An audit of root canal treatments completed by students and dentists at an academic hospital

INTRODUCTION

The University of Pretoria Oral Health Centre (UPOHC) houses the School of Dentistry where dental, oral hygiene and post graduate students are trained. Dentists employed at the School of Dentistry generally do not complete root canal treatments (RCTs) due to their academic and research commitments but mainly perform emergency dental procedures such as pulpectomies for the relief of acute pain. The pulpectomy procedure includes the extirpation of the necrotic or inflamed pulp, minimal shaping of the canal and irrigating with sodium hypochlorite. This is followed by placing a medicament with an anti-inflammatory action such as Ledermix® or calcium hydroxide and sealing the tooth with a temporary restoration. The patient is then placed on a waiting list (approximately 18 months) for completion of the RCT by students in their fourth and fifth year of study. Dentists complete RCTs mainly in cases where previous attempts made to locate the canals were not successful or where files have fractured in the canals or when retreatment is indicated.

The students complete a limited number of RCTs due to the time-consuming nature of the procedure and their relative lack of skill and experience.1 During the fourth year of study the students are required to complete five RCTs on teeth with one and two canals. The clinical quota for the students in the fifth year of study is five RCTs on teeth that have three or four canals.2

Several studies3-7 have been conducted on the acceptability of root canal obturations with regard to the technical quality as viewed on post-operative radiographs. The studies in question reported an acceptable technical quality of 47.4%, 84.1%, 61.35%, 57% and 44% respectively.3-7 In four of these, the RCTs assessed were completed by undergraduate students. Root fillings between 0.5mm to 2mm from the radiographic apex, consistent density and uniform taper were the criteria used to categorize the RCT as acceptable. Peak et al. also included the absence of apical pathology in the criteria.6 To date no research has been conducted on the technical quality of root canal fillings at tertiary institutions in South Africa.

METHODS

Study design

The design was an observational retrospective record based study.

A random sample of 500 from amongst 1050 teeth that had received an emergency pulpectomy between 1 July 2012 and 30 June 2013 was selected. A total of 224 of these 500 teeth had reached the obturation phase of the RCT by 30 June 2014. The maximum period before root canals were completed was thus 24 months. Four of the cases had no post-operative radiographs, although it was recorded on the file that radiographs had been taken. The clinician had failed to successfully capture the digital x-ray image on the Kodak software program. A sample size of 220 therefore remained.

The electronic and paper records of the 220 teeth on which a RCT had been completed by either a dentist or student were analysed at the UPOHC.

Technical quality assessment

The post-operative intraoral periapical radiographs were accessed on the Kodak software programme (version 6.12). In the cases where the RCT had reached the obturation phase, a decision was made as to whether the RCT was completed adequately or inadequately, based on technical quality as viewed on the post-operative radiographs. The investigator who examined the radiographs is a full-time dentist with 14 years’ experience as a clinician.
had supervised dental students at the UPOHC during endodontic clinical sessions for six years and had obtained a Diploma in Endodontology and a Master’s degree in Radiology. Where examination of the radiograph resulted in a categorisation of the RCT as inadequate, the reasons for that assessment were recorded. The criteria used were those proposed by Román-Richon et al.7 and others.4, 8-11 These are displayed in Table 1.

### Ethical considerations

All necessary ethical approval to access patient files and digital radiographic material was obtained from the relevant authority at the University of Pretoria, Faculty of Health Sciences. Complete anonymity of the sample was ensured.

### RESULTS

The results of the treatment outcomes as obtained from the patient files and digital records are displayed in Table 2.

A total of 126 (57.27%) root fillings were adequate and 94 (42.73%) were deemed as inadequate.

In addition, a differentiation was made between RCTs completed by dentists and those completed by students. The calculation of data showed that the fourth and fifth year dental students completed 120 (54%) of the 224 RCTs and the qualified dentists completed 104 (46%) RCTs (Table 2).

Table 3, below, displays the result of the technical quality of the obturation differentiating between clinical provider type (student or dentist).

The data showed (Table 3) that the dental students completed 59.66% of their RCTs adequately and 40.34% inadequately. The dentists, on the other hand, completed 54.46% adequately and 45.54% inadequately. These differences were not statistically significant (Chi²-test).

