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ORIGINAL ARTICLE

Root canal treatment in Hospital Universiti Sains Malaysia Dental Clinic – a 5-year retrospective study

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Abstract Root canal treatment (RCT) requires high level of technical skills of the dentist. Its outcome is an important part of evidence-based practice and become the basis of treatment planning and prognostic considerations. Adequate removal of micro-organisms and prevention of recolonization of residual micro-organisms through the placement of root filling with satisfactory coronal seal ensures success. This retrospective record review study aimed to investigate the practices of RCT in Hospital Universiti Sains Malaysia (HUSM) Dental Clinic, Kota Bharu, Kelantan. It involved 333 randomly selected patient records at the HUSM Record Unit. Data was obtained by careful analyses of daily treatment progress sheets and analyzed using SPSS version 12.0. A total of 2996 RCT cases were seen and 59.8% of patients were females. The age range of patients varied from 14 to 64 years. The maxillary anterior teeth were most commonly treated (52.6%). Most operators (99.1%) used step-back technique and 97.6% used files to prepare root canals. The most commonly used material for obturation and sealing was gutta-percha and epoxy resin-based sealer (AH26). About 82.9% used calcium hydroxide as intra-canal medication. About 25.5% of cases had no periapical pathology, 65.8% with pre-existing periapical radiolucencies healed in 1-3 months whereas 2.1% of cases with periapical pathology eventually healed after a year. About 6.9% cases failed after retreatment. The number of radiographs taken was two to four pieces. RCT is a useful intervention to maintain longevity of teeth. Decision making and current updates of methods and materials are essential among practitioners as well as administrators to ensure success.

Introduction

Root canal treatment (RCT) is one of the most technically demanding procedures and a very specialized aspect in restorative dentistry requiring high level of technical skills. It involves a series of steps to aid in clinical decision-making. A reliable preoperative diagnosis with radiographic assessment is essential (Gutmann *et al.,* 2005). This will enable correct determination of the desired working length during canal preparation, master gutta percha and obturation. Thus many aspects of RCT such as instruments, medicaments and materials have been developed and modified. Many studies regarding cleaning and shaping techniques quoted that commonly applied techniques were step-back, crown-down and double-flare technique (Ahmed *et al.,* 2000; Che-Ab-Aziz *et al.,* 2006; Fava, 1983; Goldman *et al.,* 1988; Weine *et al.,* 1975). These techniques were chosen as they removed the bulk of micro-organisms which harbour at the apical area (Peak *et al.,* 2001). However, there were still doubts regarding the effectiveness of using intracanal medicament although it was proven to eliminate micro-organisms in the root canal. Calcium hydroxide and Ledermix had been advocated as the most widely used medicaments (Che-Ab-Aziz *et al.,* 2006; Foreman and Barnes, 1990; Moskow *et al.,* 1984; Pitt-Ford *et al.,* 1983).

Conventionally endodontic files were made from stainless steel. However since the end of 1980's, nickel titanium files were available and claimed to lead to a better prognosis in root canal therapy (Pettiette *et al*., 2001; Smith *et al*., 1993). Radiographs were

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used as an important diagnostic tool for working length measurement during RCT (Ahmed *et al.,* 2000; DeCleen *et al.,* 1993; Molven and Halse, 1988; Peak *et al.,* 2001; Smith *et al.,* 1993). With the availability of electronic apex locators, its use was well accepted as it proved to be equally accurate if not more (Shuping *et al.,* 2000).

Reporting success rates of RCT have met with different views of treatment outcomes. The Clinical Guide to Endodontics published by the American Association of Endodontics (AAE) came up with several criteria such as no adverse clinical signs and symptoms exist. Several authors have used several criteria such as tenderness to palpation, tooth mobility, sensitivity to percussion and so on (Gutmann *et al*., 2005).

Dental services in the Hospital Universiti Sains Malaysia (HUSM) Dental Clinic were open to the public since December 2002. It offered all types of dental treatment including RCT. The collection of important information from past records provides evidence of current practices, success rates, and other information which are useful in upgrading materials selection, instrumentation option, operator skills as well as standard facilities in our effort to provide best treatment for patients (Eckerbom *et al.,* 1989; Teixeira *et al.,* 2004). To date, RCT in this institution has never been reported in detail and it is hoped that this study will provide useful evidence to help administrators upgrade the dental service. Therefore, this study aimed to investigate one aspect of endodontic treatment which was RCT employed by dental practitioners in this institution.

