ORIGINAL ARTICLE

Assessment of the Impact of Quality of Canal Obturation, Coronal and Apical Seal on the Healing of CBCT-Diagnosed Periapical Lesions in Endodontically Treated Teeth in Sri Lanka

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Abstract

Background: Previous literature has investigated the association between the attribute of coronal restoration and root canal obturation with the radiographic periapical status of endodontically treated teeth.

Objectives: This study intends to assess the status of periapical lesions/pathology and, the main factors influencing the healing of periapical lesions of root canal-treated teeth clinically and radiographically exploiting CBCT. The quality of coronal restoration, canal obturation, and apical seal were selected to be assessed, as they have a greater impact on healing peri apical pathology.

Methods: This aretrospective study was conducted at the Department of Restorative Dentistry and the Division of Oral Medicine and Radiology, Faculty of Dental Sciences, University of Peradeniya, Sri Lanka. All the patients who presented between January 2020 and January 2021, had root canal treatment done at least one year prior, were referred for CBCT assessment for some other conditions, and fulfilled the inclusion criteria, were selected. Root canal-treated teeth were recognized by radio-opaque filling material inside the canals in any anterior or posterior teeth.

Results: A sum of 50 CBCT reports from 50 patients was encompassed in the dissertation. Median age was 26 (±4) years, with 37.5% of reports belonging to males. Statistical analysis was performed utilizing Statistical Package for Social Sciences (SPSS) version 20.0 software (IBM Corp). Out of fifty patients, 32 had been found to have adequate clinical coronal seal while 31 have been found to have adequate radiographical coronal seal. Further, 31 patients were found to have insufficient obturation and 28 were found to have adequate apical seal. A significant association was observed between periapical healing and adequate coronal restoration in root-filled teeth (p=0.048). However, the association between the healing of the periapical region, and adequate root canal obturation (p=0.09) and adequate apical seal (p=0.777) were found to be non-significant.

Conclusion: The most influential factor for the healing of periapical lesions in endodontically treated teeth appears to be adequate coronal restoration, compared to root canal obturation and apical seal, in a cohort of patients in Sri Lanka.

Keywords: *Prognosis, clinical outcomes, endodontics, root canal therapy, CBCT, periapical lesion, teeth, Sri Lanka.*

INTRODUCTION

Assessing the periapical status across various populations proves beneficial, aiding in the determination of treatment requirements for each populace and assessing the impacts of different endodontic mediations on treatment results [1]. In numerous countries, cross-sectional and epidemiological studies employing diverse approaches and criteria, have documented the ubiquity of apical periodontitis (AP) [1, 2]. AP is the local inflammation of the periapical region that originates from pulp inflammation which may happen with the progress of dental caries, trauma, or as a result of operative dental procedures [3]. The primary reason for apical periodontitis is the infected pulp, resulting from a kinetic interplay between microbial elements, and host defences at the boundary of infected root pulp and periodontium. This dynamic leads to local inflammation, hard tissue resorption, periapical tissue destruction, and the gradual formation of various pathologies termed periapical lesions [4]. With proper endodontic treatment, healing of periapical lesions progresses, distinguished by gradual decline and resolution of apical radio transparency in following radiographs [5, 6].

Not all endodontically treated teeth may experience a reduction in apical radiolucency, as "endodontic failure" may manifest through persistent or enlarging periapical lesions, clinical signs of apical inflammation, and ongoing root resorption. Advanced complications, including endodontic failure, may arise post-endodontic treatment due to pre-operative factors such as the size of periapical lesions, the presence of sinus lesions, and perforations. They could also result from intraoperative challenges like difficulty in achieving canal patency and instrumentation up to the apical extent, overextension of filling materials, insufficient aseptic management, and post-operative elements like scarce of tight coronal seals [7].

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The efficacy of root canal treatment (RCT) hinges on the careful selection of clinical protocol. This selection relies on several factors, including the canal disinfection process (comprising instruments implementation, irrigant solution, irrigating technique, and canal dressing), determination of the apical restrict for canal preparation, obturation, and the characteristics of the sealer used [8].

Some cross-sectional studies have implied, that the success rate of RCT is greatly influenced by the attribute of coronal restoration. In contrast, other investigations have emphasized a positive relation between the success ratio of RCTs and the technical standards of root obturation, with the attribute of coronal restoration playing a lesser role in endodontic treatment outcomes [9-12]. Yet another study has concluded that both factors wield a comparable influence on the accomplishment of RCT [13].

