

Evaluation of Periapical Healing Outcomes of Single-visit Non-surgical Endodontic Retreatment of Teeth with Apical Periodontitis in Patients with Type 2 Diabetes Mellitus: a Retrospective Study

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Objective: To compare the results of non-surgical endodontic retreatment (NSER) applied in a single visit between type 2 diabetes mellitus (DM) patients with teeth with apical periodontitis (AP) and healthy individuals.

Methods: The subjects enrolled were divided into two groups. The type 2 DM group was composed of 26 single-rooted mandibular teeth belonging to 26 patients (aged 45.04 ± 10.13 years; 19 women and 7 men) who did not have any other systemic disease. The control group, meanwhile, consisted of 27 single-rooted mandibular teeth from 27 patients (aged 37.78 ± 12.61 years; 15 women and 12 men) with no systemic disease. Both groups received single-visit non-surgical endodontic retreatment. Periapical radiographs were taken with a parallel technique before NSER and at least 6 months after treatment. Periapical index scores (PAI) for the relevant teeth were recorded. The data obtained were analysed statistically. $P < 0.05$ was considered significant.

Results: In both groups, postoperative PAI values decreased compared to the initial values after NSER treatment applied in a single visit ($P < 0.05$); however, there was no significant difference in the change in PAI values over time between the control and type 2 DM groups ($P > 0.05$). There was also no significant difference in healing between men and women in both groups ($P > 0.05$).

Conclusion: Following single-visit NSER in teeth with apical periodontitis, similar treatment outcomes were achieved in patients with type 2 DM and healthy individuals.

Keywords: diabetes mellitus, endodontic treatment, periapical index

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The biological mechanisms involved in the repair of periapical tissues after endodontic treatment are significantly affected by genetic and systemic factors with regard to the patient's health status (for example age, nutrition, stress, hormones, vitamin intake, hydration

status and diabetes, cardiovascular diseases, osteoporosis and smoking habit).^{1,2} Diabetes mellitus (DM) is a chronic metabolic disease characterised by impaired insulin secretion or utilisation, leading to a state of chronic hyperglycaemia.³ DM affects various functions of the immune system, making the patient more vulnerable to chronic inflammation, progressive tissue damage and reduced tissue repair, and type 2 DM constitutes 85% to 90% of DM cases.⁴ Apical periodontitis (AP) is a chronic inflammatory lesion that originates from the pulp and affects the periapical tissues. It has been reported that AP occurs as a result of missed root canals, the presence of persistent microorganisms in the canal, low radiographic quality of existing root canal treatment, low quality of the existing coronal restoration,

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$\alpha = 0.05$ and $b = 0.80$. It was determined that 23 teeth per group was statistically sufficient for the present study.

Inclusion criteria

- teeth with a single root and a single canal;
- teeth with adequate quality root canal filling after NSER and ending in the apical 2 mm¹⁵;
- teeth without instrument fractures and calcified canals;
- teeth without compatibility problems in permanent restorations¹⁶;
- teeth with standard periapical radiographs taken using the parallel technique with the same intraoral X-ray device (Kodak 2100 230V; Carestream Health, Rochester, NY, USA) and parameters (60 KVP, 6 mAs), and of sufficient quality that the tooth and surrounding tissues be clearly displayed without artefacts, superposition or image distortion;
- teeth with follow-up periapical radiographs taken at least 6 months after NSER;
- teeth with a periapical lesion diameter of less than 5 mm.

Teeth that met abovementioned conditions¹⁷ could be included in the study. Patients needed to be periodontally healthy and non-smokers, generally healthy or have no systemic disease other than controlled type 2 DM characterised by an HbA1c level below 7%.¹⁸

Subjects were divided into two groups. The type 2 DM group was composed of 26 mandibular teeth from 26 type 2 DM patients (45.04 ± 10.13 years; 19 women and 7 men), whereas the control group included 27 mandibular teeth from 27 patients (37.78 ± 12.61 years; 15 women and 12 men).