Materials and methods

This retrospective record review study involved randomly selected records of patients attending the HUSM Dental Clinic for RCT from December 2002 – December 2007. The sampling frame was the list of 2996 RCT cases seen within the 5-year period whereby all teeth indicated for RCT were included. Sample size calculation was based on the estimation of a single proportion of expected prevalence of P=73% (Ahmed *et al*., 2000). Considering 10% of incomplete data, a total sample of 333 patient records was determined. These were selected using systematic random sampling with a sampling interval of 1:9. The variables studied were sex and age groups, type of tooth treated, canal preparation techniques, instruments for cleaning and shaping, techniques and choices of obturation materials, intracanal medications used, success rates and the use of periapical radiographs. Data were extracted from patient records obtained at the HUSM Record Unit after approval of the Hospital Director. Patient identification and details of their medical conditions were kept confidential. Data were analysed using SPSS version 12.0. Frequency and percentages were calculated for the study variables.

Operational definitions in this study

a) *Type of tooth treated* – all teeth in the maxilla and mandible.

b) *Canal preparation technique* – include various techniques such as step-back, crown-down, rotary or double flare technique.

c) *Instruments for cleaning and shaping* – various brands of nickel titanium or stainless steel files, Gates Gildden burs.

d) *Obturation material* – gutta percha, a semi-solid material, essentially inert when in contact with periapical tissues and most commonly used as the core filling material (Nguyen, 1994; Johnson, 2002).

e) *Root canal sealer* – include calcium hydroxide-based (Sealapex), zinc oxide eugenol-based (Tubliseal), resin-based (AH26, AH Plus, Diaket), dentine adhesive-based (Ketac-endo) and gutta percha (plasticized)-based sealer (Thermafill).

f) *Intracanal medication* – calcium hydroxide, Ledermix, Endopaste, Formocresol and Pulpdent.

g) *Success rate* – successful clinical outcomes as recommended in the Clinical Guide to Endodontics by AAE that include no adverse clinical signs and symptoms. Some criteria used were tenderness to palpation, tooth mobility, sinus tracts, sensitivity to percussion, functional tooth, signs of infection or swelling or radiographic evaluation of teeth with pre-existing periapical radioluscency, teeth without pre-existing periapical radioluscency that ceased from symptoms such as pain and discomfort.

h) *Retreatment* – comprise of nonsurgical and surgical procedures performed on teeth that was previously subjected to endodontic treatment (Johnson, 2002).

i) *Failed RCT* – include teeth with canal perforation, overextension, underfilled, those with coronal leakage and presence of persistent signs and symptoms such as pain, discomfort, sinus tracts and periapical radioluscency after retreatment and require extraction.

j) *Periapical radiographs* – are routine intra-oral radiographic films used in dentistry at preoperative, operative and postoperative stages. Currently, there is no specific protocol as to how many radiographs should be taken during RCT. The number of films used usually varies according to case.

Results

In the 5-year study duration, 2996 RCT cases were seen. Most patient folders (98%) were available with details of treatment records. A small percentage of patient records (2%) revealed that some patients did not turn up regularly or attend only once for RCT although indicated for. Table 1 described the profile of subjects and teeth treated for RCT.

Table 1 Profile of study group and tooth type

Variables	n (%)
Ethnicity	
Malays	319 (95.8)
Chinese	8 (2.4)
Indian	2 (0.6)
Others	4 (1.2)
Sex	
Male	134 (40.2)
Female	199 (59.8)
Age group in years	
10-14	
Male	14 (4.2)
Female	21 (6.3)
15-19	
Male	19 (5.7)
Female	28 (8.4)
20-24	
Male	17 (5.1)
Female	23 (6.9)
25-19	
Male	15 (4.5)
Female	26 (7.9)
30-34	
Male	14 (4.2)
Female	23 (6.9)
35-39	
Male	13 (3.9)
Female	24 (7.2)
40-44	
Male	14 (4.2)
Female	15 (4.5)
45-49	
Male	13 (3.9)
Female	15 (4.5)
50-54	
Male	9 (2.7)
Female	10 (3.0)
55-59	
Male	5 (1.5)
Female	7 (2.1)
60-64	
Male	1 (0.3)
Female	7 (2.1)
Tooth type	
Maxillary anterior	175 (52.6)
Mandibular molar	73 (21.9)
Maxillary premolar	43 (12.9)
Mandibular premolar	31 (9.3)
Maxillary molar	7 (2.1)
Mandibular anterior	4 (1.2)