Both clinical and radiological assessments can aid in diagnosing periapical periodontitis. Clinical findings such as tenderness to percussion (TTP), swelling, apical abscess, discharging sinus, mobility of tooth, and, deep pockets, are indicative of periapical periodontitis. On the other hand, radiological findings including broadening of the periodontal ligament space, loss of lamina dura, presence of periapical radiolucent areas, and lasting root resorption are diagnostic of periapical periodontitis [14]. Endodontic successes are typically evaluated through a comprehensive clinical examination, complemented by plain film radiographs. These assessments aim to identify the absence or reduction of the factors above indicative of successful treatment [15].

Several studies have detailed the use of conventional periapical radiographs, along with evaluations of the standard of canal obturation and, coronal restoration, as methods for assessing thrive in endodontics [10, 16].

The primary drawback of periapical radiographs in periapical assessment lies in the superimposition of dental structures across many planes. This can impede their interpretation and potentially lead to false-negative results [17, 18].

Moreover, the deficiency in resolution and the incapacity to evaluate conditions three-dimensionally can additionally hinder proper assessment. In response to these limitations, the employment of cone beam computed tomography (CBCT) technology has been advocated to conquer the constraints of two-dimensional periapical radiographic images and to enhance the precision of detecting periapical lesions compared to other dental radiographic methods [19].

Therefore, CBCT has been considered a leading tactful diagnostic way to recognize PA [20]. Nevertheless, it is not accepted for regular endodontic diagnostic motives due to its comparative inaccessibility and the high dose of radiation exposure associated with CBCT.

In identifying the clinical significance, the results of this research could elucidate the factors contributing to the healing of periapical lesions in root canal-treated teeth. The study findings will also underscore the importance of coronal seals [21].

Therefore, this investigation aims to appraise the status of periapical lesions/pathology and the strands influencing the healing of periapical lesions in CBCT-diagnosed endodontically treated teeth within a Sri Lankan setting.

MATERIALS AND METHODS

Between 2020 and 2021, a retrospective cross-sectional study was conducted. It utilized 50 CBCT images from patients aged 16 to 50. The sample size was the total number of patients who presented to the Department of Oral Medicine and Radiology Department for a CBCT for any other purpose and who fulfilled the study criteria. The sample was collected by filtering the total 250 CBCT taken in that year. These images, sourced from the annals in the Division of Oral Medicine and Radiology at the Faculty of Dental Sciences, University of Peradeniya, Sri Lanka, were originally referred for various assessments, including impacted teeth, dento-alveolar pathology, implant site evaluation, and other pathological conditions. The inclusion criteria encompassed patients aged 16 to 50 years with teeth exhibiting closed apices and having undergone endodontic treatment at least 3 months prior (as evidenced by radio-opaque material within the root canals). Additionally, these teeth were required to have remained untreated until the CBCT appointment. Patients meeting any of the following criteria were excluded from the study: those who had undergone retreatment of root canal treatment (RCT) or subsequent modification of coronal restorations, individuals with teeth exhibiting open apices or poorly developed roots, patients with severe periodontitis, resulting in bone loss around the evaluated teeth, individuals with prior-endo lesions, specific systemic conditions, or undergoing certain drug therapies such as diabetes mellitus, bisphosphonate therapy, or treatment for multiple myeloma. Additionally, teeth with a history of trauma post-RCT, avulsed or severely intruded teeth, those subjected to any surgical procedures related to the tooth, or those treated with Mineral Trioxide Aggregate (MTA) were also excluded. Further, any tooth with breakage of instruments inside the root canals, perforations, or any error in preparation or obturation of the root canal was denied. The research

protocol received approval from the Ethics Review Committee of the Faculty of Dental Sciences, University of Peradeniya. The CBCT scans were conducted utilizing a CBCT scanner (Vatech Corporation, South Korea) using a range of 18-200Usv, 60 to 90 kbp, and 2-15 Ma allowing any adjustment within each FOV and voxel size under standard settings. The resulting images were stored and transformed into a DICOM file format using the acquisition software integrated into the above CBCT machine. Quantifications were acquired utilizing EzDent software with a precision of 0.1 mm. Two calibrated observers interpreted all selected CBCT scans in the axial, coronal, sagittal, and trans-axial planes using the least possible persisting slice thickness. Firstly, all 5o scans were analyzed by the junior expertise with 10 years of clinical experience and finally, the results were confirmed by the most senior expertise with 15 years' experience. Consensus was reached in cases of interpretation disagreement. All measurements were taken at the occlusal plane level, yielding the following results.

Following the acquisition of written informed consent, all patients underwent a comprehensive session comprising history taking, clinical examination, and radiological assessment. The history encompassed the chief complaint, past medical and surgical history, current drug regimen, and detailed dental history, counting specifics of root canal treatment such as timing, number of visits until completion, timing and material used for coronal restorations, instances of dislodgement, timing thereof, and whether rubber dam isolation was utilized. The details of root canal treatment were collected from the patient's folder.

