ORIGINAL ARTICLE

Obturation Quality Evaluation and Number of Visits Required to Complete Root Canal Treatment Performed by Undergraduate Students

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ABSTRACT

Introduction: Assessment of root canal treatment (RCT) quality performed by undergraduate students is important in evaluating the teaching of endodontic. Hence, this study aims to evaluate the obturation quality of root canal treated teeth and the number of visits required by patients to complete RCT rendered by undergraduate students in School of Dental Sciences, Universiti Sains Malaysia (USM). **Methods:** All RCT cases performed by fourth year and final year undergraduate dental students in 2017/2018 were included in this study with a total of 258 teeth. Both digital and conventional periapical radiographs of all treated teeth were assessed. Evaluation of the obturation quality was classified as acceptable and unacceptable based on the length in relation to the radiographic apex and density of the obturation in relation to the presence of voids. The number of visits required to complete each RCT case by the students were also assessed. **Results:** Out of the total 258 teeth, 63.6% were maxillary and 36.4% were mandibular comprising 53.5% anteriors, 14.7% premolars and 31.8% molars. Overall acceptable obturation quality was 71.3%. There was significant association between obturation quality and type of teeth as well as location of teeth. **Conclusion:** Students in this institution performed significantly better obturation quality on anterior teeth than on premolars and molars as well as on maxillary teeth as compared to the mandibular teeth. Patients seemed to require more visits for RCT of molars than anteriors and premolars.

Keywords: Radiographic evaluation, Obturation quality, Visits number, Root canal treatment, Dental students

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INTRODUCTION

Root canal treatment (RCT) or endodontic treatment is a routine dental treatment indicated for irreversibly inflamed or infected pulp of a tooth to eliminate the infection and pain (if present) in order to save the tooth from extraction. There are many steps involved during root canal procedures. Obturation is the final step which is defined as sealing of the cleaned, shaped and debrided root canal system with root canal sealer and obturation material (1). All the RCT procedures should be properly done as mishaps in any of those procedures may lead to unsatisfactory obturation which consequently compromise the outcome of RCT.

The quality of root canal obturation is assessed radiographically according to the length and density of obturation material (2). An acceptable obturation length that appear at least ≤ 2mm to the radiographic apex as well as a uniform obturation density that appear without voids in the canal space fulfil the requirements of a good quality root canal obturation. Two-dimensional conventional and digital intraoral radiography are the two most used periapical radiographs for assessing this obturation quality. The newer imaging techniques of computed tomography (CT) and cone-beam computed tomography (CBCT) are able to produce three-dimensional images of the teeth and their surrounding tissues whereas conventional images compress three-dimensional anatomy into a two-dimensional image which greatly limit the diagnostic performance of maxillofacial region (3). However, in this study, CBCT was not used due to limited availability, ethical consideration, dose-dependent exposure, significant capital investment and medico-legal considerations.

According to the competency guidelines for new dental graduates in Malaysia (4), dental students must demonstrate a skilful RCT of single rooted teeth and

display the ability (with some confidence and proficiency) to perform uncomplicated RCT of multirooted teeth upon graduation. The teaching of endodontics is considered a challenge as students must be knowledgeable in dental anatomy and skilful in operative dentistry prior to learning endodontics. The structure of endodontic training in this learning institution involves a holistic curriculum with knowledge-based input in the form of lectures, seminars and reading/self-study (5). This cognitive aspect accounts for 62.5 hours. The acquisition of basic skills (psychomotor) with the integration of knowledge (cognitive) through pre-clinical endodontic training and assessment to achieve the required level of competency according to the standard set by Malaysian Dental Council (MDC) prior to performing RCT on patients takes another 86.3 hours of student learning time. The competency of the students is assessed at the end of the pre-clinical endodontic training. The students must pass the pre-clinical assessment before allowed to perform RCT on patients. For each of the clinical endodontic cases, students are given guidance, feedback and grading on their performance in order to enhance and improve their endodontic knowledge and skills.

Performing RCT procedures on patients with complex root canal anatomy are quite challenging especially for undergraduate students as beginners. Therefore, this study on evaluation of radiographic obturation is done partly to audit their work to ensure adequate standard of RCT being delivered to the patients (6) and indirectly reflect the outcome of endodontic teaching in this institution.

