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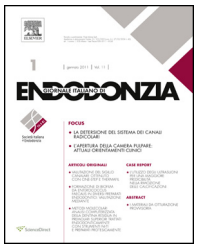

ORIGINAL ARTICLE/ARTICOLO ORIGINALE

Periapical healing after simplified endodontic treatments: A digital subtraction radiography study

Guarigione periapicale a seguito di trattamenti endodontici semplificati: studio con digital subtraction radiography

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KEYWORDS
Carrier-based systems;
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Abstract
Aim: To evaluate the 6-month outcome of endodontic treatment of periapical lesions with integrated systems by clinical examination and digital subtraction radiography (DSR).
Methodology: Eighty-four patients with chronic periapical pathosis were randomly allocated to two groups and received endodontic treatment with Revo-S/One Step Obturator (G1, $n = 41$) or GTX/GTX Obturator (G2, $n = 43$). Six months later, clinical examination and DSR analysis were performed. Non-parametric statistical methods were used ($p < 0.05$).
Results: Total healing, partial healing and failure occurred in 48.4%, 48.4% and 3.2% of cases in G1, in 50.0%, 43.8% and 6.2% of cases in G2, respectively. No significant difference was detected.
Conclusions: The integrated endodontic techniques allowed for a high 6-month success rate in both groups in accordance with literature data.

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PAROLE CHIAVE
Digital subtraction radiography;
Guarigione;
Paradentite periapicale;
Sistemi carrier-based;
Trattamento endodontico.

Riassunto
Obiettivi: Valutare la guarigione a sei mesi di lesioni periapicali trattate con sistemi endodontici integrati tramite esame clinico e digital subtraction radiography (DSR).
Materiali e metodi: Ottantaquattro pazienti con patologia periapicale cronica sono stati assegnati a due gruppi, trattati con Revo-S/One Step Obturator (G1, $n = 41$) o GTX/GTX Obturator (G2, $n = 43$). Dopo sei mesi sono stati eseguiti esame clinico e analisi DSR. L'analisi dei dati è stata condotta con test non parametrici ($p < 0,05$).
Risultati: Guarigione totale, parziale e fallimento si sono verificati rispettivamente nel 48,4%, 48,4% e 3,2% dei casi in G1, nel 50,0%, 43,8% e 6,2% in G2. Non è emersa differenza significativa.
Conclusioni: Le tecniche endodontiche integrate hanno consentito un elevato tasso di successo in entrambi i gruppi, in linea con i dati della letteratura.

Introduction

Radicular cysts and periapical periodontitis are common inflammatory odontogenic lesions of the jaws[1] and they arise as result of pulp necrosis and microbial root canal infection.[2–4] It is known that the healing of these lesions depends on proper mechanical and chemical removal of the infected endodontic content and three-dimensional canal obturation.[5]

Traditionally, the outcome of endodontic therapy has been assessed by means of clinical examination and periapical radiographs.[6] The endodontic success is reached when the following requirements are satisfied one year after the treatment: (i) absence of signs and symptoms, (ii) preservation of masticatory function, and (iii) normal radiographic appearance of the periodontal ligament width.[7]

Periapical radiographs have some shortcomings that can hinder the image reading. Radiograph misinterpretation may derive from the superimposition of three-dimensional structures on a two-dimensional plane, the interference caused by the maxillary sinus and root overlapping in case of multirooted teeth.[8,9] The introduction of the digital subtraction radiography (DRS) improved the ability to distinguish the variations of bone mineralization, with the capability of detecting quantitative and qualitative changes of bone structure after only 90–180 days.[8]

Among root canal filling techniques, several warm gutta-percha compaction methods and devices have been described. Carrier-based systems consist on a semi-rigid core coated with gutta-percha that matches the shape of the canal preparation. These systems were found to be less operator-dependent than the continuous wave of condensation technique when used by novices.[10] Nowadays, manufacturers of endodontic instruments promote a trend of technique simplification, offering systems characterized by fewer files and shape correspondence among the shaping, drying and filling instruments. Both Revo-S (Micro-Mega, Besançon, France) and GTX rotary files (Dentsply Tulsa Dental Specialties, Tulsa, OK, USA) have dedicated root-filling systems, namely, the One-Step Obturator (CMS Dental ApS, Copenhagen, Denmark) and GTX Obturator (Dentsply Tulsa Dental Specialties). The correspondence between nickel–titanium rotary riles and carrier-based filling instruments is an expression of classic techniques simplification and may be advantageous for clinicians.[11]

The aim of the present study is to compare by DRS and clinical examination the 6-month healing rate of chronic periapical lesions in patients treated with Revo-S/One-Step Obturator or GTX/GTX Obturator integrated techniques.

