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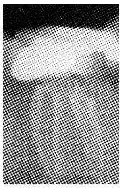

CLINICAL ARTICLE

A 5-year review of teeth filled with the noninstrumentation technology

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Abstract

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Aim The aim of this *Case Series* was to evaluate the radiographic quality of root fillings performed 5 years previously using the noninstrumentation technology (NIT)-obturation method and to assess radiographically the outcome of these root canal treatments.

Methodology Seventeen patients requiring root canal treatment participated in this study and were re-evaluated after 5 years. After instrumentation with K-Flexofiles, Calcium-Hydroxide inter-appointment dressing, re-entry and copious irrigation with NaOCl, the teeth were root filled using the NIT.

Results Immediately after obturation the root fillings were (–0.78 ± 0.11 mm) short when taking the radiographic apex as a reference point. After 60 months these values were –0.85 ± 0.11 mm. No statistical difference was found ($P > 0.05$). In the periapical region, PAI rating 1 and 2 increased from 20.1% to 75.6% after 60 months.

Conclusions

- This prospective *Case Series* demonstrated the performance of the NIT-obturation method *in vivo*.
- Root canals filled by the reduced-pressure method using sealer combined with gutta-percha cones showed good radiographic quality.
- Periapical healing after 5 years was comparable with conventional filling techniques.

Keywords: long-term evaluation, noninstrumentation technology, root canal obturation, vacuum technique.

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Introduction

Modern methods of root canal treatment are based on mechanical debridement, chemical disinfection and bacteria-tight sealing of the root canals with a filling material. Unfortu-

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nately, the intricate anatomy of most canals may be one of the reasons for post-treatment disease following root canal treatment as mechanical enlargement of the main canals and the removal of infected dentine from the canal walls may not remove bacteria in those areas, which cannot be instrumented. The main function of irrigating solutions is the inactivation of these remaining bacteria and the removal of soft tissue debris.

Buckley & Spangberg (1995) found that 31.3% of root filled teeth had signs of periapical disease with only 42% of all roots adequately filled. Saunders *et al.* (1997) found that root canal fillings judged to be adequate radiographically had a reduced incidence of radiolucencies periapically. Teeth obturated beyond the apex had more radiolucencies than those obturated flush with or within 2 mm of the radiographic apex. West (1987) showed that the lack of perfect three-dimensional root canal filling including all ramifications may lead to failure. A good, dense root filling after removal of all reachable bacteria is of major importance: Ricucci (2009) stated: 'It is less likely, that only bacteria in the dentinal tubules can maintain a periapical lesion'.

In the mid nineties, a method and device was presented that allowed cleansing of root canals without the need for manual instrumentation (Lussi *et al.* 1993, 1995, 1999a). The canals were irrigated with a NaOCl solution under alternating pressure fields producing hydrodynamic turbulence, making the irrigant perfuse minute ramifications of the root canal system (Lussi *et al.* 1993). Experiments demonstrated that NaOCl concentrations above 1% were best suited for the new device (Lussi *et al.* 1993, 1997b). With this noninstrumentation technology (NIT) root canals were not enlarged mechanically to standardized dimensions. Therefore, it was necessary to develop a method for filling entirely the unprepared canal space (NIT). The concept was to produce a profound low pressure ('vacuum') within the tooth and thus aspirate sealer into the entire root canal system. It was demonstrated *in vitro* that a reduced (absolute) pressure of 15 hPa (=15 mbar) or less was sufficient to produce radiographically dense root canal fillings (Portmann & Lussi 1994, Lussi *et al.* 1995, 1999b). Even dentinal tubules and branches were filled with the NIT-method (Lussi *et al.* 1997b). Negative absolute pressures lower than 10 hPa have been achieved *in vivo* (Lussi *et al.* 1996, 1997a). However, no clinical studies to demonstrate the long-term performance of the technique were available.

The aim of this prospective *Case Series* was

1. To demonstrate *in vivo* the radiographic quality of root canal fillings performed by the NIT-obturation method after cleaning and shaping the root canals by conventional mechanical methods.

