EUROPEAN ENDODONTIC JOURNAL

ORIGINAL ARTICLE

Factors Affecting the Outcome of Non-Surgical Endodontic Treatments Performed by Undergraduate Students in a Greek Dental School

Nikolaos K. POLYZOS, Kyriakos G. SARRIS, Afroditi I. PITA, Georgios V. MIKROGEORGIS, Kleoniki M. LYROUDIA

ABSTRACT

Objective: To evaluate the outcome of initial endodontic treatments performed by undergraduate students in a Greek dental school and to determine the factors that may impact the treatment outcome.

Methods: From a randomly selected sample of 677 non-surgical endodontic treatments performed between 2012 and 2015, follow-up appointments were scheduled with patients whose dental records matched the inclusion criteria. After clinical and radiographic examination, the treatment outcome was classified as 'success' (healed/healing) or 'failure' (uncertain/unsatisfactory healing). The statistical analysis of the data was performed using generalized estimating equations. Intra-examiner and inter-examiner agreements were checked with the intraclass correlation coefficient and with Cohen's kappa. The statistical significance level was set at $p<0.05$.

Results: A total of 244 teeth (349 roots) were included for further analysis, and the mean follow-up period was 2.8 years. Overall, the success rate for the treated roots was 72.8%. Multivariate analysis revealed four decisive factors as having a positive impact on the outcome, namely, the absence of voids within the root fillings ($p<0.001$), the absence of pre-operative periapical lesions ($p=0.001$), the extension of the root filling material by 0-2 mm from the radiographic apex ($p<0.001$) and the root type (anterior roots: $p=0.015$ and premolar roots: $p=0.011$). The association of gender, arch, pulp status and type of coronal restoration with the outcome was not statistically significant ($p>0.05$). Moreover, when the outcome according to pre-operative periapical status and the technical variables of root fillings (apical extension and density) was investigated, roots without periapical lesion, with a root filling material extended 0-2 mm within the apex and without voids revealed the highest success rate (94.5%).

Conclusion: The success rate of non-surgical endodontic treatments performed in a Greek dental school was in the range of those reported in other studies. The pre-operative periapical status, technical variables of root fillings (apical extension and density) and root type were regarded as significant prognostic factors of the outcome.

Keywords: Endodontic treatment, outcome, undergraduate students, dental school

Please cite this article as: Polyzos NK, Sarris KG, Pita AI, Mikrogeorgis GV, Lyroudia KM. Factors Affecting the Outcome of Non-Surgical Endodontic Treatments Performed by Undergraduate Students in a Greek Dental School. Eur Endod J 2018; 2: 93-100

From the Department of Endodontology (N.K.P. ✉ npolyzosdent@gmail.com, K.G.S., G.V.M., K.M.L.) School of Dentistry, Aristotle University of Thessaloniki, Thessaloniki, Greece; Department of Oral Health and Diagnostic Sciences, (A.I.P.), School of Dental Medicine, University of Connecticut Health Center, Farmington, CT, United States

Received 06 February 2018, last revision received 26 February 2018, accepted 23 February 2018

Published online: 19 July 2018
DOI 10.14744/eej.2018.18291

HIGHLIGHTS

- The success rate of non-surgical endodontic treatments performed in a Greek dental school was 72.8%.
- The pre-operative periapical status, technical variables of root fillings (apical extension, density) and root type were regarded as significant prognostic factors of the outcome.
- Correlating the treatment outcome with the pre-operative periapical status, the apical extension and the density of the root fillings, roots with root fillings extending 0-2 mm from the radiographic apex and without voids, irrespective of the pre-operative periapical status, revealed the highest success rates.

INTRODUCTION

Non-surgical endodontic treatment is a therapeutic procedure performed to prevent or treat diseases of the dental pulp and periapical tissues, thereby retaining the function of the treated tooth. The abovementioned goal is based primarily on proper debridement, shaping and final obturation of the root canal system, as well as satisfactory coronal restoration (1).

The outcomes of non-surgical root canal treatments have been investigated in several studies over the past decades. However, there are few quality studies available evaluating the endodontic outcome (2). Moreover, the results of these studies vary considerably due to differences in items such

as the composition of the study material (sample size, sample characteristics, and case selection criteria), treatment protocol (treatment providers, equipment, root canal preparation and obturation techniques, coronal restoration) and methodology (follow-up period, outcome assessment methods, definition of success/failure, statistical analysis).

The prognostic factors affecting the outcome of initial endodontic treatment are also of great interest. Previous studies have identified periapical status as one of the most decisive pre-operative factors influencing the outcome (3, 4), while others have investigated the impact of coronal restoration and technical quality of root fillings on the treatment outcome (5, 6).