Materials and methods

All the patients involved in the study were informed on the purpose and methods of the experimentation. Each patient expressed his/her own agreement to join the study by signing a dedicated form and was free to leave the experimental project in every phase. All the experimental procedures were conducted in full accordance with the Helsinki Declaration (version 2008).

Eighty-four patients with a tooth without previous endodontic treatment presenting periapical chronic periodontitis were randomly assigned to two treatment groups. Rubber dam was used for field isolation in all treatments. A composite resin build-up restoration was performed if needed. The canals were scouted with a size 10K file (Dentsply Maillefer, Ballaigues, Switzerland) and the working length was determined by means of an electronic apex locator (Root ZX, Morita Co., Tokyo, Japan). The canal shaping and filling protocols were the following, according to the manufacturers indications:

- Group 1 (G1, $n = 41$). The canals were shaped with Revo-S (Micro–Mega) nickel–titanium rotary files in the following sequence: SC 1 (25/.06), SC 2 (25/.04), SU (25/.06), AS 30 (30/.06), AS, 35 (35/.06), AS 40 (40/.06). Apical enlargement was carried out with manual files according to the apical gauging. Canals were irrigated with 2 ml 5.25% sodium hypochlorite (Niclor 5, Ogna, Muggiò, Italy). Sterile paper points were used to dry the canal at the end of the shaping procedure. Canal walls were smeared with the sealer Sicura-Seal (Dentalica, Milano, Italy) with a size 15K file. An obturator of the One-Step Obturator system (CMS Dental ApS) corresponding to the apical preparation size was heated in the in the One-Step Obturator Oven (CMS Dental ApS), inserted into the root canal to working length and cut at the orifice level with a dedicated bur.
- Group 2 (G2, $n = 43$): The canals were shaped with GT Series X (Dentsply Tulsa Dental Specialties) nickel–titanium rotary files in the following sequence: 20/.04, 20/.06, 30/.04, 30/.06, 40/.06, 40/.08. Apical enlargement, canal

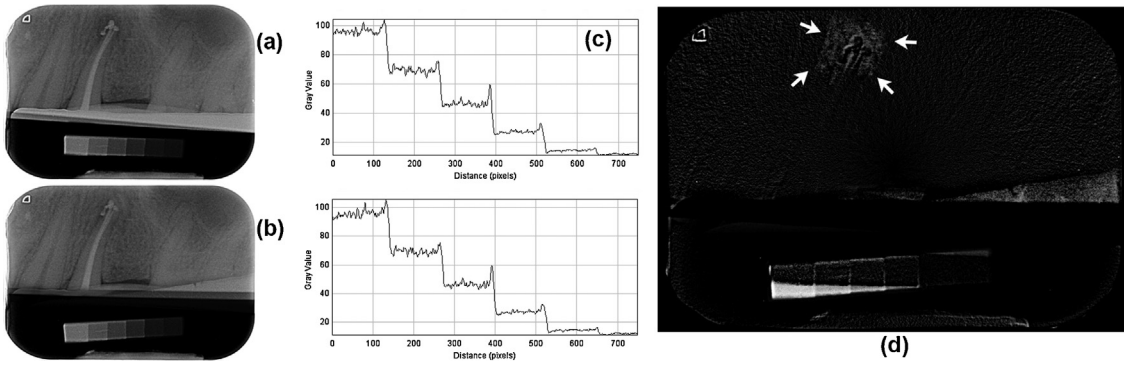

Figure 1 Digital subtraction of radiographic images: (a) postoperative radiography at baseline; (b) radiographic control after 6 months; (c) equalization of the two histograms representing the mean gray level measured on the reference scales; (d) product of the imagine subtraction, arrows indicate the mineralization area of newly formed bone.

irrigation and drying were the same as G1. The Pulp Canal Sealer (SybronEndo, Orange, CA, USA) was placed at the canal orifice with a size 15K file. An obturation procedure similar to G1 was performed, but making use of GT Series X Obturators and Thermaprep oven (Dentsply Tulsa Dental Specialties).