Clinical and radiographic assessments were carried out according to the clinical and radiographic status of coronal restoration, the radiographic status of the canal obturation, the radiographic status of the three-dimensional apical seal at the apical cross sections, and the radiographic periapical status of the teeth. The observers were two experienced specialized experts in the field of Restorative Dentistry at the Faculty of Dental Sciences.

The patients and the CBCT images were assessed and categorized as follows:

The clinical condition of coronal restorations on root canal-treated teeth was evaluated and scored based on the modified Ryge's criteria [22], which included:

1. Fine restoration edges
2. Traping of the probe
3. Aperture restricted to the enamel
4. Aperture involving the dentine
5. Fractured restoration
6. Disengaged restoration
7. Strayed restoration

Values of 1 and 2 were deemed indicative of adequate coronal restoration, while scores of 3 to 7 were classified as inadequate coronal restoration.

Additionally, root canal-treated teeth were radiographically evaluated utilizing available CBCT images, categorized as follows:

1. Unblemished restoration devoid of marginal leakage
2. Restoration with unbolted margin
3. Restoration with secondary decay

A score of 1 was regarded as indicative of adequate restoration, while scores of 2 and 3 were classified as inadequate restorations according to the modified Ryge's criteria [22].

The radiographic status of canal obturation was also evaluated based on:

1. Root obturation confining 0-2mm from the apex of the radiograph, displaying homogenous root filling, perfect condensation, and no visible vacuity.
2. Root obturation confining >2mm from the apex of the radiograph or reaching over it, showing nonhomogeneous root filling, inadequate condensation, and visible vacuity.

A score of 1 was deemed indicative of adequate root filling, while a score of 2 was considered inadequate according to the modified Ryge's criteria [22].

The Radiographic condition of the three-dimensional seal at the apex was assessed as follows:

1. The entire seal of the apex
2. insufficient seal extending less than 50% of the apex
3. insufficient seal extending greater than 50% of the apex (1 was considered as adequate apical seals 2,3 were considered as inadequate) according to the modified Ryge's criteria [22].

The periapical status of endodontically treated teeth was evaluated utilizing CBCT and the Periapical Index [23], which included the following classifications:

1. Ordinary periapical tissues
2. Broadening of periodontal space
3. Minor change in apical bone
4. Alter in bone with a few mineral losses
5. Periodontitis with sharply defined radiolucent area
6. Severe periodontitis associated with aggravating characteristics

Scores ranging from 1 to 2 were interpreted as indicative of good periapical health, while scores exceeding 3 were considered indicative of periapical pathosis.

According to the above values, six variables were set as:

- Adequate and inadequate coronal restoration,
- Adequate and inadequate root canal obturation.
- Adequate and inadequate apical seal (Different scenarios are displayed in **Figs. (1-7))**.

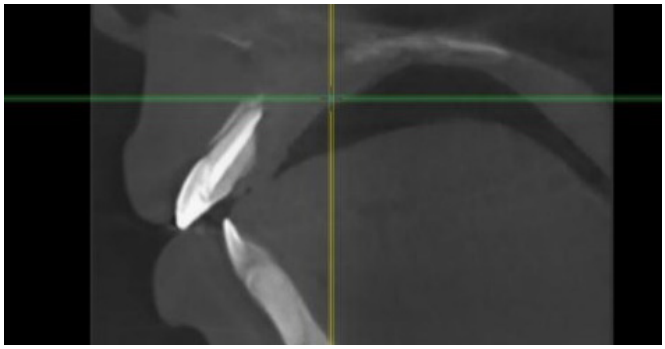

Fig. (1): Adequate coronal restoration (Intact restoration without marginal leakage.

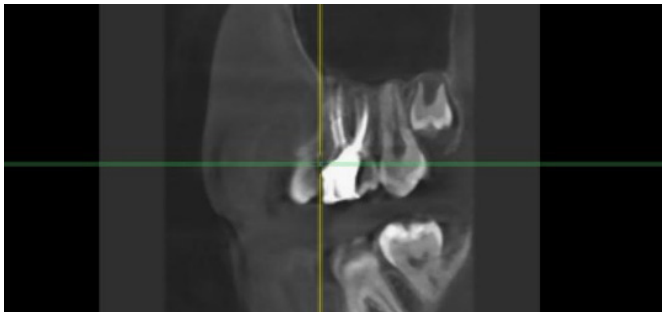

Fig. (2): Inadequate coronal restoration (Restoration with unbolted margin, 3. Restoration with secondary decay).