2. To assess radiographically, using the PAI-Index, the outcome of these root canal treatments.

Case selection

Twenty-nine patients needing root canal treatment participated in this study, 17 were re-evaluated after 5 years. Twelve patients were 'drop outs' because of: did not show up, moved away or could not be motivated for re-evaluation (11 patients), died (one patient). Three of the 17 re-evaluated cases were re-treatment cases. All treatments were performed by one specialist endodontist. The teeth were selected consecutively, applying the following exclusion criteria: no open apices, no possible 'cyst' formation (as judged by radiography) present at the time of root canal filling, no apparent communication with the paranasal sinuses or with the mandibular nerve, no primary teeth, no known allergies to material used, no severe or terminal illness.

All subjects participated voluntarily. A written consent form was signed before any treatment was carried out, and all work was approved by the Ethical Committee of the University of Bern, Switzerland.

Table 1 Distribution amongst the different tooth goups

Technique	Obturation material	Molars	Premolars	Incisors and canines	Canals
NIT and gutta-percha	AH 26 & gutta-percha points, no lateral condensation	12	1	4	46

The distribution amongst tooth groups is shown in Table 1 (patients in endodontic practice; $N = 17$, 46 root canals).

Treatment procedures

Cleaning and shaping of the root canals was performed with conventional K-files (Dentsply Maillefer, Ballaigues, Switzerland) up to a master apical file (MAF) between sizes 30 and 50 and followed by stepback flaring up to sizes 40–60 using the Balanced Force Technique (Roane *et al.* 1985). The size of the MAF was selected according to the canal width using at least a size 30 for fine and/or curved canals. In wider canals, the size of the MAF was selected when clean, white dentine shavings were produced by the balanced force movement at the tip of the instrument. Calcium hydroxide powder mixed with saline was placed in the canals for at least 1 week using a lentulo spiral and paper points.

The principle of the obturation device is shown in Fig. 1. Its mode of function has been described in detail previously (Lussi *et al.* 1995). For obturation, the teeth were connected to the 4-stage vacuum pump via tubing equipped with a valve. The pressure in the canals was reduced to at least 15×10^2 Pa (=15 hPa). AH 26 sealer (DeTrey Dentsply, Konstanz, Germany) was mixed with a powder to resin ratio of 1 : 1 (by volume). This ratio was chosen to make it more fluid yet not change the sealing properties of the material (Barthel *et al.* 1994). To reduce trapped air bubbles to a minimum, the mixed sealer was evacuated for 5 min by means of a special vibrating device connected to a vacuum pump. The sealer was placed into a reservoir and then a valve was opened allowing it to be sucked into the previously evacuated pulp space. As the diameter of the 'tubing' entering the tooth was bigger than that of the tube exiting the tooth, the obturation paste flowed into the tooth first. Evacuation was stopped as soon as sealer appeared in the evacuation tubing from the tooth to the pump.

The procedure for obtaining a tight fitting attachment to the tooth for the hose to the vacuum pump was as follows (Lussi *et al.* 1996): To keep the orifices of the canals open until obturation, flexible sterile nylon threads were inserted into the root canals. The occlusal ends of the nylon filaments were threaded into the conical connector and the latter held *in situ* whilst the gap between the access cavity and the adaptor sleeve was filled with a fast addition-curing silicone (Jet Bite, Coltène, Altstätten, Switzerland) as shown in Fig. 2a–d. After sealing and removing the nylon threads, the tooth was connected to the vacuum pump. The required vacuum indicated by a LED-display was usually reached within approximately 10 min (mean 6 min; range 2–14 min).

Upon completion of the root filling by NIT only, a first radiograph was taken (NIT group, Lussi *et al.* 2002). Then a master gutta-percha cone was inserted in the root canals and additional gutta-percha cones were placed into the root canals without using lateral condensation. The number of gutta-percha points used was recorded. Following filling, a second (parallel projected) dental radiograph was taken with the aid of a film holder (Hawe Neos Dental, Biaggio, Switzerland) in combination with a silicone impression material (President Putty, Coltène, Altstätten, Switzerland). This procedure allowed us to position the cone of X-ray machine reproducibly in every recall session during the 5-year period.