It was found that 95.8% cases were Malays, followed by Chinese (2.4%), Indians (0.6%) and others (1.2%). About three-fifths of subjects (59.8%) were females. A slightly larger number of patients were in the 15-19 years age group and in this subgroup, there were slightly more females than males. About 52.6% of cases involved the maxillary anterior teeth, 21.9% mandibular lower anterior, 12.9% maxillary premolar, 9.3% mandibular premolar, 2.1% maxillary molar and 1.2% mandibular anterior teeth.

Table 2 showed that majority of practitioners used the step-back technique of canal preparation. Almost all practitioners (97.6%) prepared root canal with hand instruments such as files.

Table 2 Canal preparation technique and instruments used

Variables	n (%)
Canal preparation	
Step-back technique	330 (99.1)
Crown-down	2 (0.6)
Rotary instrument	1 (0.3)
Instrument	
Files only	325 (97.6)
Files & Gates Glidden burs	7 (2.1)
Files and rotary instrument	1 (0.3)

Table 3 illustrated that $CaOH_2$ was the most common medicament used (82.9%).

Table 4 showed the obturation technique and materials used. Lateral condensation technique was the most common method of obturation. Majority of practitioners (65.5%) used gutta-percha with epoxy-resin-based sealer (AH26). Table 5 showed 64.3% of teeth were root filled with pre-existing radioluscency and took about 1-3 months to cease from symptoms such as tenderness on biting, dull pain etc. Approximately 84.4% of practitioners took two to four radiographs during RCT whilst 15.0% used more than 4 radiographs.

Table 3 Intra--canal medication used

Variables	n (%)
Intracanal medication	
Calcium hydroxide [$Ca(OH)_2$]	276 (82.9)
$Ca(OH)_2$ and Endopaste	19 (5.7)
Endopaste	18 (5.4)
$Ca(OH)_2$ and Ledermix	4 (1.2)
$Ca(OH)_2$,and Formocresol	4 (1.2)
Ledermix	4 (1.2)
Formocresol	3 (0.9)
Pulpdent	2 (0.6)
$Ca(OH)_2$ and Pulpdent	1(0.3)
Formocresol and Endopaste	1 (0.3)
Not medicated (non compliance to waiting time)	1 (0.3)

Table 4 Obturation technique and materials used

Variables	n (%)
Obturation technique	
Lateral condensation	321 (96.4)
Warm lateral condensation	2 (0.6)
Warm vertical condensation	1 (0.3)
Injection technique	1 (0.3)
Core carrier warm technique	1 (0.3)
Obturation material	
Gutta-percha with epoxy resin-based sealer (AH26)	218 (65.5)
Gutta-percha with $Ca(OH)_2$ - based sealer	85 (25.5)
Gutta-percha with zinc oxide-eugenol-based sealer	23 (6.9)
None due to failure to attend regularly	7 (2.1)

Table 5 Success rates and radiographs used

Variables	n (%)
Success rate	
Preoperative radiolucent periapical lesion healed after 1-3 month	214 (64.3)
Preoperative intact periapical and no signs & symptoms 1-3 month	85 (24.6)
Failure after retreatment and follow-up	23 (6.9)
Preoperative radiolucent periapical lesion >1 year	7 (2.1)
Use of periapical radiograph	
2-4 pieces	281 (84.3)
>4	50 (15.1)
1	2 (0.6)

Discussion

It is important to highlight that the results of this study may not represent best method for RCT in other university dental hospitals in the state or the country. This is because different dental schools may adopt differing methods of practice. However despite this shortcoming, this information was deemed valuable for the reasons mentioned earlier.