Despite the establishment of definite guidelines for high-quality endodontic treatment (7), a large number of general dental practitioners still lack the knowledge of basic principles and factors related to the outcome of endodontic treatment (8). Moreover, unsatisfactory periapical healing has been associated with poor-quality root canal fillings in many studies during the previous decade (9, 10). These facts prompted the European Society of Endodontology to publish the Undergraduate Curriculum Guidelines for Endodontology (11). Also a number of studies have investigated the effectiveness of undergraduate students' clinical training in dental schools, evaluating either the outcome of non-surgical root canal treatments (12-14) or the technical quality of root canal fillings (15-17).

In Greece, to date, there have been two studies that assessed the technical quality of root fillings by radiographic criteria (15, 17), while there have been no published reports evaluating the outcome. Thus, the present study was the first to evaluate the outcome of non-surgical endodontic treatments completed by undergraduate students in the Clinic of the Department of Endodontology at Aristotle University of Thessaloniki between 2012 and 2015; the impact of pre-operative, intra-operative and post-operative factors on the outcome of the above-referenced treatments was also investigated.

MATERIALS AND METHODS

Sample size calculation

The sample size calculation of this retrospective study was based on the findings of a pilot study that analysed the association between the success rate of the treatment and periapical lesion status (healthy or not healthy). The overall success rate was 67.3% (41/61), and the odds ratio of health vs. disease was 3.1. Applying the previous values and setting the alpha error probability equal to 0.05 and power equal to 0.8 in the logistic regression model of the software G*Power 3.1.9.2 (18), the appropriate sample size was calculated, which was equal to 209 teeth.

Study population

Case history sheets from 850 endodontic cases performed by undergraduate students between 2012 and 2015 were randomly selected and initially evaluated according to the following inclusion criteria:

TABLE 1. The reasons for eligible patients not attending the follow-up examination

Reason for not attending	Number of patients
Impossible communication	157
Relocation	80
No interest	40
Dissatisfied	71
Overall	348

1) Non-surgical root canal treatments of single-rooted and multi-rooted permanent teeth.

2) Treatments performed by undergraduate students

3) Fully detailed case history sheets accompanied by patient's written consent to perform endodontic treatment and a full set of periapical radiographs of good diagnostic value (initial, working length, master cone and post-obturation)

4) Patients older than 18 years at the time of treatment

5) Patients without systemic diseases such as diabetes (type I or II) or HIV

Following this evaluation procedure, 173 endodontic cases were excluded from the study (33 retreatment cases, 129 endodontic cases with radiographs of poor diagnostic value, 5 cases referred to the Postgraduate Clinic, 4 patients younger than 18 years and 2 patients with diabetes type II). As a result, 677 cases corresponding to 507 patients were deemed appropriate and at least three phone calls per patient were performed. Of these 507 patients, 159 patients with 286 endodontically treated teeth eventually presented for follow-up examination. The remainder of the patients and the reasons for them not attending are listed in Table 1.

All of the procedures were performed after receiving approval from the Ethical Committee of the School of Dentistry, University of Thessaloniki, Greece (protocol number 13/1-2-2017) and informed consent was provided by each patient.

Initial root canal treatment protocol

All of the root canal treatments were performed by undergraduate students under the supervision of a faculty member following the same treatment protocol. After consideration of the medical and dental histories of each patient, local anaesthesia was administered if needed. Then, rubber dam isolation was applied in all of the cases in order to obtain aseptic conditions. After the establishment of a straight line access, the working length was determined by an intermediate radiograph inserting a K-file in each root canal. The step back technique was used for the instrumentation of each root canal, using stainless steel K–files of a 0.02 taper (Kerr Sybron, Rumulus, MI, USA). NaOCl (2.5%) was used as an irrigation solution while in calcified root canals Rc-Prep paste (Premier Dental Products Comp. Norristown, Philadelphia, USA) was also used. Calcium hydroxide paste was used as intracanal medicament between appointments. The root canals were filled with gutta-percha cones and an epoxy resin-based root canal sealer (ADSeal, Meta Biomed,

TABLE 2. A summary of the parameters used to evaluate the technical quality of the root fillings

Parameter	Categories
Apical extension	1) The filling material ends 0-2 mm short of the radiographic apex 2) The filling material ends more than 2 mm from the radiographic apex (under-filled) 3) The filling material was extruded beyond the radiographic apex (over-filled)
Density	1) No voids are present within the material and between the material and root canal walls 2) Voids are present within the material or between the material and root canal walls

Cheongju, Korea) using the cold lateral condensation technique. All of the conventional radiographs were exposed using the bisecting-angle technique.