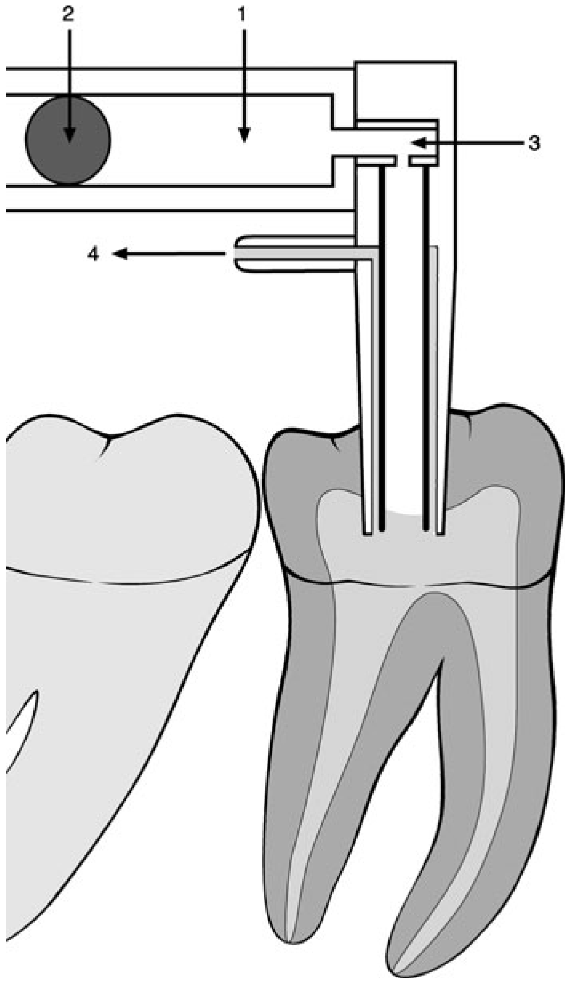

Figure 1 Principle of the new obturation procedure: The connecting piece tightly fitted in the access cavity of the tooth consists of: (1) reservoir for filling paste, (2) a steel ball placed on top of the filling paste, (3) an integrated valve, and (4) a pipe to the vacuum pump (from Lussi *et al.* 1995).

Recall

After 1 and after 5 years the teeth were re-evaluated clinically and radiographically using the same silicone-imprints and film holders as described before. Some patients attended further recalls up to 13 years after initial treatment.

Assessment

For assessing the two-dimensional quality of the root canal fillings, coded radiographs were projected onto a wall (magnification ×10), traced on paper and then analysed morphometrically (MOP, Kontron, Munich, Germany) (Lussi *et al.* 1995). A reference point RA (radiographic apex) was defined. Then, the apico-coronal extension of the root canal fillings was determined in relation to the reference point RA. Fillings beyond RA produced positive readings, fillings short of RA negative readings (mm).

In addition, the total filled area as seen radiographically was determined in three sections of the root canal as percentage of overall canal space. For these measurements,