Ethical considerations

Clinical procedure

All teeth were treated by the same endodontist and following the same protocol outlined below. Local anaesthesia (Ultracain DS Ampoule; Sanofi Aventis, Paris, France) was applied, and after rubber dam insulation, the entrance space was prepared. Previous root canal fillings were removed using an endodontic motor (WDV Gold, VDW, Munich, Germany) and ProTaper Retreatment Universal files (Dentsply Sirona, Charlotte, NC, USA). Apical patency was checked with a #10 K-type hand file (Dentsply Sirona), and working length was determined with an electronic apex locator (DTE III, Woodpecker, Guangxi, China), then confirmed by peri-apical radiographs. All root canals were prepared using ProTaper Next files (Dentsply Sirona) and the endo-

The sample size was based on a previous study of similar design,¹⁴ with a power calculation performed to determine the required sample size (G*Power 3.1 software; Heinrich Heine University, Düsseldorf, Germany), with

Table 1 Follow-up period and demographic data of control and DM groups.

Group	n	Age (y)			Follow-up period (mo)			Sex	
		Minimum	Maximum	Mean $\pm$ SD	Minimum	Maximum	Mean $\pm$ SD	Female	Male
Control	27	18	63	37.78 $\pm$ 12.61	6	48	16.85 $\pm$ 10.98	15	12
DM	26	29	65	45.04 $\pm$ 10.13	6	48	23.57 $\pm$ 25.55	19	7

SD, standard deviation.

Table 2 Preoperative PAI values in control and DM groups.

Group	PAI 1	PAI 2	PAI 3	PAI 4	PAI 5
Control	0	0	3 (33.3%)	10 (58.8%)	14 (51.9%)
DM	0	0	6 (66.7%)	7 (41.2%)	13 (48.1%)

dontic motor according to the manufacturer's instructions. The size of the master apical file was determined specifically for each root canal based on the initial canal size. After each file change, the canals were irrigated with 2 ml 2.5% NaOCl (Mikrovem, Istanbul, Turkey). For final irrigation of the root canals, 5 ml 17% ethylenediaminetetraacetic acid (EDTA; Imicryl, Konya, Turkey), 5 ml distilled water and 5 ml 2.5% NaOCl were used, respectively. All irrigation procedures were performed with a 30 G lateral vented needle (NaviTip; Ultradent, South Jordan, UT, USA). The root canals were dried and filled using the cold lateral compaction technique with gutta-percha cones (Dentsply Sironar) compatible with the file system used and epoxy resin-based root canal sealer (AH Plus; Dentsply Sirona). The permanent restoration was completed using the one-step self-etch adhesive G-Premio Bond (GC Corporation, Tokyo, Japan) and composite resin (3M ESPE, Seefeld, Germany).

Periapical conditions were scored with the PAI by awarding points from 1 to 5 to the periapical radiographs of the relevant teeth of the patients who were followed for at least 6 months before and after NSER.¹⁹ PAI scoring was performed by two independent endodontist observers for each group. In cases where there was inconsistency between the observers' scores, a consensus was reached by reevaluation (overall correlation coefficients for inter- and intra-observer reliability were 0.854 and 0.802). Treatment results were classified as "healing" (PAI < 3) or "not healing" (PAI $\geq$ 3) according to periapical radiographic criteria.¹¹

Statistical analysis

Data from the current study were analysed with SPSS v. 23 (IBM, Armonk, NY, USA). The suitability of the data for normal distribution was examined with a Shapiro-Wilk test. A Wilcoxon test was used to evaluate PAI change within the groups, and a chi-square test was employed to compare PAI change between groups. Chi-squared and

McNemar-Bowker tests were used to evaluate intra- and inter-group PAI changes according to sex. The level of statistical significance was set at $P < 0.05$.

Results

The demographic data and follow-up period for the patients included in the study are shown in Table 1.

There was no significant difference in the distribution of PAI values before the NSER procedure in the control and type 2 DM groups ($P > 0.05$) (Table 2). Postoperative PAI values were found to decrease compared to baseline after NSER applied in a single visit in both groups ($P < 0.05$) (Table 3 and Fig 1). There was no significant difference in the change in PAI values over time between the control and type 2 DM groups ($P > 0.05$).

No significant difference was detected between men and women in the change in PAI values after NSER in a single visit in either of the groups ($P > 0.05$) (Table 4). No significant difference was detected in the time-dependent change in PAI values in both men and women after NSER in a single visit between the control and type 2 DM groups ($P > 0.05$) (Table 5).

Discussion

The relationship between the patient's general health status and the aetiology of apical periodontitis and the periapical healing process in endodontically treated teeth has long been discussed in the literature.²⁰⁻²² It is reported that DM, which affects patients' general health status and is becoming increasingly common all over the world, is an important factor in both the success and aetiology of root canal treatment.²⁰ According to the results of the present study, the null hypothesis was accepted because there was no difference in the healing status of periapical tissues and treatment success after NSER applied in a single visit between individuals with type 2 DM and systemically healthy individuals.

