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In vivo evaluation of periodontal microcirculatory changes associated with endodontic treatment

ABSTRACT

Aim *The purpose of this study was to investigate in vivo the gingival microcirculatory changes associated with endodontic treatment using the continuous wave of condensation technique.*

Materials and methods *Twenty necrotic one canal roots of 20 cooperative patients of both sexes, aged between 20 and 43 years, were selected. All patients were examined by capillaroscopy before, immediately after endodontic treatment, and after 7 days. The last examination was carried out by the same operator, and repeated twice for each examined area: masticatory, buccal and labial mucosa corresponding to the endodontically treated root. All canals were prepared using a simultaneous technique with Ni-Ti files (MTwo files).*

Results *The images of the masticatory mucosa after root canal obturation showed evident micro-areas of extravasation, with significant bleeding and angio-morphological alterations due to heat. One hour after the endodontic treatment evident extravasation was observed, but a decrease of all altered parameters, was present. After seven days from treatment, in the periodontal tissues, a complete healing was observed. The in vivo evaluation of the vascular pattern during root canal obturation with System B showed that the high temperature in the canal determines visible effects on the vasculature of adjacent sites. It was found that microangiotectonic alterations decrease up to a complete healing after 7 days from treatment.*

Conclusion *All the changes in microcirculation, due to thermal shock of periodontal tissues, are reversible.*

Keywords *Capillaroscopy; Endodontic treatment; Periodontal microcirculation.*

Introduction

The ultimate aim of the endodontic treatment is a three-dimensional obturation of the root canal space [Schilder, 1967]. Several studies have shown that an inadequate sealing of the apex is one of the main causes of failure [Schilder et al., 1981; Hoen and Pink, 2002]. Gutta-percha, in conjunction with a sealer, is the preferred combination as filling material even though the sealer may be soluble and not dimensionally stable over time. Warm vertical compaction of gutta-percha minimises the amount of sealer compared to lateral condensation [Buchanan, 1994; Kulild et al., 2007; Diemer et al., 2006].The original warm vertical compaction technique [Schilder, 1967] was modified by Buchanan [Buchanan, 1994] who introduced the single continuous wave of thermoplasticised gutta-percha using a System B heat source unit. Tapered heat source pluggers, similar to the canal, have the potential to allow good adaptation of the root filling material to the canal wall thus reducing the amount of sealer to a thin layer between dentine and gutta-percha mass [Buchanan, 1994]. Many studies have reported on the transfer of intracanal heat to the root surface during warm gutta-percha obturation techniques. Concern has been expressed in the literature about both short and long-term harmful effects of excessive intraradicular heat on the tooth supporting structures as possible changes in the periodontal microcirculation during warm gutta-percha obturation techniques. The amount of heat transferred to the root surface and lateral periodontium has not been reported using this continuous heat source within the root canal. It is possible that the heat generated by this system will not only be conducted through the gutta-percha cone, but also through the dentin and attachment apparatus. The dentin thickness between the canal and external root surface, especially after canal instrumentation, tends to affect temperature transmission to the root surface [Kulild et al., 2007; Diemer et al., 2006; Goodman et al., 1981; Villegas et al., 2005; Gharai et al., 2005].

Capillaroscopy is a non-invasive diagnostic technique that allows the study of the peripheral circulation and vascular microangiopathy as manifestations of many diseases [Scardina et al., 2007a; Scardina et al., 2007b; Scardina and Messina, 2006; Scardina et al., 2006; Scardina, 2005;Scardina et al., 2005; Scardina and Messina, 2004]. It is a means for in vivo study of oral microcirculation and it can be applied to all diseases with an altered anatomical and functional microcirculation.

The purpose of this study is to investigate *in vivo*, by capillaroscopic examination, the gingival microcirculatory changes associated with endodontic treatment using the continuous wave of condensation technique.

Materials and methods

Twenty necrotic canals from 20 cooperative patients of both sexes, aged between 20 and 43 years old, were included. The research was conducted in adults because children refused therapy seeing the videocapillaroscope. All patients underwent videocapillaroscopic examination before endodontic treatment, after one minute, one hour and also after 7 days. The examination was carried out by the same operator (GAS), at the same conditions: temperature 23°C, light 6500°K, patient in a sitting position. Each examination was repeated twice for each examined area: masticatory, buccal and labial mucosa correspondence of the treated root. The use of anaesthetic with vasoconstrictor was avoided because of its potential to alter normal microcirculation and therefore influence the videocapillaroscopic examination. The videocapillaroscope used (Videocap 100 of DS Medica, Milan, Italy) exploits the technique of optical capillaroscopy and is constituted by a central body, which contains the illumination source and the digitising system of the optical data, a cord, an optical fiber and an intraoral probe (type "contact" optical, 200x, focus from 0 to 2 mm). The capillaroscope was interfaced to a PC running a dedicated software (Videocap 8.0), which allows to process the images. The measurements on capillaroscopy images were performed by computer and the results were then rechecked by two different operators. All canals were prepared by a simultaneous technique with Ni-Ti files (MTwo). Each canal was obturated using the continuous wave of condensation technique. A fine-medium plugger tip was used on the System B HeatSource model 1005 and the power level was set to 10 (250°C).

The capillaroscopic examination included the following nonparametric data:

1) visibility of capillary loops;
2) orientation of the capillary loops with respect to the surface;
3) presence or absence of micro-haemorrhages;
4) characteristics of the capillary loops (morphological parameters).

Parametric data were the number of visible capillary loops per mm^2. All non-parametric and parametric evaluations were obtained by capillaroscopic images of the masticatory, buccal and labial mucosa of the treated teeth. The statistical analysis was performed using the Mann-Whitney test, with significance value set at $P \leq 0.05$. The data were analysed using the software PAST (ver. 1.92, January 2011, Øyvind Hammer, DAT Harper and PD Ryan). The acquired data refer to the average value of the measurements for each preset parameter.