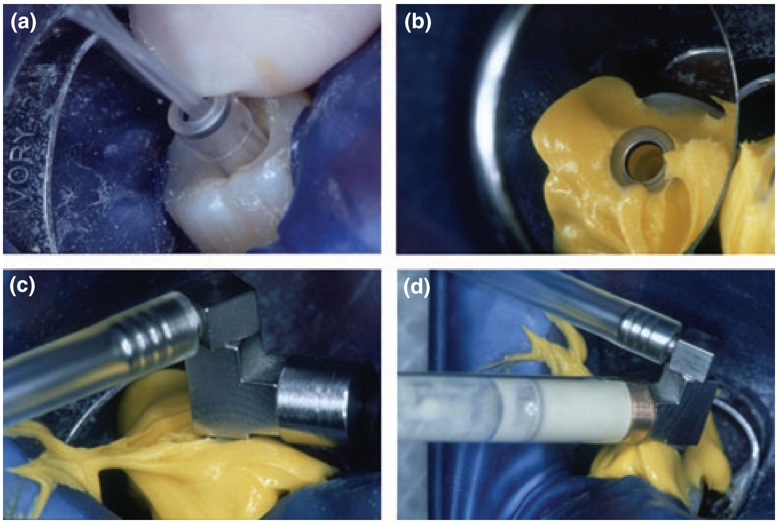

Figure 2 Procedure for obtaining a tight filling attachment: (a) After preparation of an access cavity with a standardized conical bur, flexible sterile nylon threads are inserted and the conical connector put in place. (b) A fast setting silicone is placed over the entire tooth crown. (c) The tooth is connected to the vacuum pump. (d) After reaching the required vacuum, which takes between 2 min and 14 min, the filling material is sucked into the root canal system.

a reference point AC (apical constriction) was defined at 1.1 mm coronal to the radiographic apex (Guldener & Langeland 1993): apical (0–2 mm coronal to AC), middle (2–4 mm coronal to AC) and coronal (4–7 mm coronal to AC).

The periapical region was scored according to the PAI Index (Reit & Gröndahl 1983): PAI 1: periapical destruction of bone definitely not present; PAI 2: periapical destruction of bone probably not present, PAI 3: uncertain, PAI 4: periapical destruction of bone probably present, PAI 5: periapical destruction of bone definitely present (Fig. 3). All assessment was performed by one experienced observer (PP).

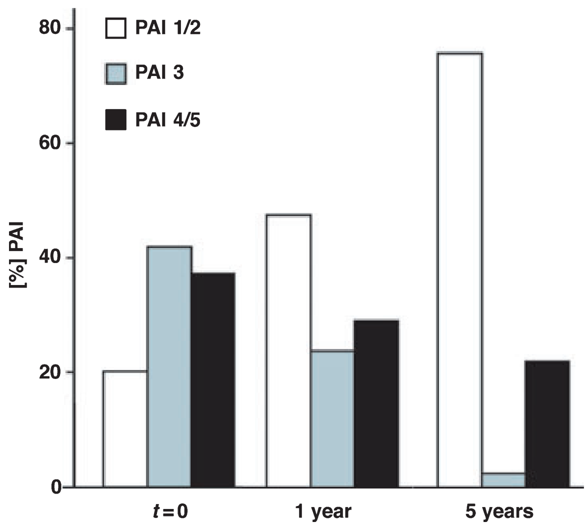

Figure 3 Periapical rating (PAI index) of teeth obturated with NIT.

Statistical analysis

The data were first analysed graphically using box plots. As they were not normally distributed, Kruskall–Wallis one-way analysis of variance was used to analyse the data. When the result indicated significant differences between groups, these groups were individually compared by means of the Mann–Whitney *U*-test, adjusting the significance level according to Bonferroni. The level of significance chosen for all tests was $P \leq 0.05$.

Results

The number of teeth with PAI rating 1 and 2 increased from 20.1% to 75.6% after 60 months. Immediately after obturation, the root fillings were −0.78 ± 0.11 mm short of RA (Fig. 4). Similar results were found after 12 and 60 months (−0.77 ± 0.13 mm and −0.85 ± 0.11 mm respectively). No statistical difference was found between the groups ($P > 0.05$).

The area of filling material apical to the apical constriction (AC) was evaluated immediately after placement. The mean value found was 0.30 ± 0.08 mm^2.

Immediately after obturation for all the teeth obturated with the NIT/gutta-percha method the values for the obturated area were 100.0 ± 0.0% in all sections of the root canal (apical, middle, coronal). After 12 and 60 months these values remained stable (100 ± 0.0%) for all areas.

Radiographs of two clinical cases are shown in Figs 5(a–d) and 6(a–e). After the end of the study the follow-up of the case shown in Figs 6(a–e) has been continued for a further 8 years (i.e. 13 years after NIT-obturation).

Discussion

In this prospective Case Series root canals instrumented by hand were filled *in vivo* using noninstrumental filling technology (NIT). Such a NIT-obturation technique will be essential for the filling of canals cleaned with a hydrodynamic method (NIT), should it become accepted as an appropriate method of canal cleaning. This technique allows debridement and disinfection of the root canals without the use of traditional endodontic instruments. It does not remove dentine from the canal wall, thus allowing the canals to maintain their irregular and often tortuous anatomy.