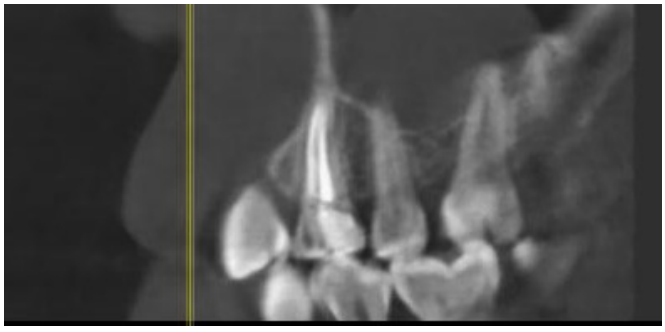

Fig. (3): Adequate canal obturation: root filling, confining 0-2mm from the apex of the radiograph and homogenous root. Canal filling, perfect condensation, denied apparent vacuity.

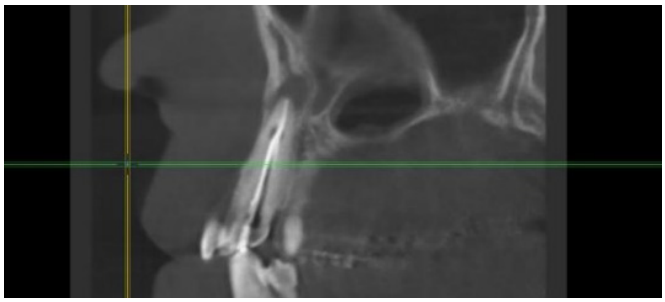

Fig. (4): Inadequate canal obturation: root canal filling confining >2mm from the apex of the radiograph, or root canal filing extending over the apex, nonhomogeneous root canal filling, deficient condensation, and apparent vacuity.

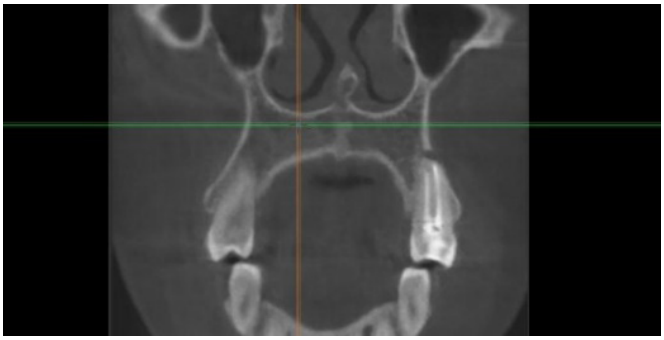

Fig. (5): Adequate apical seal: Complete closure of apex.

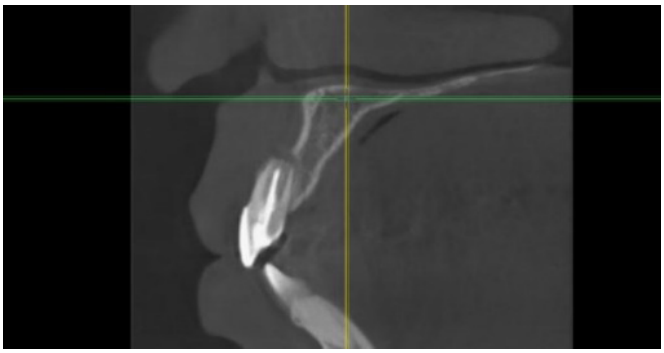

Fig. (6): Inadequate apical seal: Inadequate closure extending over less than 50% of the apex.

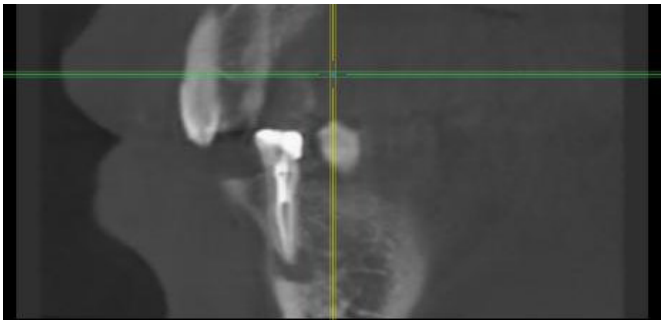

Fig. (7): Peri apical pathology.

All particulars were recorded in Excel (Microsoft) spreadsheets. Statistical analysis was performed utilizing Statistical Package for Social Sciences (SPSS) version 20.0 software (IBM Corp), and the level of significance was set at p=0.05. Associations between all six variables (adequate coronal restoration, inadequate coronal restoration, adequate root canal obturation, inadequate root canal obturation, adequate apical seal, and inadequate apical seal) were assessed using the Chi-Square test.

