Aims: This study aims to evaluate the outcome and prognostic factors related to post-treatment disease in orthograde retreatment after a minimum of 1-year follow-up period. Materials and Methods: A retrospective cohort study was performed. The data of all orthograde retreatment charts between January 2006 and March 2019 from two endodontic centers in Thailand were collected. Retreatment outcomes were evaluated and prognostic factors were analyzed by multivariable binary logistic regression. Results: The average recall period was 4.3 years, ranging from 1 to 12 years. The sample in the present study consisted of 245 teeth in 220 patients, of which 161 teeth (65.70%) were classified as “healed,” 28 teeth (11.40%) were classified as “healing,” and 56 teeth (22.90%) as “diseased.” The bivariate analysis showed that the statistically significant factors included the presence of pre-operative lesions, the pre-operative lesion size, access opening through the crown, chlorhexidine adjunctive irrigation, and solvent usage. Multivariable binary logistic regression identified pre-operative lesions and solvent usage as significant prognostic factors with adjusted odds ratios of 6.30 (confidence interval [CI], 2.72–14.63; \( P < 0.01 \)) and 2.54 (CI, 1.24–5.23; \( P = 0.01 \)), respectively. The healed rate was higher when the pre-operative lesions were absent and when the solvent was used. Conclusion: The healed rate of orthograde retreatment after 1 to 12 years of follow-up was 65.70% and 77.10% for a lenient success rate. Pre-operative lesion and solvent usage were significant prognostic factors. The healed rate was higher with the absence of pre-operative lesions and usage of solvent.

Keywords: Prognostic factors, retreatment, root canal therapy, treatment outcome

INTRODUCTION

Post-treatment disease can occur in 11.70–17.00% of endodontic cases.\(^1\,^2\) Because the majority of post-treatment disease is due to intraradicular infection, the first line of treatment is to eradicate intraradicular microorganisms by orthograde retreatment.\(^3\,^4\) The prognosis of teeth and outcome of treatment are crucial information for operators and patients to evaluate the proper treatment for each patient. There were several previous retreatment outcome studies that were conducted mostly in Europe and America, but none was studied in Southeast Asia, especially in Thailand.\(^1\,^2\,^5\,^21\) Therefore, this study aims to evaluate orthograde retreatment outcomes and prognostic factors after at least 1-year follow-up period. The null hypothesis is that the pre-operative and intra-operative factors are not related to retreatment outcomes.

Address for correspondence: Ms. Titalee Jirathanyanatt, Department of Operative Dentistry and Endodontics, Faculty of Dentistry, Mahidol University, No. 6, Yothi Road, Ratchathewi District, Bangkok 10400, Thailand. E-mail: Titalee.jir@mahidol.ac.th

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: reprints@medknow.com

How to cite this article: Ponsri S, Jirathanyanatt T. Treatment outcome and prognostic factors of orthograde retreatment: A retrospective study. J Int Soc Prevent Communit Dent 2022;12:442-8.
MATERIALS AND METHODS
The retrospective cohort study protocol was approved by the Faculty of Dentistry/Faculty of Pharmacy, Mahidol University, Institutional Review Board (Ref. 2019/038.2006). The data from all endodontic charts and radiographs of orthograde retreatment cases between January 2006 and March 2019 were collected from two endodontics clinics: the Faculty of Dentistry, Mahidol University and Maha Chakri Sirindhorn Dental Hospital, Thailand.

The inclusion criteria for this study were as follows:
1. Permanent mature endodontically treated teeth that had undergone retreatment after at least 1-year follow-up period;
2. Pre-operative, intra-operative, and follow-up data were completely recorded in the endodontic charts;
3. Available and adequate quality of the original film, final film, and follow-up film for interpretation;
4. Teeth diagnosed with a disease within the first year after orthograde retreatment;
5. Teeth extracted due to the endodontic failure within and over 1-year follow-up period.

RETREATMENT PROCEDURE
The treatments were performed by post-graduate endodontic students. Rubber dam isolation was performed in all cases. The crowns (if any) were either removed or openings were accessed through them. All caries or defective restorations were removed, and replacement of restorations was done to prevent coronal leakage. Posts were removed using ultrasonic vibrations with a dental operating microscope. Gutta-percha was removed with hand files, rotary nickel-titanium instruments, ultrasonic tips, or heat carriers with or without gutta-percha solvent, chloroform, eucalyptol oil, d-limonene (Nishika’s GP Solvent; Nippon Shika Yakuhin Co., Ltd, Japan), or a citrus fruit extract (GuttaClear®; M-Dent, Bangkok, Thailand). Silver cones and separated instruments were primarily loosened with hand files or ultrasonic tips and retrieved, if possible. The cleanliness of any previous root canal filling removals was evaluated with a periapical radiograph. Perforations (if any) were repaired with mineral trioxide aggregate (MTA; ProRoot® MTA, Dentsply Tulsa, Tulsa, OK, USA) or glass ionomer cement (GI Fuji II LC®, GC America, USA), and resin composite before referring for the permanent crown restoration.

DATA COLLECTION
The demographic data including age, gender, and systemic disease were recorded. The pre-operative, intra-operative, and follow-up information were collected from chart records and radiographs.

