዎች ህክምና ከተደረገላችው በኋላ ያለዉን የህክምና ሂደት መከታተል እና ምን ያህሉ በትክክል እንደታከሙ መረጃ ይሰጣል። ከዚህ ጥናት የሚገኘዉ ዉጤት ደግሞ የጥርስ የህክምና ጥራትን ለማሻሻል ጉልህ ሚና ይኖረዋል።

**ስጋት እና አለመመጣጠን፡** በዚህ ጥናት ዉስት በመሳተፎ ምክንያት የሚፈጠር ምንም ዓይነት ስቃይ እና ጭንቀት አይኖርም። ከርሱዎ የሚፈለግዎ ዉድ ጊዚዎትን ነው እና ራጅ ለመነሳት ፍቃደኛ መሆን ነዉ።

**ማበረታቻዎች**፡ በዚህ ምርምር ውስጥ ለመሳተፍ ምንም ማበረታቻ አይሰጥዎትም።

**ሚስጥራዊነት**፡- ከዚህ የምርምር ፕሮጀክት የምንሰበስበው መረጃ በሚስጥራዊነት ይቀመጣል። ከጥናቱ የሚሰበሰበው መረጃ በፋይሉ ውስጥ ይቀመጣል ፣ ስምዎ በእሱ ላይ የማይገኝበት ፣ ግን የተመደበለት ቁጥር ነው ።

**ላለመቀበል ወይም ላለመመለስ መብት**፡- በዚህ ጊዜ ለመሳተፍ ካልፈለጉ ወይም ለመነሳት የማይፈልጉ ከሆነ በዚህ ምርምር ውስጥ ለመሳተፍ የመከልከል ሙሉ መብት አለዎት። ነገር ግን የእርስዎ በዚህ ጥናት ዉስጥ መሳተፍ ለአላማችን ስኬት ትልቅ ጠቀሜታ አለው፣ እናም ጥናቱ ለእርስዎ ምንም ስጋት የለውም። መለስተኛ ጊዜ የሚፈጅ ከ 10 እስከ 20 ደቂቃ በስተቀር ። ስለሆነም በዚህ ጥናት ላይ እንዲሳተፉ ትብብራችሁን በትህትና እንጠይቃለን።

ተጨማሪ መረጃ ከፈለጉ፣ ከዚህ በታች ስማቸዉ የተዘረዘሩትን ሰዎች ያነጋግሩ

ዶ/ር ሰላም ፍስሃ (በጅማ ዩኒቨርሲቲ የጥርስ ሃኪም ና የኢንዶዴንቲክስ ድህረ-ምረቃ ተማሪ)

አሜል፡ selamfiseha2@gmail.com ,   Mob No:  0988442121

## የፍቃድ ቅጽ

ስለ ጥናት መረጃ ተሰጥቶኛል። ለዚህ ጥናት መረጃ እንድሰጥ  ተጠይቄያለሁ። በመግቢያው ክፍል ውስጥ የተገለጹትን መረጃዎች በሙሉ የተነበቡ ሲሆን ማንኛውንም አሻሚ ጥያቄ ለመጠየቅ እድሉ አግኝቻለሁ ለተጨነቁኝ ሁሉ አጥጋቢ መልስ አግኝቻለሁ ። ስለሆነም ስለሁኔታው ሙሉ ግንዛቤ በመሆኔ በእውቀት ላይ የተመሠረተ ፈቃዴን የሰጠሁ እና በጥናቱ አካሄድ ውስጥ በፈለግኩበት ጊዜ የምተባበር ነው ።

በጥናቱ ለመሳተፍ መስማማቴን በፊርማዬ አረጋግጣለው።

የ ስምምነ ት   ቁጥር   _______________የ ተሳ ታፊ   ኮድ________________ፊርማ ___________   ቀን __________

የመረጃ ሰብሳቢው ስም ________________________ፊርማ____________ቀን________________

## Annex-4: Data collection tool

***Q1. Unique key________(questionnaire #____)***

***Q2. Age in years -----***

***Q3. Sex***

1. Male
2. Female
3. Not recorded

***Q4. Occupation of clients***

1. Governmental employees
2. NGO
3. Private sector
4. Student
5. Farmer
6. House wife
7. Other

***Q5. Does the client take medication? (if no Q5 skip to Q8)***

1. Yes, and taken antibiotic
2. Yes, and taken analgesic
3. Yes , and taken both Antibiotic and analgesic
4. No
5. Not recorded