The specific objective of this study was to determine the association between radiographic obturation quality performed by undergraduate students with the type and location of teeth. The next objective was to evaluate the number of visits required to complete each RCT case in relation to the type of teeth.

MATERIALS AND METHODS

Patients' information retrieval

Information retrieved from patients who visited School of Dental Sciences, Universiti Sains Malaysia (USM). The information pertaining to the patients' procedures, treatment and radiographs were collected from the record department based on students' endodontic logbooks. All completed RCT cases performed by fourth year and final year undergraduate dental students in 2017/2018 with total sample size of 258 were examined. These were the selected cases suitable for undergraduate students that follow the guidelines according to the standard set by MDC. The suitable cases included teeth with straight root canal, curvature less than 45 degrees and diagnosed as irreversible pulpitis, pulp necrosis, apical periodontitis, apical abscess and elective endodontic. Previously initiated RCT and re-treatment cases were also included. For the purpose of this study, the inclusion criteria were completed RCT cases treated by undergraduate students and availability of the radiographs with clear images for interpretation whereas the exclusion criteria were incomplete RCT, unavailability of radiographs/inability to interpret the images and elective RCT. The reason for exclusion of elective RCT cases was due to the high probability of the elective RCT completion in just one visit which will affect the results of the last objective of this study. This work was approved by Human Research Ethics Committee of USM vide ethical approval number USM/JEPeM/17040219.

RCT procedures were conducted under aseptic technique using rubber dam isolation according to standard protocol and guideline (7). Students were supervised by experienced supervisor being in practice for more than ten years with lecturer: student ratio of 1:7-9. The anterior (referring to incisors and canines) and premolar teeth were prepared using step back technique while the obturation of cold lateral condensation followed by vertical compaction techniques were used. For molars, the teeth were prepared under manual crown-down technique followed with obturation using single cone gutta-percha with or without additional accessory points. Exceptional anatomy of molar canals for example c-shaped canals that were unsuitable for crown-down technique were prepared using step back technique with subsequent obturation of cold lateral condensation and vertical compaction or thermo-mechanical compaction techniques were applied depending on the suitability of the cases. Periapical radiographs were taken before, during and immediately post RCT. The post-operative radiographs with the total of two-hundred-and-fifty-eight radiographs were examined in this study and classified according to the criteria used by Barrieshi-Nusair et al (8) and Abraham and Abdullah (9). There were 60 conventional film radiographs and 198 digital radiographs. The data were interpreted and recorded by an undergraduate student (examiner) which was verified by a supervisor.

Conventional film radiographs

The radiographic obturation quality of conventional films was assessed using Kodak illuminated viewer box (United States) with the aid of an x-ray film magnifier (Directa, Sweden). Measurements were recorded using a stainless-steel ruler of 0.5 mm accuracy (Rustless, Germany).

Digital radiographs

For digital images, the viewing and assessment were done using Planmeca Romexis software version 2.9.2.R (Finland) directly on the liquid crystal display (LCD) screen size of 17 inches and resolution of 1280 x 1024 dpi (Dell, United States).

Evaluation of the radiographic obturation quality

The evaluation of post-operative conventional and

digital films was standardized using the parameters as described (8,9) and presented in Table I. The teeth were grouped according to the type and location. An acceptable radiographic obturation quality must fulfil both criterion of acceptable length and density of root canal obturation.

Table I: Parameters used for evaluation of radiographic obturation quality

Parameter	Criteria	Definition
Length of root canal filling	Adequate (Acceptable)	Root filling ending ≤ 2mm from radiographic apex
	Over-filling (Unacceptable)	Root filling beyond the radiographic apex
	Short-filling (Unacceptable)	Root filling > 2mm from radiographic apex
Density of root canal filling	Acceptable	Uniform density of root filling without voids and canal space not visible.
	Unacceptable	Not uniform density of root filling with clear presence of voids and canal space is visible.

Evaluation of the number of visits

The number of visits were obtained from the patients' records based on the first date of the patient's appointment until the final date of RCT when obturation was completed. A three-hour clinical session equals to one visit for every RCT procedure.

Statistical analysis

Data analysis was carried out using Statistical Package for the Social Sciences (SPSS, USA version 22.0). Data were collected, analysed and presented statistically using Pearson Chi-Square test and descriptive statistics. Chi-square test was used to determine the association between radiographic obturation quality and the type of teeth for the first part of this study. For the second part, chi-square test was used to determine the association between radiographic obturation quality and the location of teeth. All inferences of the results from these two parts were based on p-value in which p-value less than 0.05 was considered significant. For the third part, descriptive statistics through frequency analysis was used to tabulate the number of visits with regards to the type of teeth.