The RCTs that were inadequately completed by either qualified dentists or dental students were classified according to the evaluation of the postoperative radiographs (Table 4). The percentage could not be calculated as some teeth had two or more reasons for inadequacy. The obturated root canals of 57 teeth were under-filled and 11 over-filled. Sixteen teeth had voids in the obturation and in 11 teeth a missed canal was detected. An endodontic instrument was fractured off in five of the obturated teeth and five teeth lacked a proper coronal seal after the obturation. Radiographs revealed that in two teeth the root had been perforated. Figures 1-7 illustrates some digital radiographic examples, of the underfilled and

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**Table 1: Criteria used to assess the technical quality**

<table>
<thead>
<tr>
<th>Adequately completed</th>
<th>Inadequately completed</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Density:</strong> Absence of voids and moth eaten appearance</td>
<td><strong>Density:</strong> Voids present in the obturation; the root canal filling material was inadequately condensed</td>
</tr>
<tr>
<td><strong>Length:</strong> The root filling material is 0.5-2mm from radiological apex</td>
<td><strong>Length:</strong> The root canal filling material is more than 2mm short of the radiological apex (under-filled) or has extruded past the radiological apex (over-filled)</td>
</tr>
</tbody>
</table>

**Table 2: Frequency table for distribution of completed root canal treatments**

<table>
<thead>
<tr>
<th>Treatment procedure (x)</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCT was adequately completed</td>
<td>126</td>
<td>57.27</td>
</tr>
<tr>
<td>RCT was inadequately completed</td>
<td>94</td>
<td>42.73</td>
</tr>
<tr>
<td>RCT was completed by a dental student</td>
<td>120</td>
<td>53.57</td>
</tr>
<tr>
<td>RCT was completed by a qualified dentist</td>
<td>104</td>
<td>46.43</td>
</tr>
</tbody>
</table>

**Table 4: Frequency and reasons for inadequately obturated canals**

<table>
<thead>
<tr>
<th>Treatment procedure (x)</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCT underfilled (short of radiological apex) (Figure 1)</td>
<td>57</td>
</tr>
<tr>
<td>RCT overfilled (past the radiological apex) (Figure 2)</td>
<td>11</td>
</tr>
<tr>
<td>Voids in the obturation (Figure 3)</td>
<td>16</td>
</tr>
<tr>
<td>Missed canal/s (Figure 4)</td>
<td>11</td>
</tr>
<tr>
<td>Fractured file (Figure 5)</td>
<td>5</td>
</tr>
<tr>
<td>Loss of coronal seal (Figure 6)</td>
<td>5</td>
</tr>
<tr>
<td>Root perforated (Figure 7)</td>
<td>2</td>
</tr>
<tr>
<td>Teeth that have two reasons for inadequacy of RCT</td>
<td>13</td>
</tr>
</tbody>
</table>

**Table 3: Frequency table for outcome of RCT completed by students versus dentists**

<table>
<thead>
<tr>
<th>Classification</th>
<th>Adequate n</th>
<th>%</th>
<th>Inadequate n</th>
<th>%</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>RCT was completed by a Student</td>
<td>71</td>
<td>59.66</td>
<td>48</td>
<td>40.34</td>
<td>119</td>
</tr>
<tr>
<td>RCT was completed by a Dentist</td>
<td>55</td>
<td>54.46</td>
<td>46</td>
<td>45.54</td>
<td>101</td>
</tr>
<tr>
<td>Total</td>
<td>126</td>
<td>57.27</td>
<td>94</td>
<td>42.73</td>
<td>220</td>
</tr>
</tbody>
</table>

Chi²-test, not significant.

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![Figure 1](image1.png)  
1a: Shows an off centre access cavity preparation with a root canal obturation that is short of the radiographic apex.  
1b: Shows a root canal obturation that is short of the radiographic apex probably due to the fit of an incorrect master size GP point. Note the presence of the canal beyond the obturation material.
overfilled canals (Figures 1 and 2 respectively), voids in the obturation (Figure 3), missed canals (Figure 4), fractured files (Figure 5), loss of coronal seal (Figure 6) and a root perforation (Figure 7).