***Q6. IF yes to ques(Q5) and taken antibiotic which type of medication does the client take?***

1. Amoxicillin 500mg/PO/TID for 7 days
2. Amoxicillin 250 mg/PO/TID for 7 days
3. Metronidazole 500mg/PO/TID for 7 days
4. Metronidazole 250mg/PO/TID for 7 days
5. Azithromycin 500mg/PO/QD for 3 days
6. Augmentin 625mg/PO/TID for 7 days
7. Augmentin 1000mg/PO/BID for 7 days
8. Not taken

***Q7. IF yes to ques(Q5) and taken analgesic which type of medication does the client take?***

1. Ibuprofen 400mg/PO/ PRN
2. Diclofenac 500 mg/PO/ PRN
3. Paracetamol 500 mg/PO/ PRN
4. Tramadol 50mg/PO/PRN
5. Not taken

***Q8. Type of treatment***

1. Initial treatment
2. Retreatment

***Q9. Number of teeth infected and joined for RCT***

1. One teeth
2. Two teeth
3. Three teeth
4. Four teeth

***Q10. type of tooth type filled***

1. Molars
2. Premolars
3. Canines
4. Incisors

***Q11. Presence of peri-apical lesion(if No skip to Q14)***

1. Yes
2. No

***Q12. If yes to Q11, do you use intra-canal medicament***

1. Yes
2. No

***Q13. If yes to Q12, which type of intra-canal medicament do you used?***

1. Calcium hydroxide paste
2. Calcium hydroxide powder
3. Chlorohexidine digluconate
4. Antibiotics triple paste
5. Double antibiotics paste
6. Steroids ledermix

***Q14. Obturian length***

1. Adequate
2. Over filling
3. Under filling

***Q15 .Radiographs for technical quality of the root filling parameter assessment of length***

1. Acceptable(root filling terminating 0-2mm from radiographic apex)
2. Unacceptable (root filling extending beyond the radiographic apex(overfilled) or greater than 2mm away from apex(under filled)

***Q16. Taper of root canal filling***

1. Acceptable (Consistent taper from the coronal to the apical part of the filling, with good reflect to canal shape)
2. Poor (Not consistent taper from the coronal to the apical part of the filling)

***Q17. Obturation length _____________***

***Q18. Obturation density***

1. Void
2. No void

***Q19. Radiographs for technical quality of the root filling parameter assessment lateral adaptation***

1. Voids absent, homogenous root filling, good condensation
2. Voids present, heterogeneous root filling, poor condensation

***Q20. Density of root canal filling***

1. Poor (Not uniform density of root filling with clear presence of voids and canal space is visible)
2. Acceptable(Uniform density of root filling without voids and canal space is not visible)

***Q21. Homogeneity and length of root filling***

1. Homogeneity acceptable, length acceptable
2. Homogeneity acceptable, terminating > 2mm
3. Homogeneity acceptable, beyond radiographic apex
4. Homogeneity un acceptable, length acceptable
5. Homogeneity un acceptable, terminating > 2mm
6. Homogeneity un acceptable, beyond radiographic apex

***Q22. Prevalence of tooth type and position (FDI classification)***

1. Maxilla, molar
2. Maxilla, premolar
3. Maxilla, anterior
4. Mandible, molar
5. Mandible, premolar
6. Mandible, anterior

***Q23. Obturiation level compared to CEJ***

1. At CEJ
2. Below CEJ
3. Coronal to CEJ

***Q24. Presence of missed canal (if No skip to Q26)***

1. Yes
2. No

***Q25. If yes to Q24, which canal***

1. Distal canal
2. Miso distal canal
3. Miso bucal canal
4. Palatal canal
5. Bucal canal
6. Lingual canal

7. Disto bucal canal

***Q26. Fractured instrument (if No skip to Q28)***

1. Yes
2. No

***Q27. If yes to Q26, which site***

1. Coronal 3rd
2. Apical 3rd
3. Middle 3rd
4. Other

***Q28. Perforation***

1. Yes
2. No

***Q29. Which type of perforation***

1. Strip
2. Coronal
3. Furcation
4. Other

***Q30. How do you determine the working length?***

- Apex locator
- Radiographic methods
- Both (A and B)
- Not Applied

***Q31. What materials you used for root canal filling?***

1. Gutta-percha
2. Resilon(Epiphany)
3. Bioceramic materials
4. MTA

***Q32. What type of endodontic instrument you used for cleaning and shaping?***

1. Group I: Hand-operated endodontic instruments
2. Group I: Hand-operated endodontic instruments Barbed broaches and rasps
3. Group I: Hand-operated endodontic instruments K-type reamers and files
4. Group I: Hand-operated endodontic instruments H~ files
5. Group II: GG drill
6. Group II: peso reamer
7. Group III: Ultrasonic and sonic instruments
8. Group IV: Engine drive reciprocating rotary instrument