RESULTS

Association between obturation length, density and quality with the type of teeth

The results in Table II showed that the obturation quality was significantly associated with the type of teeth [χ^2 (df) = 20.03 (2); $p < 0.01$] in which the anterior teeth showed better obturation quality than premolars and molars. Similar significant association was found for the obturation length [χ^2 (df) = 23.31 (2); $p < 0.01$]. However, no significant association was found between obturation density and the type of teeth [χ^2 (df) = 5.52 (2); $p > 0.01$].

Table II: Obturation length, density and quality versus types of teeth

Variables	Length		Density		Quality**	
Type of teeth	**Acceptable**	**Unacceptable**	**Acceptable**	**Unacceptable**	**Acceptable**	**Unacceptable**
Anterior	132 (95.7)	6 (4.3)	116 (84.1)	22 (15.9)	113 (81.9)	25 (18.1)
Premolar	33 (86.8)	5 (13.2)	30 (78.9)	8 (21.1)	27 (71.1)	11 (28.9)
Molar	60 (73.2)	22 (26.8)	58 (70.7)	24 (29.3)	44 (53.7)	38 (46.3)
Total	225 (87.2)	33 (12.8)	204 (79.1)	54 (20.9)	184 (71.3)	74 (28.7)
χ^2 (df)	23.31 (2)		5.52 (2)		20.03 (2)	
p-value	< 0.01*		0.063		< 0.01*	

Chi-Square test was applied
* Significant at $p < 0.05$
**Quality refers to both with acceptable length and density

Association between obturation length, density and quality with the location of teeth

Table III shows a significant association between obturation quality and location of teeth [χ^2 (df) = 11.86 (1); $p < 0.01$] where maxillary teeth showed better obturation quality than the mandibular teeth. Similarly, significant association can be seen both for the obturation length [χ^2 (df) = 9.55 (1); $p < 0.01$] and density [χ^2 (df)= 7.01 (1); $p < 0.01$].

Table III: Obturation length, density and quality versus location of teeth

Variable	Length		Density		Quality**	
Location of teeth	**Acceptable**	**Unacceptable**	**Acceptable**	**Unacceptable**	**Acceptable**	**Unacceptable**
Maxilla	151 (92.1)	13(7.9)	138 (84.1)	26 (15.9)	129 (78.7)	35 (21.3)
Mandible	74 (78.7)	20 (21.3)	66 (70.2)	28 (29.8)	55(58.5)	39 (41.5)
Total	225 (87.2)	33 (12.8)	204 (79.1)	54 (20.9)	184 (71.3)	74 (28.7)
χ^2 (df)	9.55 (1)		7.01 (1)		11.86 (1)	
p-value	0.002*		0.008*		0.001*	

Chi-Square test was applied
* Significant at $p < 0.05$
**Quality refers to both with acceptable length and density

Association between the number of patients' visits required to complete RCT with the type of teeth

The result in Table IV shows that for anterior (n-138) and premolar (n-38) teeth, the students were able to complete the RCT procedures mostly in three visits (37%, n=51; 39.5%, n=15). As for the molar teeth (n=82), the majority of visits needed to complete the RCT was five (29.3%, n=24). The maximum visits required for the students to complete RCT was nine which was one case of a molar tooth. In general, most teeth (28.3%, n=73) required three visits for RCT to be completed, followed by two visits (22.9%, n=59) and four visits (19.8%, n=51).

Table IV: Number of visits and types of teeth

Number of Visits	Type of teeth			Total	
	Anterior	**Premolar**	**Molar**	**N**	**%**
		n (%)			
1	7 (5.07)	0 (0)	0 (0)	7	2.7
2	49 (35.5)	7 (18.4)	3 (3.7)	59	22.9
3	51 (37)	15 (39.5)	7 (8.5)	73	28.3
4	23 (16.7)	9 (23.7)	19 (23.2)	51	19.8
5	3 (2.2)	5 (13.2)	24 (29.3)	32	12.4
6	3 (2.2)	1 (2.6)	17 (20.7)	21	8.1
7	1 (0.7)	1 (2.6)	10 (12.2)	12	4.7
8	1 (0.7)	0 (0)	1 (1.2)	2	0.8
9	0 (0)	0 (0)	1 (1.2)	1	0.4
Total	138(100)	38(100)	82(100)	258	100