The concept of the NIT-filling method is to produce a reduced pressure within the tooth and thus aspirate sealer into the entire root canal system. This study has demonstrated that it was possible to reach negative pressures lower than 10 hPa *in vivo* in a dental practice setting.

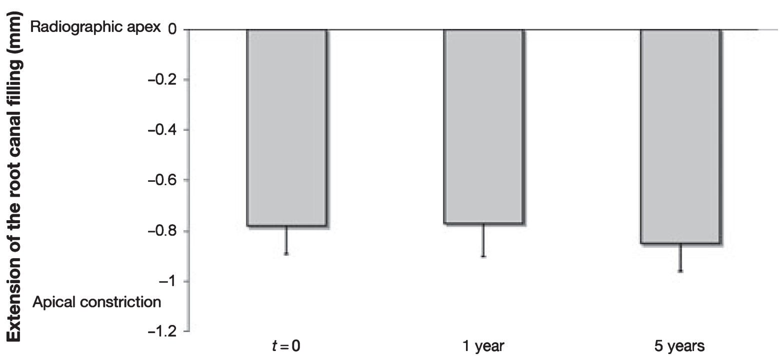

Figure 4 Extension of the root canal filling. Reference point (zero) was the radiographic apex RA. Negative values are fillings short of RA.

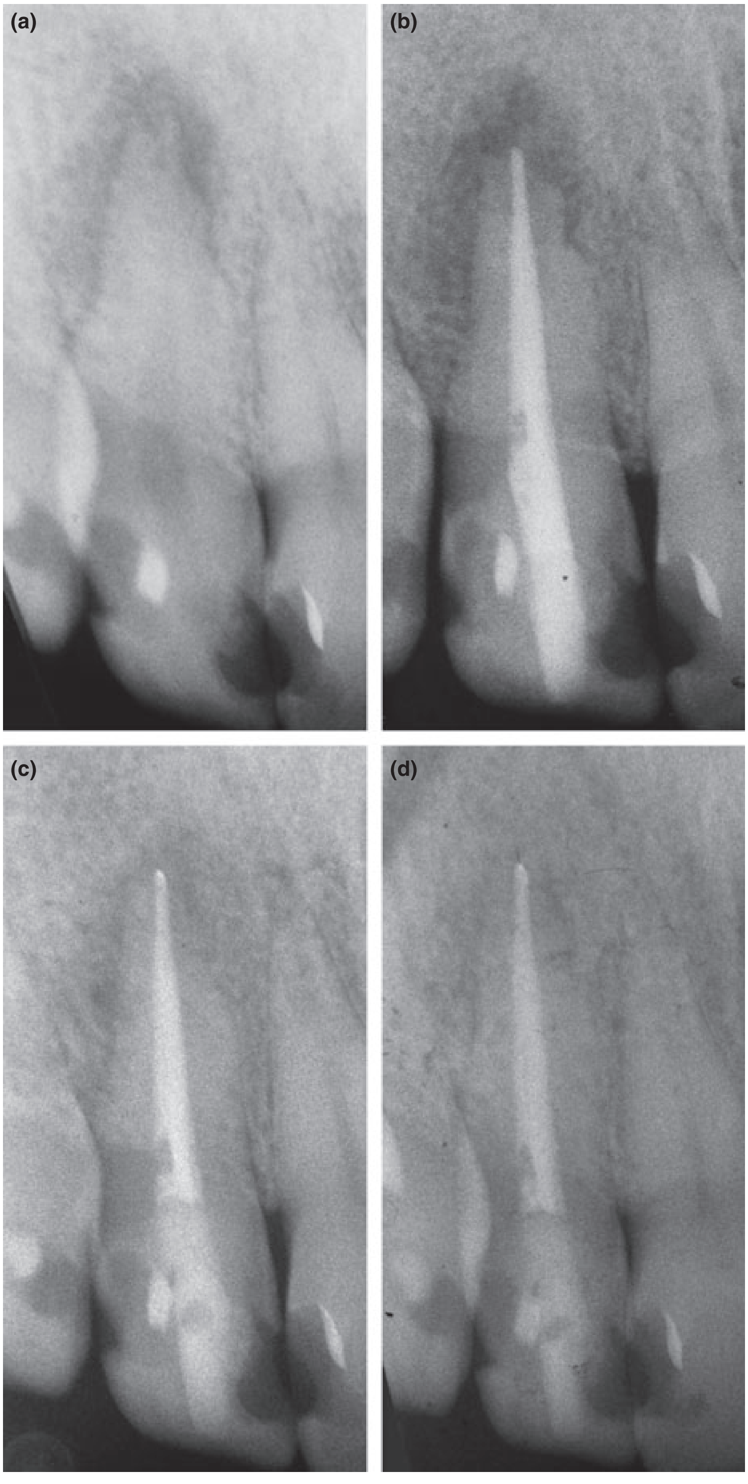

Figure 5 Tooth 12 needing root canal treatment because of chronic periapical periodontitis: (a) Preoperative radiograph. (b) Radiograph taken immediately after NIT-obturation. The tooth was shaped to size 40 with 1 mm step back to 45; after obturation with NIT one master- and three additional gutta-percha points were placed. (c) Radiograph taken at 1-year recall. (d) Radiograph taken at 5-year recall.