Women have been very passionate and interested about their oral health. Data regarding women and oral health is valid in many countries whereby more women were found to attend dental services more often for various treatments (Nuttal *et al.,* 2001; Oral Health Division, 2004; Todd and Lader, 1991). With increased dental awareness, more people are beginning to understand that not all problematic teeth require extraction because some can be root treated to save the teeth and maintain aesthetic and function. Thus in our study we found that a larger proportion of the sample were women which was perhaps true of their consciousness regarding oral health. Slightly more patients who attended for RCT were in the 15-19 years age group. Again there were slightly more females than males in this subgroup.

In our study, the maxillary anterior teeth were most commonly treated. This could be due to better success rates than other types of teeth. Access was better at the front of the mouth and the root canal anatomy was more amenable to treatment i.e. single, straight and more circular in cross-sectional view allowing better cleaning and obturation. Other authors agreed with this finding (Pitt-Ford, 2004; Saunders and Saunders, 1997). Multi-rooted teeth with curved root canals present as a challenge in all stages of RCT and their higher failure rates may be due to factors other than filling technique alone e.g. lack of access, poorer cleaning and accessory canal anatomy (Trope and Debelian, 2005). The step-back technique was the technique of choice for canal preparation among practitioners in HUSM. Effective cleaning of the root canal ensured adequate removal of microorganisms to prevent the progress of bacterial growth. This study showed that all practitioners used files to prepare the canal such as K-files, Hedstrom and Protaper files. The advantage of using files includes good tactile sensation which is useful in determination of root length, cleaning and shaping of root canal (Ruiz-Hubard *et al*., 1987). However, with higher pressure, operators may tend to penetrate the canal, transporting the apical foramen, overextend through the apical foramen and sometimes break off an instrument within the canal. This condition may lead to failure of the treatment resorting either to retreatment, apicectomy or extraction (Briggs and Scott, 1997).

Gutta-percha as core material for obturation was preferred by all practitioners in this study. The use of warm gutta-percha for obturation is now commonly accepted (Ahmed *et al*., 2000; Barbakow *et al*., 1980; Johnson, 2002; Molven and Halse, 1988). Gutta-percha has no effect on the physical properties of the tooth (Oguntebi and Shen, 1992.). The lateral condensation technique was most commonly employed to obturate root canals. Other variants such as warm vertical condensation, continuous wave obturation, injection of thermoplasticised gutta-percha and carrier-based gutta-percha were not commonly practiced. The use of root canal sealers are an important component of the obturation process. It helps fill the space between the canal wall and the core obturation material. Sealers are grouped by type such as zinc-oxide-eugenol formulations, calcium hydroxides, resins, dentine adhesives and gutta-percha (Johnson, 2002).

The introduction of resin-based materials were said to increase the strength of the tooth root by bonding to dentine and forming a monobloc (Teixeira *et al.,* 2004). Early tests suggest that resin materials may have a place in endodontic obturation (Orstavik and Mjör, 1988). The first resin sealer, AH26 had good sealing and adhesive properties as well as antibacterial

activity but gave an initial severe inflammatory reaction (Harty, 1984). The choice of canal sealer is not only dependent on its ability to create a sound seal, but it must also be well tolerated by periradicular tissues and be relatively easy to manipulate so that its optimum physical properties can be achieved (Limkangwalmongkol *et al.,* 1992; Oguntebi and Shen, 1992). When the root canal system has been obturated it is important to protect it from subsequent microbial contamination (Saunders and Saunders, 1997). Thus the coronal seal is an important consideration. Routine practice in this institution was the placement of glass ionomer cement after excess gutta-percha and sealer have been removed. Common intracanal medication was calcium hydroxide. The clinical value of calcium hydroxide in RCT is now linked to its beneficial antimicrobial effects without a simultaneous risk for severe tissue damage (Foreman and Barnes, 1990; Sirén *et al., 2004*). Bystrom *et al.* (1985) found that infected root canals treated with calcium hydroxide for 1 month were successfully disinfected in 97% of cases. The effectiveness of calcium hydroxide *in vivo* may vary depending on the initial composition of microbial flora and the effectiveness of cleansing procedures carried out.