DISCUSSION

Success rate of RCT is positively correlated with good obturation quality which reflects the technical part of this treatment (10). Hence, the assessment of the RCT quality performed by undergraduate students is important in evaluating the teaching of endodontic in any institutions. In this study, the criterion in Table I (8,9) was used to evaluate the first objective for radiographic assessment of obturation quality. Many of other similar studies found that the quality of RCTs performed by undergraduate dental students are poor and improvement in both pre-clinical and clinical endodontic training had become a concern (11-14). A study from Saudi dental college showed that the overall acceptable quality of the evaluated root canals was 36% in relation to the length, density and taper of the root canal obturation (14). Another similar study that was done at the University of the West Indies, Jamaica found only 10.9% acceptable root canal obturation out of 460 root canals examined (12). Furthermore, an evaluation of the quality of root canal obturation performed by senior undergraduate dental students in Iran results in slightly higher percentage of 45% acceptable obturation (13). However, due to different radiographic evaluation criteria used in determining the obturation quality, the findings from our study and most of previous studies were non-comparable. Two different criteria were the number of root canals instead of the number of teeth as used in this study and the tapering shape of root canal obturation that was not considered in the current study.

Based on this study, both length and quality of obturation showed significant association with the type of teeth that were categorised into anteriors, premolars and molars. Among these three categories, anterior teeth (81.9%) showed the highest percentage for fulfilling the acceptable criteria of obturation quality, followed by premolars (71.1%) and molars (53.7%) as shown in Table II. Such results are consistent with other findings (13,15,16). The reasons for this may be attributable to the smaller number of root canals as well as simpler and straight canal anatomy of anterior teeth. In general, the number and complexity of the canal system increases towards the posterior region. A study on root canal morphology of a Malaysian subpopulation using CBCT found that most of the anterior teeth have one canal and less than 15% of mandibular anteriors have two canals (17). Most of premolar teeth have one root with one main canal especially mandibular premolars with a small percentage of two to three roots. They also reported that 11.5% of maxillary first premolar teeth have one canal and 88.2% have two canals while 53.5% of maxillary second premolar have one canal and 46.5% with two canals (17). As for the molar teeth, the root canal morphology varies among population and races (18) and unpredictable such as complex anatomical system of the main canals and accessory canals (19), very small canal orifices that are hard to locate, sclerosed and curve canals. Exceptional skills, time and patience are required by the operator in order to adequately clean, shape and obturate the root canal of molars.

The present study showed that the overall acceptable root canal obturation quality is significantly higher in maxillary arch (78.7%) as compared to mandibular arch (58.5%), $p < 0.001$ (Table III). This result can be seen in the higher acceptable percentage on maxilla both for length (92.1%) and density (84.1%) as compared to those on mandible (78.7%) and (70.2%) respectively. Pan et. al (17) reported that 100% of maxillary incisors presented only with single canals as compared to mandibular incisors in which 5.1% of mandibular central incisors and 12.3% of mandibular lateral incisors were found to have two canals. Difficulties are expected in doing RCT of these teeth as they are very small in size. Mandibular teeth presented with variations of root canals as compared to maxillary teeth especially for the mesial root of mandibular molars (18). Variation of mandibular molars especially mandibular first molars were reported with three to four canals in different population (20,21). 20% of mandibular molars was reported to have three mesial canals (14). Furthermore, in a small proportion of second mandibular molar teeth especially in Asian population, the root canals may be fused resulting in one c-shaped canal in cross section (20). The incident of c-shaped canal in Malaysian subpopulation was found to be as high as 48.7% (17). The c-shaped canal provides a challenge with respect to debridement and obturation resulting in unsuccessful complete sealing ability of the canal, overlooked canal, over-obturate and iatrogenic problems (20). Besides, this type of canal may present with unusual anatomic appearance, deeply located canal entrance that are relatively small and it is unclear whether the c-shaped orifice found on the floor of the pulp chamber actually continues with the apical third of the root (22). Based on these findings, we can conclude that the location of the teeth (maxillary

or mandibular) did affect the obturation quality of an endodontic treatment.