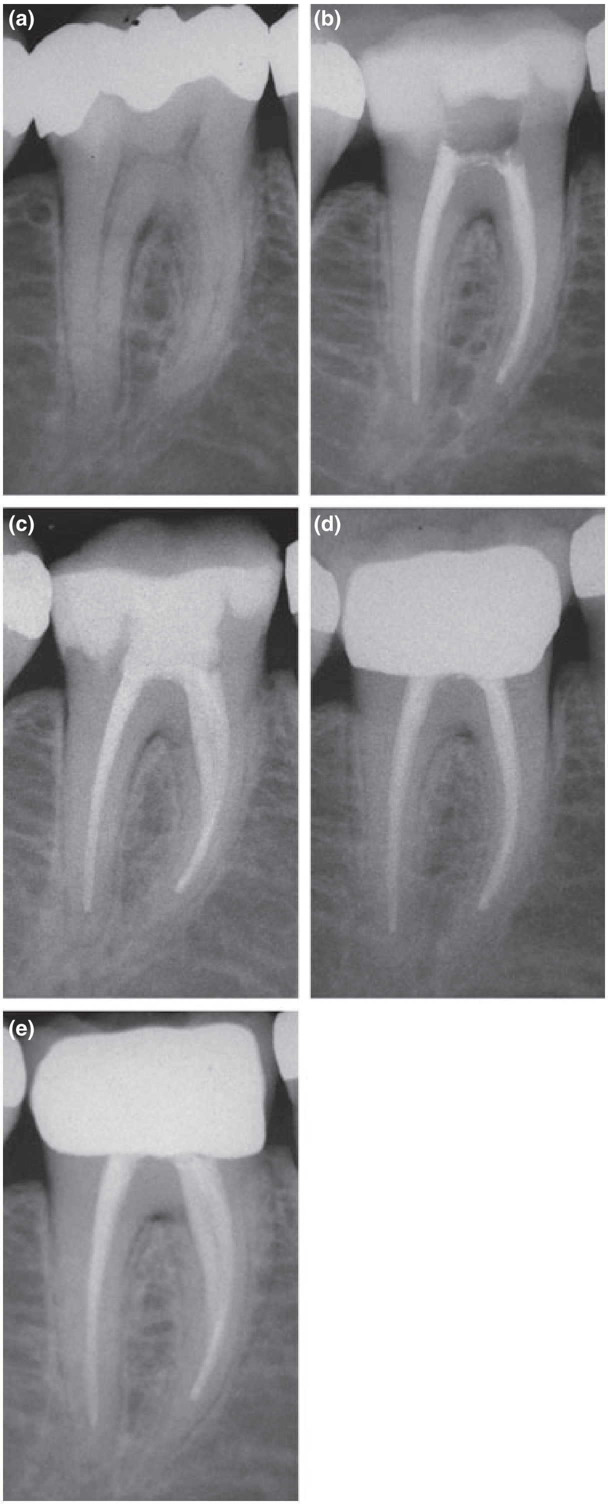

Figure 6 Tooth 46 needing root canal treatment because of chronic pulpitis: (a) Preoperative radiograph. (b) Radiograph taken immediately after NIT-obturation. The tooth was shaped to size 30 with step back to 40. (c) Excentric radiograph taken at 1-year recall. (d) Radiograph taken at 5-year recall. (e) Excentric radiograph taken 13 years after NIT-obturation.

The NIT-filling method allows filling of complex root canal systems, including lateral canals. Internal resorptions, C-shaped as well as Type-II canals. Nevertheless, it is only reasonable to use such a technique in combination with the NIT cleansing device. In fact, previous studies have demonstrated that even dentinal tubules and branches could be filled with the NIT-method (Lussi *et al.* 1997b). This phenomenon may explain the better seal created *in vitro*, even after artificial ageing of the NIT root filled teeth (Lussi *et al.* 1999b, Lussi & Imwinkelried 2000). An adequate seal created by the root filling is important for long-term success of any root canal treatment. This is even more important, with the NIT-method, as potentially infected dentine is not removed and removing the nutritional supplies for remaining bacteria is important for the success of the treatment. Using the NIT-method, Stojan (2000) found a higher penetration of the sealer in the dentinal tubules of the root canal compared with conventionally filled teeth.

Calcium hydroxide is advocated as an inter-appointment therapeutic dressing because of its antibacterial effect. However, removal is often difficult with conventional irrigation (Goldberg *et al.* 2002). Further investigation has to be undertaken to show whether the NIT-method is also efficient in removing calcium hydroxide. In this study, calcium hydroxide was always used as an inter-appointment dressing, because a vacuum could only be created in vital cases after vascular healing in the periapical area. Attin *et al.* (2002) showed, that NIT does not work properly when used in a first visit on vital teeth because of bleeding from the pulp stump.