The concepts of success and failure of endodontic treatment is a very complex issue. There is some truth in the explanation that there is no such thing as failure, just different degrees or rates of success because of the difficult objective definition of success and failure (Chong, 2004). According to Strindberg (1956) the only satisfactory post-operative outcome after a certain post-operative period is a clinically symptom-free tooth and the radiological appearance of a normal peri-apex. Thus a failure can be defined as the presence of signs and symptoms that indicate disease or problems. Both clinical assessment and the use of radiographs are vital for evaluation. More than half of teeth in this sample were treated with pre-existing periapical radiolucencies. Generally, teeth with periapical radiolucencies had better success rates than those without (Peak *et al*., 2001). Radiographic reviews and follow-up intervals varied among practitioners and as such, may have influenced our results. Majority of cases (65.5%) in the current study had pre-existing periapical radiolucent lesions which healed in about 1-3 months after RCT. About 25.5% cases had no pre-existing periapical radiolucent lesions but took 1-3 months to cease from symptoms such as dullness or discomfort. A small percentage (2.1%) of cases took more than a year to be completely free of signs and symptoms. However, there were 6.9% cases of failure after retreatment. The exact reason for failure after retreatment is multifactorial such as persistent signs and symptoms, foreign body reaction, fibrous healing and misdiagnoses and this cannot be easily determined.

The number of radiographs used by each practitioner in the current study during the whole treatment period varied from two to four. Almost all practitioners used radiographs to determine working length. The reliance on preoperative radiograph and tactile sensation to determine working length has no place in modern endodontics, and practitioners should be aware of the serious complications that may arise from inappropriate methods of determining length such as perforation, incomplete instrumentation and underfilling (Chong, 2004). Other then for length determination, radiographs were also used to assess the location, shape and number of roots as well as to assess the filling material after obturation and to diagnose extent of lesion. Inferior technique and quality of root filling has been considered to be the main cause of clinical failure. Incomplete obturation leaves residual space for microbial colonization and proliferation and may also imply that cleaning was incomplete. The operator then has to decide on the possibility of non-surgical retreatment. This decision-making is again a very complex aspect of endodontic practice.

Conclusion

This retrospective study investigated the practices of RCT in HUSM Dental Clinic over a five-year period. Some interesting findings observed were the high percentage of step-back canal preparation using files, common use of calcium hydroxide intra-canal medication, lateral condensation technique using gutta-percha with epoxy resin-based sealer, good success rate and appropriate use of radiographs. RCT is a useful intervention to maintain sound dentition. Decision making and current updates of methods and materials are very important among practitioners. It also aid administrators regarding the need to upgrade services in the aspect of materials and instruments.

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References

Ahmed MF, Elseed AI and Ibrahim YE (2000). Root canal treatment in general practice in Sudan. *Int Endod J*, **33**(4): 316-319.

Barbakow FH, Cleaton-Jones P and Friedman D (1980). An evaluation of 566 cases of root canal therapy in general dental practice. 2. Postoperative observations. *J Endod*, **6**(3): 485-489.

Briggs PFA and Scott BJ (1997). Evidence-based dentistry: endodontic failure--how should it be managed? *Br Dent J*, **183**(5): 159-164

Che-Ab-Aziz ZA, Abdullah M, Vello CDS and Thangavelu K (2006). General dental practitioners' knowledge and practice on root canal treatment. *Annal Dent Univ Malaya*, **13**(1): 12–17.

Chong BS (2004). *Managing Endodontic Failure in Practice*, 1st edn. London: Quintessence.

DeCleen MJ, Schuurs AH, Wesselink PR and Wu MK (1993). Periapical status and prevalence of endodontic treatment in an adult Dutch population. *Int Endod J*, **26**(2): 112-119.

Eckerbom M, Andersson JE and Magnusson T (1989). A longitudinal study of changes in frequency and technical standard of endodontic treatment in a Swedish population. *Endod Dent Traumatol*, **5**(1): 27-31.

Fava LR (1983). The double-flared technique: an alternative for biomechanical preparation. *J Endod*, **9**(2): 76-80.

Pitt-Ford TR (2004). *Harty's Endodontics in Clinical Practice*, 5th edn. Edinburgh: Wright.

Foreman PC and Barnes IE (1990). Review of calcium hydroxide. *Int Endod J*, **23**(6): 283-297.

Goldman M, White RR, Moser CR and Tenca JI (1988). A comparison of three methods of cleaning and shaping the root canal in vitro. *J Endod*, **14**(1): 7-12.

Gutmann JL, Dumsha TC and Lovdahl PE (2005). *Problem Solving in Endodontics: Prevention, Identification, and Management.* 4th edn. St. Louis: Mosby.