Clinical and radiographic follow-up examination

Two clinicians (NP and KS both postgraduate students) proceeded to perform clinical and radiographic examinations. The following features were recorded: i) presence of discomfort, pain, swelling, sinus tract or crown fracture, ii) measurement of the pocket depth, iii) palpation of the surrounding tissues, and iv) results from a percussion test.

Follow-up radiographs taken with the parallel technique were digitally obtained with photostimulable phosphor plates using DIGORA OPTIME DXR-60 (Soredex Tuusula, Finland). The conventional periapical radiographs (pre, post-obturation) were digitalized and were recorded together with the follow-up images of each tooth in files and saved in the local disc of a computer.

Calibration procedure

Initially, the two assessors (NP and GM assistant professor) were calibrated by discussing and assessing some selected cases that were not included in this study. Furthermore, as part of the calibration procedure, 87 randomly selected cases included in the study were evaluated by each assessor for a second time after one month, and both the intra-examiner and inter-examiner agreements were checked.

Periapical status and quality of root filling assessment

The two examiners independently examined the periapical status and technical quality of root fillings in a darkened room and recorded their answers in an evaluation form. Root was considered the evaluation unit. The evaluation procedure was composed of three sessions. Each session lasted no more than 60 minutes. The digital images (the pre-operative, post-obturation and follow-up radiographs) were imported in Scanora software (SOREDEX Tuusula, Finland) and the option of measuring the distance between the end of the root filling material and the radiographic apex was provided to the examiners. No manipulation of the images and no use of the brightness or contrast tools of the programme were allowed. In cases in which the two examiners disagreed (42 roots for periapical status, 40 roots for apical extension and 33 roots for presence of voids), they met with a third examiner (KL), and the radiographs were re-evaluated until a consensus was reached.

The Periapical Index (PAI) (19) was used to assess the periapical condition of each root both at the baseline and the follow-up appointment. PAI score <3 signified absence of apical periodontitis while PAI score ≥3 signified presence of apical periodontitis. Moreover, the root filling of each root was assessed in terms of the apical extension and density of the filling materials. When a root had more than one root canal, the canal with the worst root filling quality was considered. Table 2 shows the categories for each technical parameter in which a root filling could be classified.

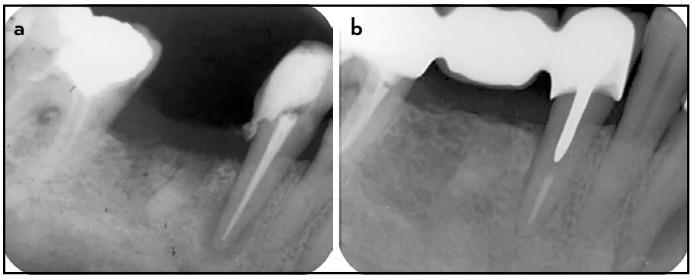

Figure 1. a-b. Images of a mandibular right first premolar classified as "healed" following endodontic treatment. (a) The post-operative radiograph shows periapical radiolucency around the apex. (b) The 4-year follow-up radiograph shows complete resolution of periapical radiolucency

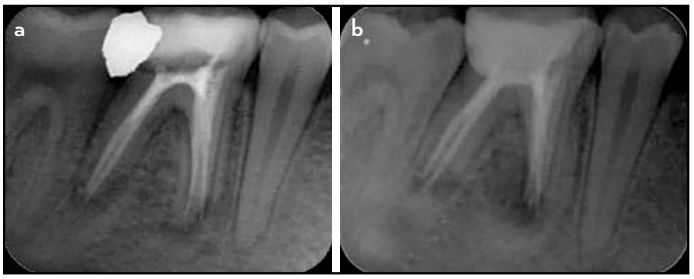

Figure 2. a-b. Images of a mandibular right first molar following endodontic treatment. The tooth was symptomatic at the follow-up appointment and both roots were classified as unsatisfactory healing. (a) The post-operative radiograph indicated periapical radiolucency in both roots. The mesial root revealed perforation of the apical third. (b) The 3-year follow-up radiograph showed that periapical radiolucency was still present in the distal root, with signs of external inflammatory root resorption. The periapical radiolucency in the mesial root increased in size

Outcome assessment

Radiographic and clinical criteria were used to classify the outcome in two categories:

A) Success: i) healed, absence of radiographic signs of apical periodontitis (PAI score <3) and no clinical signs other than tenderness to percussion and no symptoms

ii) incomplete healing (for cases with <3 years follow-up period), reduction in the size of periapical lesion but not completely resolved with no clinical signs other than tenderness to percussion and no symptoms