The radiographic protocol consisted on two periapical radiographs: the postoperative control (t_0) and a second radiograph after 6 months (t_1). In order to have reproducible film position at the two experimental time points, the bite-block of a Rinn film mount (Dentsply Rinn, Elgin, IL, USA) was adapted to act as impression tray for silicon occlusal registration (Optosil putty, Heraeus Kulzer, Hanau, Germany). The digital films (Durr Dental, Bietighein-Bissingen, Germany) were exposed to the same X-ray source (2200 Intraoral X Ray System, Kodak Dental Systems, Rochester, NY, USA) set at 70 kV, 8 mA, 0.20 s. An aluminum scale presenting steps that were 8, 6, 4, 3, 2 and 1 mm high was included in the radiographs according to the protocol described by Benfica et al.[8]

The analysis of digital images was carried out by means of two computer programs: Adobe Photoshop CS (San Jose, CA, USA) and ImageJ (U.S. National Institutes of Health, Bethesda, Maryland, USA, http://imagej.nih.gov/ij/, 1997—2011). Gamma and contrast correction of the images taken at baseline and after 6 months were equalized according to the 8-bit gray-value arbitrary units histograms measured on the scale (0 = black, 255 = white). The two corrected images were superimposed and underwent digital subtraction.[12] The resulting images were assessed to identify remineralization areas inside the periapical radiolucencies (Fig. 1). The scoring method described by Katebzadeh et al.[13] was adopted:

1. Healed: normal trabecular bone aspect and periodontal ligament width.
2. Improved: reduction of lesion size.
3. Failed: bigger or unchanged lesion.
4. X: unreadable radiograph due to technical errors.

Before starting the treatment and at the 6-month recall, tooth vertical percussion test and palpation in the vestibular fold near the apical region of the root tips were also performed and registered as binary data (presence/absence).

Collected data were analyzed with statistical software (Statistical Package for Social Sciences v15.0, SPSS Inc., Chicago, IL, USA). The experimental groups were tested for the homogeneity of the baseline parameters (age, number of canals per tooth, maximum apical diameter, positivity to percussion and palpation) with the Mann—Whitney and Chi-squared tests. The same tests were used to assess the significance of the differences between the groups in terms of radiographic score and clinical examination (percussion and palpation), respectively. The value of α was set at 0.05.

Results

The patients' preoperative data, the outcome of clinical tests and the radiographic scores are summarized in Table 1. No differences were pointed out in terms of age, number of canals per tooth, maximum apical diameter, response to percussion and palpation preoperative tests. Of the 84 patients enrolled for the study, 63 (75%) attended controls. The radiographic success rate was: in G1, healing 48.4%, improvement 48.4% and failure 3.2%; in G2, healing 50.0%, improvement 43.8% and failure 6.2%. Only one patient per group was found to be positive to clinical tests after 6 months and both were scored as radiographic failure. No significant differences between groups in terms of radiographic score and positivity to clinical tests came forth from the statistical analysis.

Discussion

The statistical analysis of the baseline parameters did not identify any significant difference between experimental groups, thus attesting that the randomization process had been carried out effectively. The failure of endodontic treatment is the result of a microbial infection.[14] Areas of uninstrumented root canal wall, infected dentin tubules and voids in the root filling permit the survival of bacterial biofilm.[15] A great amount of scientific literature has been produced on the success of the endodontic treatment, but there is a remarkable variability of reported success rates.[16] The assessment methods for endodontic success used in the studies on human subjects involve clinical and radiographic examinations, but they are often different and not standardized. The success rate that can be drawn ranges from 75 to 97%.[6,15—19] These data are extracted from retrospective

Table 1 Anamnestic variables, endodontic data, clinical and radiographic parameters registered at baseline and after 6 months: comparison between groups.

	Age (y)	No. of canals per tooth (*n*)	Maximum apical diameter (mm)	Vertical percussion test at baseline (%)		Palpation test at baseline (%)		Vertical percussion test after 6 months (%)		Palpation test after 6 months (%)		Radiographic score (*n*)			
				+	−	+	−	+	−	+	−	1	2	3	4
G1	41.9 ± 16.6	2.0 ± 1.1	0.35 ± 0.06	5	95	10	90	3	97	3	97	15	15	1	0
n_b = 41															
n_{6m} = 31															
G2	45.1 ± 17.7	2.0 ± 1.0	0.37 ± 0.06	12	88	7	93	3	97	3	97	16	14	2	0
n_b = 43															
n_{6m} = 32															
Diff.	p = 0.405	p = 0.720	p = 0.203	p = 0.263		p = 0.645		p = 1.000		p = 1.000		p = 1.000			

n_b, sample size at baseline; n_{6m}, sample size after 6 months; Diff., statistical significance of difference between groups.