RESULTS

A sum of 50 CBCT reports owned to 50 patients were enrolled in the experimentation. The mean age was 26 (±4) years. Thirty-seven to five percent of the reports belonged to males. All teeth in a patient that were root-filled were considered as the sample. The majority of the patients (81.2%) presented with more than one canal in the tooth that was treated. The average number of teeth

per individual investigated was 1. The detailed results of the 6 variables are attached in **Appendix 1** and their summary is as follows, (**Tables 1** and **2**).

Table 1: Clinical and radiographic status of coronal restoration in root-filled teeth.

Factor	Adequate	Inadequate
Clinical coronal restoration	32 teeth	18 teeth
Radiographically, coronal restoration	31 teeth	19 teeth
Radiographically canal obturation	31 teeth	19 teeth
Radiographically apical seal	28 teeth	22 teeth

Table 2: Radiographic status of apical seal among the patients.

Peri apical status	Number of teeth
Healthy peri apical tissues	26
Peri apical pathology	24

Association Between Variables

Overall results reveal that most of the patients had an adequate response in periapical healing after the root canal treatment. A significant association was observed between periapical healing and adequate coronal restoration in root-filled teeth (p=0.048). However, the association between the healing of the periapical region and adequate root canal obturation (p=0.09) and adequate apical seal (p=0.777) was found to be non-significant.

Further, the clinical status of coronal restoration significantly positively corresponded with a radiographic status of coronal restoration (r=0.958, p<0.001) (**Fig. 8**) and the clinical status of coronal restoration was significantly positively related to radiographic periapical status (r=0.614, p<0.001) (**Fig. 9**). Further, positive correlations were observed in the radiographic status of coronal restoration with the radiographic periapical status of the root-filled tooth (r=0.650, p<0.001) (**Fig. 10**).

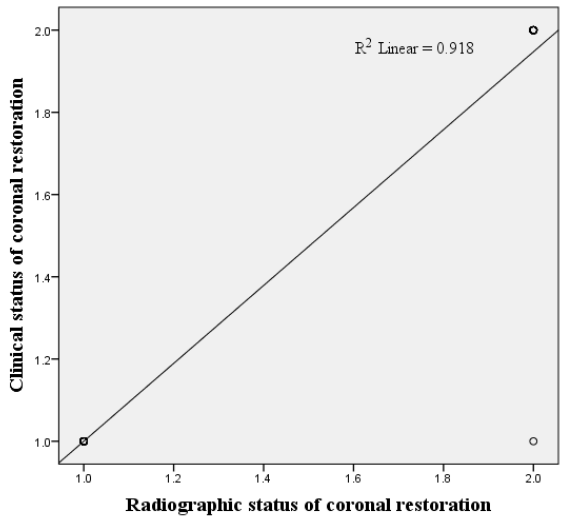

Fig. (8): Correlation of clinical status of coronal restoration with the radiographic status of coronal restoration.

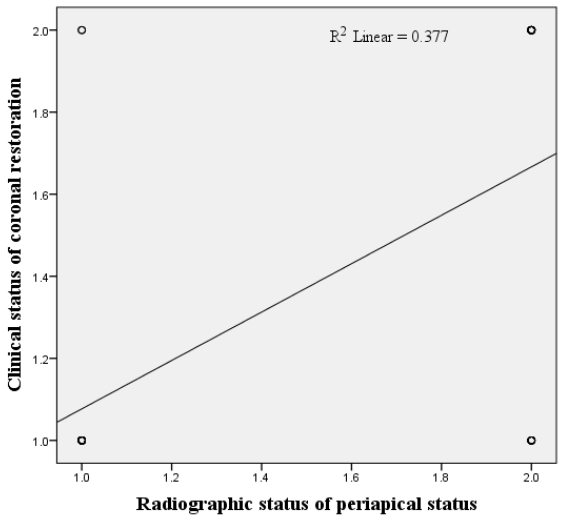

Fig. (9): Correlation of clinical status of coronal restoration with the radiographic periapical status.

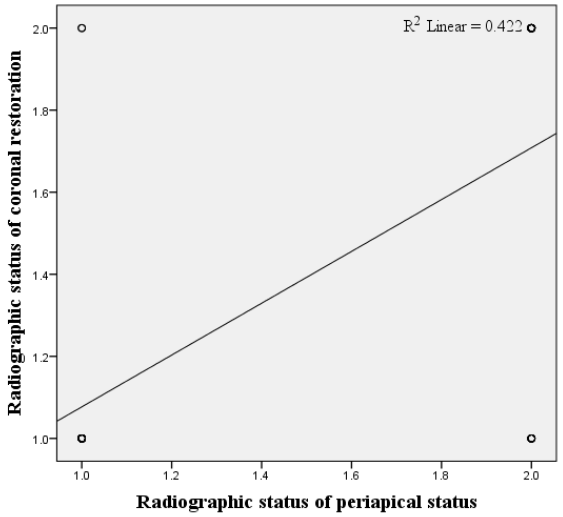

Fig. (10): Correlation of radiographic status of coronal restoration with radiographic status of periapical status.