TABLE 3. The results of univariate analysis of prognostic factors related to the success rate of treatment

Factors	No. of roots	Success	OR	95% CI	Wald χ^2	df	p-value
Pre-operative							
Gender							
Male	164	119 (72.6%)	1.00	0.6 - 1.6	0.007	1	0.931
Female	185	135 (73%)	1.00				
Arch							
Maxillary	212	163 (76.8%)	1.6	1.0-2.7	4.557	1	0.033
Mandibular	137	91 (66.4%)	1.00				
Root type							
Anterior	98	83 (84.7%)	3.6	1.9 - 6.8	15.258	1	<0.001
Premolar	98	78 (79.6%)	2.5	1.4 - 4.5	9.435	1	0.002
Molar	153	93 (60.8%)	1.00		.	.	
Pulp condition							
Vital	149	119 (79.9%)	1.9	1.2 - 3.1	6.488	1	0.011
Non-vital	200	135 (67.5%)	1.00				
Periapical lesion							
Absent	227	181 (79.7%)	2.6	1.6 - 4.3	15.37	1	<0.001
Present	122	73 (59.8%)	1.00				
Intra-operative							
Apical extension							
0-2 mm	176	153 (86.9%)	2.7	1.0 - 7.3	4.034	1	0.045
>2 mm	149	84 (56.4%)	0.5	0.2 - 1.4	1.738	1	0.187
Overfilling	24	17 (70.8%)	1.00		.	.	
Voids							
Absent	251	209 (83.3%)	5.9	3.5 - 9.8	44.872	1	<0.001
Present	98	45 (45.9%)	1.00				
Post-operative							
Type of restoration							
Crown+post	97	78 (80.4%)	2.3	1.1-4.7	4.881	1	0.027
Filling	190	136 (71.5%)	1.4	0.8-2.6	1.362	1	0.243
Crown	62	40 (64.5%)	1.00		.	.	

B) Failure: i) uncertain healing, no radiographic sign of reduction in the size of periapical lesion with no clinical signs/symptoms

ii) unsatisfactory healing, development of a new periapical lesion or increase in size of an existing lesion or presence of clinical signs/symptoms

Examples of the treatment outcomes are represented in Figures 1 and 2.

Statistical analysis

The statistical analysis of the data was performed using generalized estimating equations (20) in SPSS software (IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp). The results were given as the odds ratio (OR) with the 95% confidence interval, and pairwise comparisons were performed with the sequential Bonferroni method. Additionally, the intra-examiner and inter-examiner agreements were studied with the ICC for numeric-ordinal data and Cohen's kappa for nominal data. The statistical significance was set at $p<0.05$.

RESULTS

Intra-examiner and inter-examiner agreement

The intra-examiner agreement for the pre-operative PAI score variable showed an ICC=0.805 and ICC=0.895, and the inter-examiner agreement showed an ICC=0.877. The kappa scores for intra-examiner agreement for the apical extent variable were 0.907 and 0.915 and 0.881 for inter-examiner agreement. The kappa scores for intra-examiner agreement for the voids were 0.891 and 0.872, and the kappa score for the inter-examiner agreement was 0.951. Finally, the intra-examiner agreements for the follow-up PAI score variable were ICC=0.881 and ICC=0.852, and the inter-examiner agreement for this variable was ICC=0.876. Kappa scores greater than 0.8 (21) and ICC scores between 0.75 and 0.9 (22) indicate good agreement.

Treatment outcome

A total number of 159 patients with 286 teeth were presented to the follow-up appointment. However, 42 out of 286 teeth were not included in further analyses (11 teeth without permanent restoration, 7 extractions due to periodontal disease, 19 extractions for prosthetic considerations, 5 extractions due to complications/discomfort) resulting in a final sample of 133 patients with 244 teeth (349 roots).

The follow-up periods ranged from 2 to 5 years, and the mean follow-up period was 2.8 years (SD=0.7 years). According to the assessment criteria, 245 roots (70.2%) were classified as healed and 9 roots (2.5%) underwent incomplete healing, constituting a group of 254 roots (72.8%) with favourable outcome (success). In contrast, 89 roots (25.5%) showed unsatisfactory healing, and 6 roots (1.7%) showed uncertain healing, constituting a group of 95 roots (27.2%) with unfavourable outcome (fail-

TABLE 4. The results of multivariate analysis of the prognostic factors related to the success rate of treatment