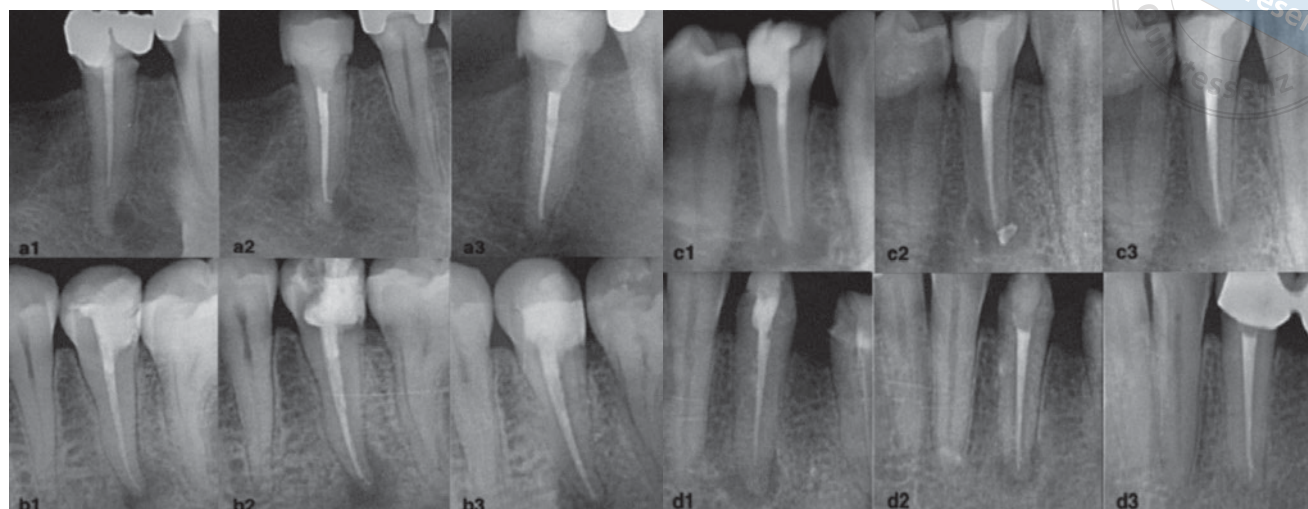


Fig 1 Four cases of radiographic follow-up of periapical status before and after NSER in type 2 DM patients (a and b) and healthy individuals (c and d). Preoperative (a1, b1, c1, d1); postoperative (a2, b2, c2, d2); 12-month follow-up after NSER (a3, c3); 24-month follow-up after NSER (b3); 18-month follow-up after NSER (d3).

Table 3 Postoperative PAI values in control and DM groups.

Group	PAI 1	PAI 2	PAI 3	PAI 4	PAI 5
Control	17 (51.5%)	3 (37.5%)	3 (50.0%)	4 (66.7%)	0
DM	16 (48.5%)	5 (62.5%)	3 (50.0%)	2 (33.3%)	0

Table 4 Time-dependent change in PAI values according to sex in the control and DM groups.

Group		Sex			P value
		Male	Female	Total	
Control	Healed	7 (70%)	13 (76.5%)	20 (74.1%)	0.525
	Not healed	3 (30%)	4 (23.5%)	7 (25.9%)	
DM	Healed	7 (100%)	14 (73.7%)	21 (80.8%)	0.177
	Not healed	0	5 (26.3%)	5 (19.2%)	

Table 5 Time-dependent change in PAI values according to sex between the control and DM groups.

Variable		PAI		P value
		PAI 1–2	PAI 3–5	
Sex	Female	27 (65.9%)	9 (75%)	0.621
	Male	14 (34.1%)	3 (25%)	

Short- and long-term success results of endodontic treatment were evaluated, and the age, sex and general health conditions of the patients included in the study affected the study results.^{23–25} The healing process of endodontic treatment may slow down due to patients' age, malnutrition and the increased incidence of systemic diseases such as age-related diabetes.^{26,27} Considering all these factors, patients between the ages of 18 and 65 years were included in the present study, and as a result of the statistical analysis, it was determined that there were similarities between the groups in terms of sex distribution and mean age.