There was a weak positive correlation between the radiographic status of the apical seal and the radiographic status of periapical status (r=0.35, p>0.05) Apart from that, the radiographic status of canal obturation did not significantly correspond with the periapical status (r = -0.010, p>0.946).

DISCUSSION

In the present study, just below half of the patients presented with inadequate peri-apical healing or having peri-apical radiolucency following root canal treatment which confirms the reported percentage of prevalence of peri-apical radiolucency (32.2%-67%) in the literature [17]. Two third of the studies in the literature have shown the most affecting factor for the healing of peri apical lesions as the coronal restoration. Our study of the Sri Lankan population was also tallied with literature. However, some studies still proved that the quality of canal obturation was having a huge impact on this.

In a cross-sectional study, three out of the four factors exerting influence on the outcome of RCT can be evaluated. These factors include the attribute of the coronal restoration, the solidity of the obturation, and its apical extent. The only factor not assessed here is the preoperative apical status. Due to the lack of information regarding the pathological history and systemic diseases of the patients, it is challenging to ascertain, whether the apical lesion is healing or progressing [7]. However, in this study, only patients who had completed root canal treatment one year prior and had not undergone any dental treatment thereafter for the specific tooth were included. This timeframe appeared sufficient to determine apical alterations following endodontic treatment [23].

Most of the studies were carried out using plane radiographs together with clinical evaluation. Only a few recent studies were carried out using more detailed cone beam computed tomography [10, 17]. The main drawback of plane radiographs is the superimposition of structures in multiple planes which leads to false negative results and voids in obturation are underestimated. Therefore, to avoid the problem, CBCT imaging mode with clinical evaluation of certain possible factors were together considered for this study. However, CBCT also has some disadvantages, such as overestimation of voids, complications due to scattered X-ray artefacts, high cost, and unavailability in every centre. Further, radiation exposure is higher which is about four to five times greater compared to a more localized two-dimensional plane radiograph for a simple routine diagnosis purpose [24]. It has an almost double capacity for diagnosis of peri-apical lesions after endodontic treatments and the ability of early detection compared to two-dimensional radiographs [25, 26]. Occasionally, healing may occur with fibrous tissues which is inappreciable in an apical granuloma in radiographic images. The estimation error is unavoidable in these types of studies [10]. Therefore, the ideal mode of detection is histopathological imaging which is no longer practical in our context.

The result would help the clinicians in Sri Lanka to pay more attention to proper coronal restoration without leakage to be placed following RCT to minimize possible failures.

LIMITATION OF THE STUDY

The study was carried out in a sample presented to the Faculty of Dental Sciences, University of Peradeniya, and would not represent the whole population in the country. Further, the period between root filling and the CBCT scan was not measured in the sample. Other influencing factors for the success of RCT such as pre-operative factors, patient's systemic conditions, oral hygiene practices, diet habits, and technical variations were not assessed. Also, a large sample would be preferred during an extended time frame.

CONCLUSION

Based on the findings of the present study, it appears that adequate coronal restoration, root canal obturation, and apical seal contribute to favorable outcomes of RCT in a cohort of patients at our center in Sri Lanka. Traditionally, the combination of high-quality endodontic obturation and coronal restoration has been associated with successful outcomes in endodontically treated teeth. This study with a limited sample, in Sri Lanka, suggests that the attribute of coronal restoration has an enormous influence on the healing of periapical pathosis. However, some studies support this finding, others argue that the quality of canal obturation is more crucial.

Furthermore, the study indicates that there is a positive correlation between clinical and radiological assessments of the status of coronal restoration, suggesting consistency between these two evaluation methods. However, it's important to note that the cross-sectional study design may have constraints, as it supplies information about a population at a single point in time and lacks details on how the RCT was performed.

To enhance our understanding of RCT outcomes in Sri Lanka, future studies with wide-reaching sample sizes, more precise information on the duration following RCT, and consideration of other influencing factors such as patient factors, systemic factors, oral hygiene practices, and RCT techniques, are recommended. This would help to broaden our knowledge of the factors impacting RCT outcomes and inform clinical practices in the region.

ETHICAL APPROVAL

An ethical clearance certificate was obtained from the Ethical Review Committee of the University of Peradeniya, Sri Lanka (REF letter No. ERC/FDS/UOP/E/2019/24). All procedures performed in studies involving human participants were following the ethical standards of the institutional and/ or national research committee and the Helsinki Declaration.

CONSENT FOR PUBLICATION

I am hereby giving consent for the publication of the manuscript detailed above, including any accompanying images and data contained within the manuscript.