Factors	No. of roots	Success	OR	95% CI	Wald χ^2	df	p-value
Pre-operative							
Gender							
Male	164	119 (72.6%)	1.00	0.5-1.7	0.038	1	0.845
Female	185	135 (73%)	1.00				
Arch							
Maxillary	212	163 (76.8%)	1.4	0.75-2.5	1.114	1	0.291
Mandibular	137	91 (66.4%)	1.00				
Root type							
Anterior	98	83 (84.7%)	2.6	1.2-5.4	5.950	1	0.015
Premolar	98	78 (79.6%)	2.5	1.2-5	6.404	1	0.011
Molar	153	93 (60.8%)	1.00		.	.	
Pulp condition							
Vital	149	119 (79.9%)	1.2	0.5-2.7	0.264	1	0.607
Non-vital	200	135 (67.5%)	1.00				
Periapical lesion							
Absent	227	181 (79.7%)	4.1	1.7-9.1	11.243	1	0.001
Present	122	73 (59.8%)	1.00				
Intra-operative							
Apical extension							
0-2 mm	176	153 (86.9%)	4.1	2.1-7.8	18.987	1	<0.001
>2 mm or overfilling	173	101 (58.4%)	1.00				
Voids							
Absent	251	209 (83.3%)	5.7	3.1-10.5	31.974	1	<0.001
Present	98	45 (45.9%)	1.00				
Post-operative							
Type of restoration							
Crown+post	97	78 (80.4%)	1.2	0.5-3.0	0.222	1	0.638
Filling	190	136 (71.5%)	1.0	0.4-2.0	0.038	1	0.845
Crown	62	40 (64.5%)	1.00				

TABLE 5. A summary of the treatment success rate according to the periapical status, apical extension and presence/absence of voids

Prognostic variables	Overall roots	Number of roots with success (%)	OR	95% CI	Wald χ^2	df	p-value
Periapical lesion+Apical extension+Voids							
absent+0-2 mm+absent	91	86 (94.5%)	137.6	24.53-771.87	31.325	1	<0.001
absent+0-2 mm+present	17	13 (76.5%)	26	4.09-165.1	11.935	1	0.001
absent+>2 mm or overfilling+absent	72	60 (83.3%)	40	8.11-197.19	20.54	1	<0.001
absent+>2 mm or overfilling+present	47	22 (46.8%)	7.04	1.45-34.1	5.878	1	0.015
present+0-2 mm+absent	52	46 (88.5%)	61.33	11.22-335.2	22.565	1	<0.001
present+0-2 mm+present	16	8 (50%)	8	1.37-46.81	5.322	1	0.021
present+>2 mm or overfilling+absent	36	17 (47.2%)	7.16	1.43-35.77	5.748	1	0.017
present+>2 mm or overfilling+present	18	2 (11.1%)	1.00				

ure). This result indicated a statistically significant difference between the success rate and the failure rate (95% CI: 2.1 – 3.4, Wald $\chi2(1)=66.872$; $p<0.001$), with the chance of success being nearly 2.7 times greater than that of failure.

The distribution of the prognostic variables in relation to the treatment outcome is represented in Table 3. However, multivariate analysis (Table 4) highlighted four significant variables affecting the outcome. 1) The root type showed a statistically significant difference in the success rate between the anteriors, premolars and molars. In particular, the anteriors exhibited a 2.6-fold higher probability of success (95% CI:1.2-5.4; p=0.015) and the premolars exhibited a 2.5-fold higher probability of success (95% CI: 1.2-5; p=0.011) than molars. 2) For periapical lesions, roots without pre-operative periapical lesion showed a 4.1-fold greater chance of success (95% CI: 1.7-9.1; p=0.001) compared to roots appearing with a pre-operative periapical lesion. 3) Concerning apical extension, roots with fillings of 0-2 mm within the radiographic apex exhibited a 4.1-fold greater chance of success (95% CI: 2.1 - 7.8; p<0.001) than roots with underfilled (>2 mm short of radiographic apex) or overfilled canals. 4) Lastly, regarding voids, roots with no voids showed a 5.7-fold greater chance of success (95% CI: 3.1-10.5; p<0.001) than roots with voids within the root filling material or between the root canal walls and root filling material.

When the correlation between pre-operative periapical lesion, apical extension and voids with the treatment outcome was

checked (Table 5), the sub-group periapical lesion present+>2 mm or overfilling+voids present showed the lowest success rate (11.1%), while the other sub-groups revealed a 7.04- to 137.6-fold greater chance of success ($p<0.05$).