It has been reported in the literature that factors such as tooth type, preoperative lesion size and number of visits also affect endodontic treatment results.^{12,28} Ng et al²⁹ reported that success rates were higher in teeth with a lesion size smaller than 5 mm than in those with a lesion size larger than 5 mm. In contrast, another study reported that there was no significant difference between lesion sizes and success rates.³⁰ In the present study, teeth with a lesion size of less than 5 mm were included to ensure standardisation and that the study results were not affected by the lesion size. Another factor that is said to affect the outcome of endodontic treatment is tooth

type. Periapical radiographs provide two-dimensional imaging; thus, superimpositions of molar tooth roots in the evaluation of endodontic treatment results may affect the study results.³¹ For this reason, the present study was conducted on single-canal mandibular teeth to ensure standardisation and that the results were not affected by changes in the root canal anatomy.

Over time, it has been reported that endodontic treatment can be completed successfully in a single visit, with the development of techniques that facilitate and accelerate treatment for physicians and patients, the use of irrigation activation methods and the production of new instruments. For this reason, endodontic treatment performed in a single visit has become popular in recent years.³² Some studies report that there is no difference in complications occurring during treatment, postoperative pain level or success rates when endodontic treatment applied in a single visit is compared with treatment applied in multiple visits.^{33,34} In line with this information, the NSER procedure was performed in a single visit in the present study; however, it is important for patients to attend a control appointment at least 6 and 12 months after the end of treatment. Clinical and radiographic follow-ups performed within the reported period make it possible to evaluate the obturation quality, coronal seal and tissue response in the periapical region.³⁵ Thus, patients with a minimum of 6-month follow-up radiographs were included in the present study.

As a result of this study, it was determined that PAI values decreased compared to initial values after NSER performed in a single visit in both the control and type 2 DM groups. This shows that healing occurred in the periradicular tissues in both groups after treatment. In contrast, Wang et al³⁶ evaluated the long-term prognosis of NSER treatment in patients with DM and reported that DM was an effective factor in related tooth loss. According to this study, type 2 DM was determined to be an important risk factor for tooth extraction due to negatively affecting NSER results. Supporting the present findings, Uğur Aydın et al³⁷ evaluated the results of endodontic treatment applied to the molars of healthy patients and those with type 2 DM using fractal analysis. They reported that the size of the apical lesion decreased after root canal treatment in both the type 2 DM and control groups, and the fractal size in the lesion area increased due to healing.³⁷ Similarly, Rudranaik et al³⁸ reported that there was no difference in time-dependent change in PAI after primary endodontic treatment applied in a single visit in controlled and uncontrolled type 2 DM patients with teeth with AP whose HbA1c values were measured. Based on the

results of this study, the clinical and radiographic healing results of single-visit endodontic treatment were delayed in patients with uncontrolled type 2 DM.³⁸ In the present study, healing rates were found to be 74.1% in the control group, 80.8% in the type 2 DM group and 77.4% in total at the end of the follow-up periods. Similar success rates may have been observed in the type 2 DM group as a result of the effective application of the chemomechanical preparation technique, ensuring rubber dam isolation, eliminating microorganisms by applying the same irrigation protocol, and achieving coronal and apical sealing.

No difference was found between the type 2 DM and control groups in terms of time-dependent change in PAI scores. In contrast to these findings, Arya et al³⁹ reported that periapical healing after endodontic treatment in mandibular teeth with periapical lesions (size $\geq 2 \text{ mm} \times 2 \text{ mm}$) was less in individuals with type 2 DM (43%) than in healthy individuals (80%) over a 1-year period. Fouad and Burleson⁴⁰ reported that the success of primary endodontic treatment in individuals with type 2 DM was lower than in healthy individuals after a 2-year follow-up. The present authors believe that the differences in the study results are due to differences in factors such as lesion size, tooth group and treatment procedure, which are among the factors affecting the success of endodontic treatment. In contrast to these findings, Ferreira et al¹⁴ reported that the success rate of endodontic treatment is similar in healthy individuals (80%) and individuals with type 2 DM (62%), which also supports the present results. In a retrospective study, Uğur Aydın et al³⁷ reported that there was no difference in the time-dependent change in PAI in mandibular molars between healthy individuals and individuals with type 2 DM after primary endodontic treatment. Cheraskin and Ringsdorf⁴¹ evaluated the primary endodontic treatment results for patients with low and high plasma glucose levels and reported that periapical lesions healed at a higher rate in the group with low plasma glucose levels over the 30-week follow-up period. Since type 2 DM patients whose plasma glucose levels were regulated by drug treatment were included in the present study, the present authors do not think there is any difference between the control group and the type 2 DM group; however, advanced glycation end products and metabolic conditions were associated with larger periapical lesion sizes and more severe alveolar bone resorption in patients with type 2 DM.^{42,43} In order to ensure standardisation, however, patients with lesions smaller than 5 mm were included in the present study. This may have been effective in patients with type 2 DM, whose NSER success rate was

similar to that of healthy individuals.