DISCUSSION
Most root canal treatment failures develop when initial treatment procedures, mainly technical in nature, have not succeeded to thoroughly eliminate pathogenic factors. Dammaschke et al. concluded that root canal therapy can be a durable way of preserving teeth even when the RCT is carried out by students.13

Assessment of the technical quality of the RCT’s in this study showed that 57.27% of completed cases were of acceptable quality (using the criteria described in Table 1). This percentage appears to be lower than those found in other studies which focused on the quality of the root canal fillings done by undergraduate students.4,14 In a study by Lynch et al. in 2006, 70% of the RCTs performed had acceptable

Figure 2: Exhibits canals filled past radiographic apex (overfilled).
2a: Shows over extension of gutta-percha done probably due to over-preparation.
2b: Shows an overfill of obturation material in the distal root canal system.

Figure 3: Exhibits voids (density inadequate) in the obturation.
3a & b: Shows inadequate root canal obturation. Note the poor condensation of the gutta-percha and voids in the obturation material. This is probably due to using a poor lateral condensation technique and the canal not being flared (shaped) correctly.

Figure 4: Exhibits missed canals.
4a: Shows the mesial canal missed in a mandibular first premolar.
4b: Shows a mesial canal that was missed when preparing and obturating the canals of the 17.

Figure 5: Exhibits fractured instruments.
5a: Shows a fractured instrument in the apical curvature of the distal canal of the 36. The mesial canal is obturated short of the working length.
5b: Shows fractured instruments in the apical areas of both mesial and distal root canal systems. There is also loss of coronal seal at the distal interproximal area of the crown (46) in b.

Figure 6: Exhibits loss of coronal seal.
6a: The arrow indicates loss of coronal seal. The canal is also underfilled.
6b: The arrow indicates loss of coronal seal at the distal interproximal area of the crown.
Endodontics is indeed a difficult skill\textsuperscript{19,20} and the clinician’s competency is the predominant factor determining the success of the outcome of root canal treated teeth.\textsuperscript{20} Duvivier et al. emphasized the need for purposeful repetition of practical tasks in order to gain the necessary clinical skills. As part of the current curriculum at the UPOHC, the dental students in their third year of study practice RCT on extracted teeth in the laboratory. They are allowed to treat endodontic patients in their fourth year of study only once they have passed the preclinical practical exam. Although these students start at an early stage in their studies to identify the root canal system, more extensive training could be considered for incorporation into the curriculum. Scaffolding is an approach to enhance a student’s self-governed learning skills.\textsuperscript{21} At every level of study the students should have adequate assistance in the initial phases of endodontic training and then be gradually weaned off instruction as they master the endodontic milestones independently.\textsuperscript{22} This means gradually reducing the support and progressively expanding the student’s responsibility.\textsuperscript{22}

In view of the findings of this study it is recommended that an increase in student clinical quotas for endodontics be considered at the UPOHC. Endodontics could be introduced more extensively at an early stage, in the preclinical third year of study. Practical application of modern technology such as the rotary instrumentation and the electronic determination of working lengths should be incorporated in this preclinical year.\textsuperscript{6,23} The technique for obturation of root canal treated teeth currently being taught to undergraduate dental students at the University of Pretoria is cold lateral condensation. Use is made of gutta-percha which Hammad et al. documented as showing the minimum amount of voids during root section.\textsuperscript{25} The final year students are however, additionally taught to use the ProTaper Universal (Dentsply Maillefer) system which consists of rotary nickel-titanium files. An earlier introduction of the use of rotary instruments (particularly the use of rotary instruments on extracted teeth in the laboratory) may improve the acceptable outcome of completed RCTs. However, use of rotary instruments in clinical wards must be preceded by thorough practice on extracted teeth.