Results

The study showed the following statistically significant data for the capillary density of the masticatory mucosa in correspondence of the treated root canal ($P < 0.05$).

- Step 1, pre-treatment: mean capillary density (55 ± 13.22 loop/mm^2) (Fig. 1).
- Step 2, 1 minute after endodontic treatment: mean capillary density (27.33 ± 3.38 loop/mm^2) (Fig. 2).
- Step 3, one hour after endodontic treatment: mean capillary density (73 ± 14.88 loop/mm^2).
- Step 4, 7 days after endodontic treatment: mean capillary density (55 ± 9.77 loop/mm^2) (Table 1, 2).

Discussion and conclusion

Several parameters influence the heating of gutta-percha during vertical compaction, because canal systems are complex and narrow. Some factors are more important than others such as dentine thickness, residual roots dimension and periradicular blood circulation. The various influences related to the heating of guttapercha can be classified as follows: mechanical, physical, chemical and biological [Venturi et al., 2002].

Many problems may arise during warm vertical compaction techniques, especially in small canals, because it can be difficult to obtain real thermal effects on the apical portion of the root canal filling materials. It has been demonstrated [Goodman et al., 1981] that an increase of 4°C of the apical gutta-percha (over the body temperature of 37°C) is the ideal level to obtain the correct softening for an excellent compaction. The suggested working temperature for the System B heat source unit, using the smallest tip at a distance of 5-7 mm from the apex, is 185°C [Buchanan, 1994]. In this study, a different temperature setting was selected (250°C) because previous studies reported that the temperature read on display was inaccurate, and often higher than the true temperature on the tip [Venturi et al., 2002]. This *in vivo* study by capillaroscopic examination of the periodontal microcirculation, evaluated all changes associated with the endodontic treatment using the continuous wave of condensation technique. The use of videocapillaroscopy, before, immediately after, one hour, and 7 days after endodontic treatment, allowed us to evaluate the changes in the oral microcirculation at the the examined sites. One minute after endodontic treatment, all capillaries of the masticatory mucosa appear increased in density. Haematic extravasation of small capillaries is visible, usually a pin-head-sized hemorrhage becomes larger and haemorragic areas are visible. This is due to the transmission of the intense heat developed by System B that goes through dentin, cementum, alveolar bone, and consequently to the masticatory mucosa. The microcirculation of the masticatory mucosa appears morphologically altered. There are large areas of vasodilation similar to microhaemorrhages likely due to thermal stress. On the buccal aspect of non-adherent mucosa, after obturation with gutta-percha, capillaries appear shorter and more tortuous, and the presence

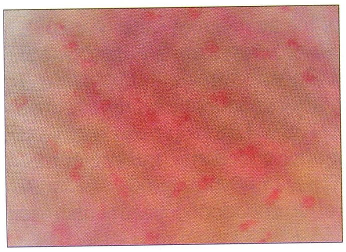

FIG. 1 Capillaroscopic analysis of gingival mucosa before endodontic treatment (t0) (Magnification 200X).

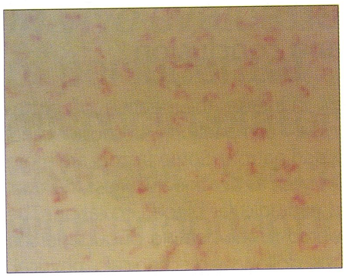

FIG. 2 Capillaroscopic analysis of gingival mucosa after endodontic treatment (t1): increased density is appreciable (magnification 200x).

STEP	Mean capillary density (loop/mm²)
1	55±13.22
2	27.33±3.38
3	73±14,88
4	55±9.77

TABLE 1 Mean capillary density on masticatory mucosa of endodontically treated teeth.

STEP	1	2	3	4
1	-	S	S	NS
2	S	-	S	S
3	S	S	-	S
4	NS	S	S	-

TABLE 2 Significance (S / NS) of the differences in capillary density in the different phases of the endodontic treatment. It is considered statistically significant (S) a difference with P <0.005.

of these small areas of extravasation is probably due to transmission of heat to the area surrounding the treated site. The microcirculation of the buccal mucosa is altered, in fact there is vasodilatation and increased capillary density. After one hour from the endodontic treatment, extravasation is still evident, but there is a progressive reduction of the phenomenon of angioectasia and capillary density. On the buccal mucosa, one hour after the endodontic treatment, capillaries appear short and crooked. After one week from the endodontic treatment a complete recovery can be observed, with little signs of residual extravasation on the masticatory mucosa. Capillary density returns to normal level in line with the pre-treatment values.

The use of videocapillaroscopy allowed to appreciate that after one minute from the endodontic treatment a significant decrease of the density in correspondence with the masticatory mucosa ($P \leq 0.005$) is present, justified by the fact that the capillaries tend to appear together and form an unique capillary area similar to a microhaemorrhage. One hour after endodontic treatment there is a significant increase in density that occurs after the insult caused by the abrupt increase of heat due to the introduction of the plugger into the root canal. Within an hour the effect starts to diminish and the capillaries resume a normal density through this transition. The evaluation at seven days shows the return of a normal capillaroscopic image from the morphological and parametric point of view, and only small areas of extravasation remain.

In conclusion it can be said that the endodontic treatment with the use od System B determines transient and reversible changes, without permanent changes of the microcirculation except for sparse and minimal areas of extravasation, which probably tend to completely, though slowly, disappear. The present research shows that the endodontic treatment using the continuos wave of condensation technique does not determine microcirculatory damage and that it can be used in pediatric dentistry with absolute safety.

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