AVAILABILITY OF DATA

All data are available with the corresponding author and can be accessed on request.

FUNDING

Declared none.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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Declared none.

AUTHORS' CONTRIBUTION

1. EMKS Ekanayake; Conceptualization, Methodology, data collection and analysis, Writing - original draft, Writing - review & editing.
2. MCN Fonseka: Methodology, Investigation, Writing - review & editing, Data curation
3. RMJ Jayasinghe; Conceptualization, Methodology, Investigation, Data curation, Writing - original draft, Writing - review & editing, Project administration.
4. RD Jayasinghe: Conceptualization, Methodology, Investigation, Resources, Writing - review & editing, Supervision, Project administration.

REFERENCES

1. Huumonen S, Ørstavik D. Radiological aspects of apical periodontitis. Endod Topics 2002; 1(1): 3-25. DOI: https://doi.org/10.1034/j.1601-1546.2002.10102.x
2. Sunay H, Tanalp J, Dikbas I, Bayirli G. Cross-sectional evaluation of the periapical status and quality of root canal treatment in a selected population of urban Turkish adults. Int Endod J 2007; 40(2): 139-45. DOI: https://doi.org/10.1111/j.1365-2591.2007.01217.x PMID: 17229120
3. Blake A, Tuttle T, McKinney R. Apical Periodontitis. 2023. In: StatPearls. Treasure Island (FL): StatPearls Publishing; 2023. PMID: 36943974
4. Nair PNR. On the causes of persistent apical periodontitis: a review. Int Endo J 2006; 39(4): 249-81. DOI: https://doi.org/10.1111/j.1365-2591.2006.01099.x PMID: 16584489
5. Sundquist G, Figdor D, Persson S, Sjogren U. Microbiologic analysis of teeth with failed endodontic treatment and outcome of conservative re-treatment. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1998; 85(1): 85-93. DOI: https://doi.org/10.1016/s1079-2104(98)90404-8 PMID: 9474621
6. Wong YJ. Root canal treatment outcomes not affected by increasing age of the patient. Evid Based Dent 2017; 18(2): 47. DOI: https://doi.org/10.1038/sj.ebd.6401238 PMID: 28642563
7. Ng YL, Mann V, Rahbaram 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. Int Endo J 2007; 40(12): 921-39. DOI: https://doi.org/10.1111/j.1365-2591.2007.01322.x PMID: 17931389
8. Holland R, Filho JEG, Cintra LTA, de Azevedo Queiroz ÍO, Estrela C. Factors affecting the periapical healing process of endodontically treated teeth. J Appl Oral Sci 2017; 25(5): 465-76. DOI: https://doi.org/10.1590/1678-7757-2016-0464 PMID: 29069143
9. Hommez GMG, Coppens CRM, Moor RJG. Periapical health related to the quality of coronal restoration and root fillings. Int Endo J 2002; 35(8): 680-9. DOI: https://doi.org/10.1046/j.1365-2591.2002.00546.x PMID: 12196221
10. Gambarini G, Piasecki L, Miccoli G, Gaimari G, Di Nardo D, Testarelli L. Cone beam CT in the assessment of peri apical lesions in endodontically treated teeth. Eur J Dent 2018; 12(1): 136-43. DOI: https://doi.org/10.4103/ejd.ejd_320_17 PMID: 29657539
11. Ray HA, Trope M. Periapical status of endodontically treated teeth in relation to the technical quality of the root filling and the coronal restoration. Int Endod J 1995; 28(1): 12-8. DOI: https://doi.org/10.1111/j.1365-2591.1995.tb00150.x PMID: 7642323
12. Olcay K, Ataoglu H, Belli S. Evaluation of related factors in the failure of endodontically treated teeth: a cross-sectional study. J Endod 2018; 44(1): 38-45. DOI: https://doi.org/10.1016/j.joen.2017.08.029 PMID: 29246376
13. Gillen BM, Looney SW, Gu LS, Loushine BA, Weller RN, Loushine RJ, *et al*. Impact of the quality of coronal restoration *versus* the quality of root canal fillings on success of root canal treatment: a systematic review and meta-analysis. J Endod 2011; 37(7). DOI: https://doi.org/10.1016/j.joen.2011.04.002 PMID: 21689541
14. Jawad S, Taylor C, Roudsari RV, Darcey J, Qualtrough A. Modern Endodontic Planning Part 1: Assessing Complexity and Predicting Success. Dent Update 2015; 42(7): 599-600, 602-4, 606-8 passim. DOI: https://doi.org/10.12968/denu.2015.42.7.599 PMID: 26630858
15. Mustafa NS, Kashmoola MA, Majeed KRA, Qader OAJA. Assessment of the success rate of endodontically treated patients attending outpatient polyclinic. Eur J Dent 2018; 12(4): 540-5. DOI: https://doi.org/10.4103/ejd.ejd_377_17 PMID: 30369800
16. Kaya BU, Kececi AD, Guldas HE, Orhan H. A retrospective radiographic study of coronal-periapical status and root canal filling quality in a selected adult Turkish population. Med Princ Pract 2013; 22(4): 334-9. DOI: https://doi.org/10.1159/000346940 PMID: 23406692
17. Gomes AC, Nejaim Y, Silva AIV, Haiter-Neto F, Cohenca N, Zaia AA, *et al*. Influence of endodontic treatment and coronal restoration on status of periapical tissues: a cone-beam computed tomographic study. J Endod 2015; 41(10); 1614-8. DOI: https://doi.org/10.1016/j.joen.2015.07.008 PMID: 26307508
18. Tsai P, Torabinejad M, Rice D, Azevedo B. Accuracy of cone-beam computed tomography and periapical radiography in detecting small periapical lesions. J Endod 2012; 38(7): 965-70 DOI: https://doi.org/10.1016/j.joen.2012.03.001 PMID: 22703662