studies or reviews of the literature, where the success rates obtained in teeth with or without periapical disease are not always distinguished. A study comparing the outcome of endodontic treatments performed with nickel–titanium rotary instruments and Thermafil technique reported success rates of 94.4% in teeth without periapical lesion and 48.2% when the lesion was present.[20] According to Ng et al.,[21] the endodontic success is 8–13% lower in case of periapical radiolucency compared to the treatment of teeth with healthy periodontum. If one considers only the radiographic scores of complete healing, the present study found that the success rate were 48.4% in the group treated with Revo-S/One Step Obturator system and 50.0% in the GTX/GTX Obturator group. However, it is reasonable to suppose that at least a part of the improved periapical conditions could be expression of an ongoing healing process that has not ended yet. With this in mind, the findings of the present study have the potential to reveal success rates around 96% in G1 and 94% in G2; nevertheless, extending the follow-up time for these cases remains mandatory. In the present study, similar success rates were found regardless of the treatment protocol.

The nickel–titanium rotary files chosen for this study were selected because they are manufactured by following modern concepts and are offered with a dedicated carrier based-system, which tends to reduce the operator dependence. GTX instruments are the evolution of the GT rotary files. The manufacturer claims that the new cutting-edge design with coil angulation and variable radial planes can increase the cutting efficiency of the instrument. GTX files are constituted of M-Wire alloy, which is obtained through a series of thermic treatments with the intent to grant improved mechanical properties. There is still concern about this issue; in fact, the early studies did not find any significant increase of resistance to cyclic fatigue[22] and torsional stress,[23] whereas more recent works reported greater resistance to flection[24] and torsion[25] and prolonged cyclic fatigue life[26] when compared with GT files. Revo-S instruments are characterized by an asymmetric section with three different radii that generates as many cutting edges. This feature would make the activated instrument move inside the canal with a snake-like motion that, in the manufacturer's opinion, allows for better removal of dentin debris. Revo-S instruments have been introduced recently and only few studies have tested them. Basrani et al.[27] found that their prolonged use did not affect their fracture resistance under torsional stress. The incidence of dentinal microcrack formation associated with Revo-S files was lower than HERO Shaper (Micro-Mega), Twisted File (SybronEndo) and ProTaper (Dentsply Maillefer).[28] Recent studies on Revo-S files demonstrated their ability to maintain the original canal curvature assessed by cone-beam computed tomography[29] and a tendency to apical extrusion similar to manual files.[30]

Mirfendereski et al.[10] demonstrated by micro-computed tomographic analysis that a carrier-based technique, presenting similar characteristics to the systems tested in the present study, can produce a significant lower amount of voids in the apical 6 mm of the canal than the continuous wave of condensation technique. The root filling ability of Thermafil, forerunner of current carrier-based systems, has been largely investigated under several experimental conditions. It was found that Thermafil presents similar or superior

filling and sealing ability to cold lateral condensation and continuous wave of condensation technique.[31–33]

The DSR method was useful for the identification of radiographic changes of periapical lesions after 6 months. The examined endodontic techniques allowed healing rates nearly of half of the patients at the end of the observation period. Despite only three cases of failure, the improvement of clinical and radiographic parameters can be interpreted as an incomplete healing process. For these reasons, the follow-up time should be prolonged for near the half of the patients. A potential shortcoming of DSR analysis is that the images to be subtracted must be acquired very accurately at different experimental time points.[34] The effectiveness of this analysis strictly depends on the reproducibility of the radiograph regarding contrast, brightness and geometrical distortion.[12] The use of the long cone paralleling technique with an impression on the biteblock of film mount has been advocated to optimize image quality and reduce distortion.[35]

Cone-beam computed tomography is a recent alternative method whose high diagnostic sensibility has been already reported.[36] This analysis is unfortunately not free from disadvantages for the clinician, e.g. the generation of artifacts when metallic prostheses are present and the irradiation of the patient with a relatively higher radiation dose than conventional radiographs.[8]

The present study unveils the possibility to identify by DSR early bone tissue mineralization. That is a potential advantage from a clinical point of view, because it would be possible to anticipate the definitive rehabilitation of teeth with uncertain prognosis.

Conclusions

Within the limitation of the present study and bearing in mind that the registered success rates are consistent with the data available in literature, the considered integrated systems for endodontic treatment represent a valid alternative to traditional techniques, especially for their simplicity of use. The DSR method allows an early detection of bone remineralization and this can constitute an advantage for the anticipation of the final tooth restoration.

Clinical relevance

The shaping and filling examined systems have the potential to reduce the clinical therapeutic times and technical difficulties because they simplify the treatment techniques. At the same time, they allowed for high 6-month success rates.

Conflict of interest

The authors declare no conflict of interest.

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