In the present study, no difference was found between sexes in terms of time-dependent changes in PAI values both within and between groups. Similarly, Arya et al³⁹ reported that there was no difference between sexes in terms of healing of AP in type 2 DM patients with AP after 1 year of follow-up. In contrast, Smith et al⁴⁴ reported that the healing rate was higher in male patients after endodontic treatment applied to the anterior and posterior teeth after 5 years of follow-up, whereas Swartz et al⁴⁵ reported that the healing rate was higher in female patients after 20 years of follow-up after primary endodontic treatment applied to the anterior and posterior teeth. Britto et al⁴⁶ reported that male patients with type 2 DM had less healing in their periapical lesions after primary endodontic treatment than female patients. Variations in research results may be due to differences in factors such as sex distribution, population and age.

The success of endodontic therapy in individuals with DM has been an area of interest due to the systemic implications of the disease on tissue repair and healing processes. Regulated DM, characterised by controlled glycaemic levels ($HbA1c < 7\%$), is associated with reduced systemic inflammation and improved immune function compared to uncontrolled DM.¹⁸ These factors contribute positively to the healing process following endodontic therapy.

In the present study, the inclusion of patients with well-regulated type 2 DM ($HbA1c < 7\%$) facilitated a more precise evaluation of endodontic treatment outcomes. The results showed that the periapical healing rates in the type 2 DM group were comparable to those of systemically healthy individuals, suggesting that effective glycaemic control may mitigate the adverse effects of DM on tissue repair and inflammatory responses. This aligns with previous findings indicating that glycaemic regulation significantly enhances the success of both primary and secondary endodontic treatments.^{37,39}

In contrast, studies have reported delayed healing and lower success rates in patients with uncontrolled DM due to persistent hyperglycaemia, which exacerbates vascular damage, impairs collagen synthesis and increases the risk of infections.^{38,40} The present findings highlight the critical role of glycaemic regulation in optimising the outcomes of endodontic therapy, emphasising the need for dental practitioners to collaborate with physicians in managing the systemic health of DM patients undergoing dental treatments.

Future studies could explore the impact of varying levels of glycaemic control on the success of endodontic therapy, considering factors such as lesion size, tooth

type and long-term follow-up. Additionally, advancements in regenerative endodontics targeting angiogenesis and immune modulation might provide promising avenues for improving treatment outcomes in patients with DM.

In patients with DM, decreased tissue repair capacity due to low angiogenic potential may predispose to chronic inflammation. In addition, increased susceptibility to infections due to an altered immune response may delay the healing process and alter bone turnover, potentially affecting the success of root canal treatment in diabetic patients. These observations are supported by studies in the literature.^{38,47} Moreover, type 2 DM is one of the most common systemic diseases encountered by dental practitioners in clinical practice.⁴⁸ Thus, it is critical for dental practitioners to be aware of their patients' general health status to optimise the treatment process. Root canal-treated teeth should be monitored more frequently and over longer periods in patients with type 2 DM compared to healthy individuals.

This study is based on the comparison of the success of endodontic treatment results between type 2 DM patients and healthy individuals using periapical radiographs. Since it does not include clinical evaluation and is a retrospective study, the abovementioned conditions represent its limitations. Further retrospective and prospective clinical studies with larger sample sizes, and including both clinical and radiographic evaluations, are needed.

Conclusion

NSER applied in a single visit to teeth in patients with type 2 DM and AP resulted in periapical healing similar to in healthy individuals.

Conflicts of interest

The authors declare no conflicts of interest related to this study.

Author contribution

Dr Merve IŞIK contributed to the study design, data collection, analysis and manuscript draft and revision; Dr Tülin DOĞAN ÇANKAYA contributed to the data analysis, manuscript draft and manuscript revision; Dr Zeliha UĞUR AYDIN contributed to the study design and manuscript revision.

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