DISCUSSION

The ultimate goal of this retrospective study was to assess the outcome of non-surgical endodontic treatments performed by undergraduate students between January 2012 and June 2015. During their clinical practice (7th-10th semesters), the students dealt with endodontic cases, such as irreversible pulpitis, pulp necrosis, apical periodontitis and intentional root canal treatment of teeth for prosthetic purposes. All endodontic treatments were performed under a classic treatment protocol using stainless steel hand K-files for root canal instrumentation and conventional radiographs for working length determination. However, according to a previous study (23), the use of rotary nickel-titanium files was associated with higher healing rates compared to manual instrumentation. Moreover, the combined use of radiographs and electronic apex locators has proved to be a more accurate method for working length determination (24). These limitations of the current treatment protocol were taken into consideration by the faculty members and efforts have been made to enhance the clinical performance of undergraduate students by introducing the use of rotary files and apex locators in the Undergraduate Clinic.

The recall rate in this study was 45.4% (159 out of 350 responding patients), which is considered acceptable for continuing this research study in the future. A total of 42 of these teeth were excluded for reasons mentioned above, resulting in a sample of 244 teeth from 133 patients. Several patients included in this survey had more than one endodontically treated tooth. To avoid any influence of a patient's medical status on the treatment outcome, patients with diabetes (type I or II), or HIV were excluded. Current literature indicates a possible correlation between systematic diseases and endodontic outcome (25) while another study showed that systemic diseases had no significant impact on the outcome except affecting the healing time (14).

Follow-up appointments included both clinical and radiographic examinations. Teeth demonstrating only tenderness to percussion with no other signs/symptoms and no periapical radiolucency were not considered 'failure'. Percussion tenderness is not a pathognomonic sign of apical periodontitis, as it may be frequently associated with conditions such as traumatic occlusion and periodontal disease (3). Regarding the radiographs assessed in this study, the parallel technique was used for all of the follow-up radiographs, while the pre and post-obturation radiographs were taken using the bisecting angle technique during the treatment sessions. This lack of standardization of radiographic technique and x-ray film position was a limitation of this study resulting in difficulties in the interpretation of the post-obturation and follow-up radiographs. Thus, an effort was made to include only those with zero or minimum deformation while radiographs with overprojection of anatomical structures, such as the zygomatic bone and maxillary antrum, were excluded.

The unit of evaluation in this study was the root rather than the entire tooth, as it was more feasible to investigate the correlation of root-level parameters (apical extension and density of filling materials) with the outcome (4). Although using this unit of measure tends to overestimate the success rate (26), results from this study (72.8% of the treated roots and 73.5% of the treated teeth revealed a desirable outcome) and a previous one (27) do not support this statement.

The outcome criteria defined by the examiners were similar to those used in an earlier study (14) and could be characterized as being 'loose' (26) for roots associated with a clearly evidenced reduction in periapical radiolucency combined with the absence of signs and symptoms classified as a 'success'. In contrast, in another study, 'success' was defined only by full clinical and radiographic normalcy (3). Our decision to use 'loose' outcome criteria was derived from the fact that in this study, the average follow-up time was 2.8 years (ranging from 2-5 years), and a considerable number of cases had a follow-up time less than 4 years. However, endodontic treatment can be precisely assessed as a 'success' or 'failure' after a minimum period of 4 years, taking into account the healing time required (26). As a result, classifying the incomplete healing cases as failures could have overestimated the failure rate.

In the current study, 72.8% of the roots (73.5% of teeth) revealed a desirable outcome, which is lower than the 81% reported in an earlier study that included more experienced treatment providers (3). The success rate in this survey was also lower than that reported in the Tennessee study (14). Possible explanations for the higher success rate could be the fact that in the study of Azim et al., root canal instrumentation was performed using a rotary system, which may reflect the higher proportion of successful cases (23). In contrast, the percentage of success reported in this study was considerably higher than that reported in another study (13) when stringent outcome criteria were used (61% successful cases) and was significantly lower when lenient criteria were used (91% successful and acceptable cases).

Investigation into the possible influence of prognostic factors on the treatment outcome was another goal of this study. The multivariate analysis highlighted four important factors (pre-operative periapical lesion, voids, apical extension of the filling material and root type) that affected the outcome. Regarding periapical status, the success rate of 79.7% for the group without pre-operative lesions was nearly 20% higher than that of the group with lesions. This difference was statistically significant ($p=0.001$). Our findings corroborate those of previous studies that have also highlighted the negative impact of periapical lesions on the treatment outcome (3, 12).

Furthermore, 83.3% of the roots without voids showed a favourable outcome, whilst only 45.9% of roots with voids demonstrated success. This difference was statistically significant ($p<0.001$). One explanation for this finding could be the extended time interval between the final obturation and permanent restoration of teeth, resulting in a higher likelihood of coronal leakage when voids were present. Roots without a density problem have also been associated with higher rates

of success in previous studies (14, 28), although the number of roots with voids present was considerably small in both of these studies.