19. Estrela C, Bueno MR, Leles CR, Azevedo B, Azevedo JR, Accuracy of cone beam computed tomography and panoramic and peri apical radiography for detection of peri apical periodontitis. J Enodod 2008: 34(3): 273-9.
DOI: https://doi.org/10.1016/j.joen.2007.11.023 PMID: 18291274

20. K Horner, O'Malley L, Taylor K, Glenny A. Guidelines for clinical use of CBCT: a review. Dentomaxillofac Radiol 2015; 44(1): 20140225.
DOI: https://doi.org/10.1259/dmfr.20140225 PMID: 25270063

21. Atlas A, Gandini S, Martignoni M. Evidence-based treatment planning for the restoration of endodontically treated single teeth: importance of coronal seal, post *vs* no post, and indirect *vs* direct restoration. Quintessence Int 2019; 50(10): 772-781.
DOI: https://doi.org/10.3290/j.qi.a43235 PMID: 31559397

22. Orstavik D, Ford TP. Apical periodontitis; Microbial infection and host response. Essential Endodontology 1998: pp. 1-10.
DOI: http://dx.doi.org/10.1002/9781119272014.ch1

23. Patel S, Wilson R, Dawood A, Foschi F, Mannochi F. The detection of periapical pathosis using digital periapical radiography and cone beam computed tomography - part 2: a 1-year post-treatment follow-up. Int Endod J 2012; 45(8); 711-23
DOI: https://doi.org/10.1111/j.1365-2591.2012.02076.x PMID: 22775142

24. International Atomic Energy Agency (IAEA). Radiation Protection in Dental Radiology. Safety Reports Series No. 108, Vienna (2022). Available from: https://www-pub.iaea.org/MTCD/publications/PDF/PUB1972_Web.pdf

25. Cone Beam Computed Tomography (CBCT) in Endodontics by American Association of Endodontologists College of Excellence, 2011.

26. Estrela C, Holland R, de Araújo Estrela CR, Alencar AHG, Sousa-Neto MD, Pécora JD. Characterization of successful Root canal Treatment, Braz Dent J 2014; 25(1): 3-11.
DOI: https://doi.org/10.1590/0103-6440201302356 PMID: 24789284

APPENDIX 1

Number of clinical and radiographic observations in patients.

Clinical status of coronal restoration		**N**
1	Fine restoration edges	29
2	Trapping of the probe	3
3	The aperture restricted to the enamel	0
4	Aperture involving the enamel	4
5	Fractured restoration	6
6	Disengaged restoration	4
7	Strayed restoration	4

Radiographic status of coronal restoration		**N**
1	Unblemished restoration devoid of leakage	31
2	Restoration with unbolted edges	7
3	Res restoration with secondary decay	12

Radiographic status of canal obturation		**N**
1	Root obturation confining 0-2mm from the apex of the radiograph and homogenous root filling, perfect condensation, no visible vacuity	31
2	Root obturation confining >2mm from the apex of the radiograph, or root filing reaching over the radiographic apex, inhomogeneous root filling, inadequate condensation, and visible vacuity.	19

Radiographic status of apical seal		**N**
1	Entire closure of the apex	28
2	Insufficient closure extending less than 50% of the apex	10
3	Inadequate closure extending greater than 50% of the apex	12

Radiographic status of periapical status		**N**
1	Ordinary periapical status	0
2	Broadening of periodontal space	15
3	Minor alteration in bone	11
4	Alter in bone with a few mineral loss	9
5	Periodontitis with sharply defined radiolucent area	10
6	Severe periodontitis associated with aggravating characteristics	5