This study also measures the number of patients' visits spent by undergraduate students to complete RCT. Most students spent three visits to complete RCT of anteriors and premolars and five visits for molars. There were cases involving anterior teeth with only one visit to finish the RCT. This result is in line with a survey done among general dental practitioners in north Jordan that reported of positive relationship between the number of visits required to complete RCT with the number of root canals in a tooth (23).

To the best of our knowledge, this is the first study to document the number of visits required by patients to attend RCT provided by undergraduate students to complete the whole procedures up to the obturation stage. Thus, it is difficult to make a comparison with previous studies regarding this issue. Even so, this study is beneficial as it indirectly assesses the skills of the students in performing RCT as well as their management of the patients. From time to time, unexpected situation may occur which might result in the failure to achieve ultimate goal in accomplishing the treatment according to plan in time. Many factors that influence the total visits to complete RCT range from patient to operator and clinical equipment factors.

Patients who failed to attend the appointment on time for various reasons (attitude, work etc.) causing the students to lose their time and ending up with little work that could be done in that visit. In many cases, the teeth requiring RCT are severely compromised with little tooth structure remains after caries or existing restoration removal. In such circumstances, extra efforts are needed for both isolation and restoration procedures, including the use of deep-reaching clamp and clamping the adjacent tooth for multiple teeth isolation. Provision of interim restoration using glass ionomer cements, composite material or amalgam supported by copper ring or orthodontic band usually required in these cases apart from the use of tooth-coloured temporary crown which is more acceptable in the aesthetic region. These time-consuming techniques are necessary to provide a good coronal seal until RCT is completed and definitive restoration can be provided (24).

Next, the tooth type is expected to affect the number of visits of RCT. By comparison, anterior teeth have less canal with more simpler canal anatomies, meanwhile, more complex root canal and smaller canal anatomies are usually found in posterior teeth (12). Thus, posterior tooth required more visits as it is more challenging in doing the access cavity, shaping as well as obturation.

Among the operator factors that could affect the number of visits is the lacking of skills and experience of undergraduate students in handling RCT cases. Every procedure of RCT starting from removal of caries or existing restoration (if present), placement of pre-endodontic restoration (if necessary) and rubber dam, endodontic access cavity which can be challenging in deep, small pulp chamber of molar, locating canal orifices including accessory canals, determine corrected working length and canal instrumentation again can be challenging in sclerosed canals. Obturation as the final procedure of RCT has its own difficulty in order to achieve a good, homogeneous condensation with a variety of complex anatomical system of root canals. In addition to these procedures, a few x-rays needed to be taken when the patients were having rubber dam with/without endodontic files in the tooth canals that added to the challenges faced by the students. Apart from that, they have to work under pressure to achieve the requirement set by the school with limited equipment available. Some of the students may not well prepared in terms of knowledge and patient management resulting in more time allocated while providing the treatment for the patients. However, this needs to be investigated further.

Limited new technology of clinical equipment could certainly influence the total visits of the patients. Less canal instrumentation and obturation time were reported with the use of rotary techniques as compared to manual techniques (25). However, the quality of obturation was not significantly different when comparing between rotary and manual technique groups (25). The past decades have witnessed rapid technological developments with the aim of improving the state of the art and science of RCT (26). An example of the use of rotary technique for obturation is by using thermoplasticized gutta-percha for more homogeneous thorough condensation of the main and lateral canals (example of using System B/Continuous wave) and better surface adaptation instead of lateral condensation technique. The newer obturation methods are expected to produce better outcomes (27). The shortcoming of lateral condensation technique is inability to efficiently fill the canal irregularities which may create spaces or voids between the gutta-percha cones and lack of surface adaptation (28). This new and rapid technology with expected good outcomes bring together the high cost and maintenance which could be unbearable for the dental school to purchase for undergraduate students use.

CONCLUSION

Students in this institution performed significantly better obturation quality in anteriors than premolars and molars and significantly better in maxillary teeth than mandibular teeth. More than half of the RCT cases can be completed in two to three visits with more visits required for molars than premolars and anteriors. In order to enhance the clinical performance of undergraduate students in endodontics and to improve the total visits required by patients for RCT, an increase in the

number of pre-clinical training sessions to enhance the practical experience of the students prior to real clinical setting, improvement in the lecturer-student ratio and encouragement to use advanced endodontic techniques and equipment are deemed necessary.

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