The success rate of roots with a root filling material that was extended by 0-2 mm from the radiographic apex (86.9%) was significantly higher (p<0.001) than that of under-filled or over-filled roots (58.4%). The latter two root length categories (under-filled and over-filled roots) were clustered into the same group for the multivariate analysis, as the number of over-filled roots was relatively small (only 24). Our finding is in line with that from another study (12). Moreover, when the treatment outcome according to the periapical status, apical extent of the root filling and presence of voids was investigated (Table 5), roots with a pre-operative periapical lesion, without voids and with a root filling material 0-2 mm from the apex showed a slightly lower success rate (88.5%) than those without a periapical lesion but with root fillings of the same technical quality (94.5%). This difference was not statistically significant (p=0.352; sequential Bonferroni method), indicating that a root filling of an adequate technical quality, irrespective of its pre-operative periapical status, is most likely associated with a desirable outcome. Finally, concerning the type of the root, significant differences in the outcomes between molar roots (60.8%) and the other two root categories (84.7% for anterior roots: p=0.015 and 79.6% for premolar roots: p=0.011) observed in this survey have also been reported in previous studies (13, 14), indicating that endodontic treatment in molars is more challenging due to the complexity of their root canal morphology and its possible variations.

The results of this study showed that type of coronal restoration had no significant impact on treatment outcome (p>0.05). All roots were permanently restored with fillings (resin composite or amalgam) or crowns or crowns+post. The sub-group of crown+post exhibited the highest success rate (80.4%) while the sub-group of crown showed the lowest (64.5%). These findings contradict those of a previous study (29) presenting the type of coronal restoration as a significant prognostic factor and associating the presence of posts with higher failure rates. In contrast, Ricucci et al. (30) demonstrated that the placement of a post did not impair the outcome. The higher success rate of roots restored by crown+post recorded in this study could be explained by the fact that in our institution it is an established principle to place a crown and post in a tooth with pre-operative lesion only when there is radiographic evidence of periapical healing.

CONCLUSION

The success rate of initial endodontic treatments performed by undergraduate students in the Clinic of the Department of Endodontology at the Aristotle University of Thessaloniki was 72.8%. Within the limitations of this study, pre-operative periapical status, apical extension and density of the root filling material and root type were regarded as decisive prognostic factors.

Disclosures

Conflict of interest: The authors deny any conflict of interest.

Ethics Committee Approval: Ethics committee approval was received for this study from the Ethical Committee of the School of Dentistry, Aristotle University of Thessaloniki, Greece (protocol number 13/1-2-2017).

Peer-review: Externally peer-reviewed.

Financial Disclosure: The authors declared that this study has received no financial support.

Authorship contributions: Concept – N.K.P., K.G.S., A.I.P.; Design – N.K.P., K.G.S., A.I.P., G.V.M., K.M.L.; Supervision – N.K.P., G.V.M., K.M.L.; Data collection &/or processing – N.K.P., K.G.S., A.I.P., K.M.L.; Analysis and/or interpretation – N.K.P., K.G.S.; Literature search – N.K.P., K.G.S., A.I.P.; Writing – N.K.P., K.G.S., A.I.P., G.V.M.; Critical review – N.K.P., K.G.S., A.I.P., G.V.M., K.M.L.