Productive use of students’ clinical time is another factor to be investigated. At the UPOHC, much time is spent by students preparing/disinfecting the surgery (cubicle) for their patients as well as on collecting materials needed for the clinical session. The output of these students could certainly be increased if they could be provided with dental assistants. Possible solutions may include the training of junior dental students to assist during clinical teaching and learning. Greater collaboration between tertiary institutions is necessary for dental assistant (dental nursing) students to be placed in the wards during the student clinical sessions so that productivity can be enhanced. If more qualified chair side assistants could be employed then these personnel could help the dental students to prepare their surgeries before and after treatments. Dental assistants could help ensure that infection control protocols are in place, gather and prepare dental materials to be used during the session, and process instruments once the treatment has been carried out. Such measures will not only increase the productivity of the students, but may even provide both the dental and dental assistant students with improved teamwork skills and competencies, which may have an additional educational benefit. A similar recommendation was made in the United Kingdom where the General Dental Council recommended that for all dental procedures students work with a dental nurse.\textsuperscript{25} Installation of additional periapical x-ray machines in the endodontic clinical wards could decrease the time students spend waiting to take radiographs. There are currently only two machines per group (varying between 10 and 20 students) during one endodontic clinical session. Another option is to utilize other wards with more periapical x-ray machines for endodontic sessions.
The results from Table 3 indicate that the outcomes of RCT’s completed by qualified dentists and by undergraduate students differ by only five percent, whether judged adequate or inadequate. It may be expected that qualified dentists should have a higher success rate compared with students. However, the staff at the UPOHC, working under severe time constraints, do the retreatments and difficult cases students could not manage, which may challenge and influence the quality of the clinical work.\(^{26,27}\) In a study at a German dental school, Stoll et al. attributed the 74% survival rate of endodontically treated teeth to the fact that at a training hospital the difficult root canal treatment cases are delegated to the dentists.\(^{28}\) Certain root canal failures such as broken file segments are sometimes impossible to reverse and as Souter & Messer suggested, should not be attempted routinely.\(^{28,29}\) A valuable insight by Hayes et al. stated that focus should be on the quality of treatment rather than quantity.\(^{30}\) Dentists at the UPOHC ideally should allocate more time to properly complete RCTs rather than perhaps aiming for quantity and compromising on quality. Proper selection of teeth for RCT, especially teeth that require retreatment, should be considered. A good coronal restoration can diminish the risk of failure of root canal treated teeth.\(^{30}\) The traditional method of restoring endodontically-treated teeth is the placement of full crown coverage. Nagasiri and Chitmongkolsuk investigated the survival of endodontically-treated teeth which had no coronal coverage.\(^{31}\) A mere 54% of teeth survived after 5 years, showing that a proper coronal restoration like a crown is essential for root canal treated teeth.\(^{31}\) However, according to latest research which is based on laboratory studies, root canal treated premolars and molars with limited destruction of hard tissue can be restored with composite without the use of posts.\(^{32}\) Post placement is beneficial however, when there is no cusp protection particularly left in premolars.\(^{32}\) Mannocci & Cowie stated that the conservation of tooth structure is crucial to the longevity of a root canal treated tooth.\(^{33}\) The preservation rather than removal of dentine is made possible with composite restorations using adhesive techniques rather than expanded mechanical retentions.\(^{30}\)

**Limitations**

Two-dimensional radiographs (conventional digital intra oral) were used to assess the technical quality of the completed root treatment. Three-dimensional radiography (a CBCT scan/cone beam) may have yielded more precise assessments. A single clinician retrospectively examined the radiographs with no repeatability assessment. It is financially costly to perform a CBCT scan on every endodontic patient and the high radiation dosage produced with the CBCT imaging makes it unethical to perform routine scans.\(^{33}\)

As with most retrospective studies, the quality of the data depended largely on the quality of the documentation of existing records\(^{34}\) including the legibility of handwriting on the hospital files. Sometimes students or dentists failed to record the entire treatment visit or omitted the tooth number on which the treatment procedure was carried out.

**CONCLUSION**

The assessment of 42.73% of a random sample of RCT’s as inadequate raises a number of concerns.

1. Auditing of root canal fillings is an important contributing factor for this provides the basis of long term survival of teeth treated endodontically by undergraduate students.\(^{5}\) Members of staff involved in clinical supervision of endodontics should be equipped with sufficient knowledge and clinical experience to evaluate and sign off RCTs which display adequately filled canals to proper working length. Shortcomings in the proper evaluation of obturated RCTs will almost certainly result in failure of the treatment.

2. There may be a need to:
   2.1 Increase student-supervisor ratio;
   2.2 Allocate more time to clinical and preclinical endodontic training in order to raise student clinical quotas;
   2.3 Re-organise the dental treatment facilities to enhance efficiency in endodontic clinical sessions;
   2.4 Ensure dentists dedicate more time to complete the more difficult RCTs and properly select the cases that can be successfully treated by students.

3. Proper plan clinical time during student endodontic sessions to allow sufficient time to complete lengthy procedures and avoid unnecessary mistakes due to a rushed effort.

This study was undertaken at a particular Dental School. It may be instructive to repeat the study at other Schools.

**References**

13. Dammascik T, Steven D, Kaup M, Ott KH. Long-term sur-