Because of the hydraulic nature of conventional filling methods a dense root canal filling can only be expected coronal to the apical constriction. According to Guldener & Langeland (1993) the apical constriction is located 1.1 mm coronal to the radiographic apex. Vande Voorde & Bjorndahl (1969) stated that the apical foramen is located 0.3 mm coronal to the anatomical apex and that the physiological foramen is 1.1 mm coronal to the anatomical apex. It was decided to define the reference point 'apical constriction' AC 1.1 mm coronal to the radiographic apex according to Guldener & Langeland (1993) and to use this reference for assessing radiologically the density of the root canal filling.

At the outset, it was not known whether or not the application of such powerful vacuum would produce discomfort or even pain to the patients. It was interesting to note that this was not the case. No patient received a local anaesthesia for the filling procedure and none reported any sensation or discomfort.

Recent opinons and literature (Buchanan 2008, Ng *et al.* 2008) indicate, that optimal root canal shaping should involve minimal preparation, in order not to weaken the tooth (risk of fracture) yet still allowing optimal irrigation/disinfection and filling flush to the canal terminus including all ramifications. NIT could be the ideal means to achieve this goal and, research and development of NIT should be continued, especially to overcome the difficulties for the clinical use of the NIT cleansing device.

Conclusions

This prospective Case Series demonstrated the performance of the NIT-obturation method *in vivo*. Root canals filled by the reduced-pressure method combined with gutta-percha cones exhibited good radiographic quality and periapical healing 5 years after root canal obturation.

Disclaimer

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References

Attin T, Buchalla W, Zirkel C, Lussi A (2002) Clinical evaluation of the cleansing properties of the noninstrumental technique for cleaning root canals. *International Endodontic Journal* **35**, 929–33.

Barthel CA, Oswald RJ, Pitts DL (1994) Dye penetration in root canals filled with AH 26 in different consistencies. *Journal of Endodontics* **20**, 436–40.