Harty FJ (1984). Endodontic treatment in England. *Int Endod J*, **17**(3): 106-112.

Ruiz-Hubard EE, Gutmann JL and Wagner MJ (1987). A quantitative assessment of canal debris forced periapically during root canal instrumentation using two different techniques. *J Endod*, **13**(12): 554-558.

Johnson WT (2002). *Colour Atlas of Endodontics*. 1st edn. Pennsylvania: Saunders.

Limkangwalmongkol S, Abbott PV and Sandler AB (1992). Apical dye penetration with four root canal sealers and gutta-percha using longitudinal sectioning. *J Endod*, **18**(11): 535-539.

Trope M and Debelian GJ (2005). *Endodontics Manual for the General Dentist*, 1st edn. London: Quintessence.

Molven O and Halse A (1988). Success rates for gutta-percha and Kloroperka N-0 root fillings made by undergraduate students: radiographic findings after 10-17 years. *Int Endod J*, **21**(4): 243-250.

Moskow A, Morse DR, Krasner P and Furst ML (1984). Intracanal use of a corticosteroid solution as an endodontic anodyne. *Oral Surg Oral Med Oral Pathol*, **58**(5): 600-604.

Oral Health Division (2004). *National Oral Health Survey of Adults 2000 (NOHSA, 2000).* Putrajaya: Oral Health Division, Ministry of Health, Malaysia.

Nguyen NT (1994). Obturation of the root canal system. In: Cohen S and Burns RC (eds.), *Pathways of the Pulp*, 6th edn. St. Louis: Mosby.

Nuttal NM, Steele JG, Pine CM, White D and Pitts NB (2001). The impact of oral health on people in the UK in 1998. *Br Dent J*, **190**(3): 121-126.

Oguntebi BR and Shen C (1992). Effect of different sealers on thermoplasticized Gutta-percha root canal obturations. *J Endod*, **18**(8): 363-366.

Orstavik D and Mjör IA (1988). Histopathology and x-ray microanalysis of the subcutaneous tissue response to endodontic sealers. *J Endod*, **14**(1): 13-23.

Peak JD, Hayes SJ, Bryant ST and Dummer PMH (2001). The outcome of root canal treatment. A retrospective study within the armed forces (Royal Air Force). *Br Dent J*, **190**(3): 140-144.

Pettiette MT, Delano EO and Trope M (2001). Evaluation of success rate of endodontic treatment performed by students with stainless-steel K-files and nickel-titanium hand files. *J Endod*, **27**(2): 124-127.

Pitt-Ford TR, Stock CJR and Loxley HC (1983). A survey of endodontics in general practice in England. *Br Dent J,* **154**: 222–224.

Saunders WP and Saunders EM (1997). The root filling and restoration continuum--prevention of long-term endodontic failures. *Alpha Omegan*, **90**(4): 40-46.

Shuping GB, Orstavik D, Sigurdsson A and Trope M (2000). Reduction of intracanal bacteria using nickel-titanium rotary instrumentation and various medications. *J Endod*, **26**(12): 751-755.

Sirén EK, Haapasalo MP, Waltimo TM and Ørstavik D (2004). In vitro antibacterial effect of calcium hydroxide combined with chlorhexidine or iodine potassium iodide on *Enterococcus faecalis. Eur J Oral Sci*, **112**(4): 326-331.

Smith CS, Setchell DJ and Harty FJ (1993). Factors influencing the success of conventional root canal therapy - a five-year retrospective study. *Int Endod J*, **26**(6): 321-333.

Strindberg LZ (1956). The dependence of the results of pulp therapy on certain factors. An analytic study based on radiographic and clinical follow-up examinations. *Acta Odontol Scand*, **14**(Suppl 21): 1-175.

Teixeira FB, Teixeira EC, Thompson JY and Trope M (2004). Fracture resistance of roots endodontically treated with a new resin filling material. *J Am Dent Assoc*, **135**(5): 646-652.

Todd JE and Lader D (1991). *Adult Dental Health 1988, United Kingdom*. London: HMSO.

Weine FS, Kelly RF and Lio PJ (1975). The effect of preparation procedures on original canal shape and on apical foramen shape. *J Endod*, **1**(8)**:** 255-262.