***Q33. DO you use paper point? (if No skip to Q35)***

1. Yes
2. No

***Q34. IF yes to ques 32, what lengths of paper point do you used?***

1. Same size of master apical file or MAF
2. Any Small size from MAF
3. large size from MAF
4. not specified

***Q35. Do you use spreader during root canal procedures?(if No skip to Q38)***

1. Yes
2. No

***Q36. If yes to ques 35, what size of spreader do you used?***

1. Same size of master apical file
2. One Small size from master apical file
3. Two Small size from master apical file
4. Three Small size from master apical file
5. Large size from master apical file

***Q37. If yes to ques 35, what length spreader do you used?***

1. 1mm decrease from the WL
2. 2mm from WL
3. 3mm-4mm from WL
4. Until the spreader is engaged in to the canal
5. Not specified

***Q38. Do you use sealant as root canal filling material?(If No skip to Q40)***

1. Yes
2. No

***Q39. If you answer Yes for Ques 38, what type of sealant do you used?***

1. Calcium silicate based sealers(CSBS)
2. Zinc oxide eugenol based sealers
3. Epoxy Resin based sealer AH26
4. Epoxy Resin based sealer AH PLUS
5. Calcium hydroxide sealers
6. Glass ionomer based sealer
7. Not specified

***Q40. What method of sealant application do you used?***

1. Lentulo spiral
2. Master gutta percha application
3. Master apical file
4. Not specified

***Q41. Selection of master apical GP***

1. based on master apical file(MAF)
2. one size smaller from (MAF)
3. any large size GP

4. Not specified

***Q42. Techniques of Shaping and Cleaning***

1. Step-back technique Conventional step-back
2. Step-back technique Passive step-back
3. Crown-down (step-down) technique Crown-down pressure less
4. Crown-down (step-down) technique Double flare
5. Crown-down (step-down) technique Balanced force
6. Hybrid technique
7. Not specified

***Q43. What is your obturation technique ?***

1. Cold lateral compaction; Single-cone obturation technique
2. Cold lateral compaction; Multiple- cone obturation technique
3. Warm vertical compaction technique
4. Warm lateral compaction technique
5. Continuous wave compaction technique
6. Thermo plasticized gutta-percha injection
7. Not specified

***Q44. Do you use accessary GP? (If No skip to Q46)***

1. YES
2. NO

***Q45. If yes for Q44, Technique of using accessary GP?***

1. one or two small size from MAG(master apical gutta purcha)
2. Smaller sequential Gp from MAG
3. equal size of MAG
4. Not specified

Q46. ***Radiographs for technical quality of the root filling parameter assessment taper***

1. acceptable (consistent taper from orifice to apex
2. unacceptable (no consistent taper from orifice to apex)

***Q47. Overall quality of root filling (dependent variable)***

1. Acceptable
2. unacceptable

***Q49. Root canal***

1. Straight
2. Curved

***Q50. Quality of root canal filing in relation to root canal location***

1. Maxillary Adequate

2. Maxillary Not adequate
3. Mandibular Adequate
4. Mandibular Not adequate

***Q51. Quality of root canal filing in relation to root canal position***

1. Anterior, Adequate
2. Anterior not Adequate
3. Posterior Adequate
4. Posterior not Adequate

***Q52. Quality of root canal filing in relation to root canal curvature***

1. Straight, adequate
2. Straight, not adequate
3. Curved, adequate
4. Curved, not adequate

***Q53. Operating dentist educational level***

1. DDM(Doctor of dental medicine)
2. BDS(bachelor of dental science)
3. Operative and endodontic specialist
4. Orthodontic specialist
5. Maxillofacial specialist
6. Undergraduate dental students
7. Other

***Q54. Operating dentist work experience on RCT***

1. 1-2 years
2. 2-4 years
3. 5-6years
4. > 6years