Buchanan S (2008) *Personal Communication. Switzerland: Universtity of Berne, January 30.*

Buckley M, Spangberg LS (1995) The prevalence and technical standard of endodontic treatment in an American subpopulation. *Oral Surgery, Oral Medicine, and Oral Pathology* **79**, 92–100.

Goldberg F, Artaza LLP, De Silvio AC (2002) Influence of calcium hydroxide dressing on the obtruation of simulated lateral canals. *Journal of Endodontics* **28**, 99–101.

Guldener PHA, Langeland K (1993) *Endodontologie. Diagnostik und Therapie. Stuttgart-New York: Georg Thieme Verlag, pp. 176–86.*

Lussi A, Imwinkelried S (2000) Long-term obturation quality using the non-instrumentation technology (NIT). *Journal of Endodontics* **26**, 491–3.

Lussi A, Nussbächer U, Grosrey J (1993) A novel non-instrumented technique for cleansing the root canal system. *Journal of Endodontics* **19**, 549–53.

Lussi A, Messerli L, Hotz P, Grosrey J (1995) A new non-instrumental technique for cleaning and filling root canals. *International Endodontic Journal* **28**, 1–6.

Lussi A, Suter B, Grosrey J (1996) *In-vivo*-Obturation von Wurzelkanälen mit der neuen Vakuumtechnik. *Endodontie* **3**, 189–94.

Lussi A, Suter B, Grosrey J (1997a) Obturation of root canals *in vivo* with a new vacuum technique. *Journal of Endodontics* **23**, 629–31.

Lussi A, Schroeder A, Hotz P, Stich H (1997b) Cleansing and obturation of the root canal system without conventional instrumentation. *Australian Endodontic Newsletter* **23**, 16–20.

Lussi A, Portmann P, Nussbächer U, Imwinkelried S, Grosrey J (1999a) Comparison of two devices for root canal cleansing by the non-instrumentation technology (NIT). *Journal of Endodontics* **25**, 9–13.

Lussi A, Imwinkelried S, Stich H (1999b) Obturation of root canals with different sealers using the non-instrumentation technology (NIT). *International Endodontic Journal* **32**, 17–23.

Lussi A, Suter B, Fritzsche A, Gygax M, Portmann P (2002) *In vivo* performance of the new non-instrumentation technology (NIT) for root canal obturation. *International Endodontic Journal* **35**, 352–8.

Ng YL, Mann V, Rahbaran S, Lewsey J, Gulabivala K (2008) Outcome of primary root canal treatment: systematic review of the literature - Part 2. Influence of clinical factors. *International Endodontic Journal* **41**, 6–31.

Portmann P, Lussi A (1994) A comparison between a new vacuum obturation technique and lateral condensation: an *in vitro* study. *Journal of Endodontics* **20**, 292–5.

Reit C, Gröndahl HC (1983) Application of statistical decision theory to radiographic diagnosis of endodontically treated teeth. *Scandinavian Journal of Dental Research* **91**, 213–8.

Ricucci D (2009) *Where Ends the Root Canal, Where Starts the Periodontium? Basel, Switzerland: Lecture, SSE Congress. Jan. 16th 2009*

Roane JB, Sabala CL, Duncanson MG Jr (1985) The ''Balanced Force'' concept for instrumentation of curved canals. *Journal of Endodontics* **11**, 203–11.

Saunders WP, Saunders EM, Sadiq J, Cruickshank E (1997) Technical standard of root canal treatment in an adult Scottish sub-population. *British Dental Journal* **182**, 382–6.

Stojan DA (2000) Penetration von Wurzelfüllungsmaterialien in die Dentintubuli. Ein Vergleich zwischen der Handaufbereitung und der maschinellen Aufbereitung (NIT). *Medizinische Dissertation*. Bern: Universität Bern.

Vande Voorde HE, Bjorndahl AM (1969) Estimating endodontic ''working length'' with paralleling radiographs. *Oral Surgery, Oral Medicine, and Oral Pathology* **27**, 106–10.

West JD (1987) Endodontic failures marked by lack of three-dimensional seal. *The Endodontic Report* Fall-Winter, 9–12.