REFERENCES

1. Chugal NM, Clive JM, Spångberg LS. Endodontic infection: some biologic and treatment factors associated with outcome. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2003; 96(1):81–90. [CrossRef]
2. Ng YL, Mann V, Rahbaran S, Lewsey J, Gulabivala K. Outcome of primary root canal treatment: systematic review of the literature - part 1. Effects of study characteristics on probability of success. Int Endod J 2007; 40(12):921–39. [CrossRef]
3. Friedman S, Abitbol S, Lawrence HP. Treatment outcome in endodontics: the Toronto Study. Phase 1: initial treatment. J Endod 2003; 29(12):787–93. [CrossRef]
4. Ng YL, Mann V, Gulabivala K. A prospective study of the factors affecting outcomes of nonsurgical root canal treatment: part 1: periapical health. Int Endod J 2011; 44(7):583–609. [CrossRef]
5. Gillen BM, Looney SW, Gu LS, Loushine BA, Weller RN, Loushine RJ, et al. Impact of the quality of coronal restoration versus the quality of root canal fillings on success of root canal treatment: a systematic review and meta-analysis. J Endod 2011; 37(7):895–902. [CrossRef]
6. Craveiro MA, Fontana CE, de Martin AS, Bueno CE. Influence of coronal restoration and root canal filling quality on periapical status: clinical and radiographic evaluation. J Endod 2015; 41(6):836–40. [CrossRef]
7. European Society of Endodontology. Quality guidelines for endodontic treatment: consensus report of the European Society of Endodontology. Int Endod J 2006; 39(12):921–30. [CrossRef]
8. Peciuliene V, Maneliene R, Drukteinis S, Rimkuviene J. Attitudes of general dental practitioners towards endodontic standards and adoption of new technology: literature review. Stomatologija 2009; 11(1):11–4.
9. Eckerbom M, Flygare L, Magnusson T. A 20-year follow-up study of endodontic variables and apical status in a Swedish population. Int Endod J 2007; 40(12):940–8. [CrossRef]
10. Tavares PB, Bonte E, Boukpessi T, Siqueira JF Jr, Lasfargues JJ. Prevalence of apical periodontitis in root canal-treated teeth from an urban French population: influence of the quality of root canal fillings and coronal restorations. J Endod 2009; 35(6):810–3. [CrossRef]
11. De Moor R, Hülsmann M, Kirkevang LL, Tanalp J, Whitworth J. Undergraduate curriculum guidelines for endodontology. Int Endod J 2013; 46(12):1105–14. [CrossRef]
12. Sjogren U, Hagglund B, Sundqvist G, Wing K. Factors affecting the long-term results of endodontic treatment. J Endod 1990; 16(10):498–504.
13. Benenati FW, Khajotia SS. A radiographic recall evaluation of 894 endodontic cases treated in a dental school setting. J Endod 2002; 28(5):391–5.
14. Azim AA, Griggs JA, Huang GT. The Tennessee study: factors affecting treatment outcome and healing time following nonsurgical root canal treatment. Int Endod J 2016; 49(1):6–16. [CrossRef]
15. Eleftheriadis GI, Lambrianidis TP. Technical quality of root canal treatment and detection of iatrogenic errors in an undergraduate dental clinic. Int Endod J 2005; 38(10):725–34. [CrossRef]
16. Er O, Sagsen B, Maden M, Cinar S, Kahraman Y. Radiographic technical quality of root fillings performed by dental students in Turkey. Int Endod J 2006; 39(11):867–72. [CrossRef]
17. Khabbaz MG, Protogerou E, Douka E. Radiographic quality of root fillings performed by undergraduate students. Int Endod J 2010; 43(6):499–508.
18. Faul F, Erdfelder E, Buchner A, Lang AG. Statistical power analyses using G*Power 3.1: tests for correlation and regression analyses. Behav Res Methods 2009; 41(4):1149–60. [CrossRef]
19. Orstavik D, Kerekes K, Eriksen HM. The periapical index: a scoring system

for radiographic assessment of apical periodontitis. Endod Dent Traumatol 1986; 2(1):20–34. [CrossRef]
20. Nurosis M. SPSS 15.0 Advanced Statistical Procedure Companion. 1st ed. New Jersey: Prentice Hall; 2007.
21. Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics 1977; 33(1):159–74. [CrossRef]
22. Koo TK, Li MY. A Guideline of Selecting and Reporting Intraclass Correlation Coefficients for Reliability Research. J Chiropr Med 2016; 15(2):155–63.
23. Cheung GS, Liu CS. A retrospective study of endodontic treatment outcome between nickel-titanium rotary and stainless steel hand filing techniques. J Endod 2009; 35(7):938–43. [CrossRef]
24. Martins JN, Marques D, Mata A, Caramês J. Clinical efficacy of electronic apex locators: systematic review. J Endod 2014; 40(6):759–77. [CrossRef]
25. Aminoshariae A, Kulild JC, Mickel A, Fouad AF. Association between Systemic Diseases and Endodontic Outcome: A Systematic Review. J Endod 2017; 43(4):514–9. [CrossRef]
26. Friedman S. Prognosis of the initial endodontic treatment. Endod Topics 2002; 2(1):59–88. [CrossRef]
27. Hoskinson SE, Ng YL, Hoskinson AE, Moles DR, Gulabivala K. A retrospective comparison of outcome of root canal treatment using two different protocols. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2002; 93(6):705–15. [CrossRef]
28. Kerekes K, Tronstad L. Long-term results of endodontic treatment performed with a standardized technique. J Endod 1979; 5(3):83–90. [CrossRef]
29. Kayahan MB, Malkondu O, Canpolat C, Kaptan F, Bayirli G, Kazazoglu E. Periapical health related to the type of coronal restorations and quality of root canal fillings in a Turkish subpopulation. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2008; 105(1):e58–62. [CrossRef]
30. Ricucci D, Russo J, Rutberg M, Burleson JA, Spångberg LS. A prospective cohort study of endodontic treatments of 1,369 root canals: results after 5 years. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011; 112(6):825–42. [CrossRef]