For the pre-operative periapical lesion size in multirooted teeth, the lesion was measured according to the root that appeared the largest in size. Pre-operative root filling quality was a result of the combination of root filling density and root filling length, which was dichotomized as either adequate or inadequate. The adequate root canal filling quality was a homogeneous filling material, with no void present and the root filling ending at the root apex or within 2 mm from the apex. The inadequate root canal filling was non-homogeneous with a void present or the filling material that was filled up to 2 mm shorter from the apex or overfilling beyond the apex.

OUTCOME ASSESSMENT
Teeth were evaluated as a tooth unit. The assessment of the orthograde retreatment outcome was dependent on the clinical and radiographic examination, which follow Friedman and Mor’s criteria.[22]

Healed; clinical and radiographic normalcy;
Healing; clinical normalcy and periapical radiolucency reducing in size;
Disease; emerging new periapical radiolucency or persisting periapical radiolucency, even when clinical signs and symptoms are normal, or presenting signs and symptoms of periapical disease even when the radiographic presentation is normal.
Functional retention; the endodontically treated tooth presenting clinical normalcy regardless of radiographic presentation.
To digitize the radiograph, the scanner (HP Scanjet G4010) was used to convert the conventional radiographs to digital radiographs. The digital radiographs were saved in JPEG formats for further analysis. The pre-operative, post-operative, and follow-up radiographs were adjusted to the same angulation and size using ImageJ software with TurboReg plug-in for the outcome evaluation. The measurement of the lesion size and root canal filling length were done using ImageJ software.

Radiograph interpretation for the treatment outcome was done by two examiners: a post-graduate endodontic student and a Thai board-certified endodontist. Intra-observer and inter-observer agreements were calculated before radiograph interpretation by using 60 sets of radiographs with Cohen’s kappa analysis. For the calibration, interpretation occurred twice with a time-lapse of 2 weeks until the “almost perfect” level of agreement was met ($\kappa = 0.81$–0.99) before the initiation of the study.

**Statistical analysis**

The treatment outcomes of the orthograde retreatment were classified as healed, healing, and diseased and were presented in percentage frequencies. Binary logistic regression was used to evaluate the association between factors and healed rates and to determine potential prognostic factors ($P <0.25$). A multivariable binary logistic regression was used to identify any significant prognostic factor. All statistical testing was performed as two-tailed at the 5% significance level ($P <0.05$) with IBM® SPSS® Statistics software version 24.0.

**Results**

The radiographic interpretation was performed by two examiners with almost perfect intra-observer agreement ($\kappa = 0.89$ and 0.96) and almost perfect inter-observer agreement ($\kappa = 0.95$). The endodontic charts from 2006 to 2019 were reviewed. There were 273 teeth in 248 follow-up patients. Twenty-eight teeth were not included because of vertical root fractures in 25 teeth and split-tooth in 3 teeth. Two hundred and forty-five teeth in 220 patients met the inclusion criteria. The average recall period was 51.78 months, ranging from 12.13 to 152.87 months.

Of the 245 teeth included in the study, 161 were classified as healed (65.70%), 28 were classified as healing (11.40%), and 56 as diseased (22.90%). For the lenient criteria of success, healed and healing rates were 77.10% and 97.10%, respectively, for the cases that could be categorized as functional retention.

The variables related to treatment outcomes categorized as healed, healing, and diseased are shown in Table 1. For the solvent usage factor, the samples were less than the overall sample size due to data missing in 56 endodontic charts. The relation between the variables and the healed rates was determined using binary logistic regression to identify the potential prognostic factors that are shown in Table 2. The statistically significant variables associated with the healed rate of orthograde retreatment ($P <0.05$) were pre-operative lesions ($P <0.01$), pre-operative lesion size ($P = 0.04$), access opening through the crown ($P = 0.01$), chlorhexidine usage ($P = 0.02$), and solvent usage ($P = 0.02$).

Pre-operative periodontal involvement, pre-operative lesions, pre-operative root canal filling quality, access opening through crown, solvent usage, adjunctive irrigation, chlorhexidine usage, triple antibiotic usage, and post-presence were potential prognostic factors to analyze in multivariable binary logistic regression [not all data are shown in Table 2]. Multivariable binary logistic regression [Table 3] identified pre-operative lesions and intra-operative solvent usage as significant prognostic factors with adjusted odds ratios (ORs) of 6.30 (confidence interval [CI], 2.72–14.63; $P < 0.01$) and 2.54 (CI, 1.24–5.23; $P = 0.01$), respectively.

**Discussion**

The outcome of this retrospective cohort study revealed the healed rate of orthograde retreatment which was 65.70%, whereas the disease cases were 22.90%. The presence of pre-operative lesions and non-solvent usage were factors that negatively affected treatment outcomes. To analyze the treatment outcomes and prognostic factors, pre-operative, intra-operative, and follow-up information were collected from all attending recall orthograde retreatment cases between 2006 and 2019. Due to the limitation of the retrospective study, attending recall cases that follow the inclusion criteria were 58.33% of all orthograde retreatment cases, because of incapability to contact the patients and declination of the patients for a regular follow-up examination.

The average recall period was 51.78 months, ranging from 12.13 to 152.87 months, which was long enough to evaluate the outcome as the highest incidence of apical periodontitis development and healing could be determined as healed, healing, and disease in the first year of follow-up. Nevertheless, some cases which required 4 years to completely heal were included as neither healed rate interpretation nor significant prognostic factor analysis. Therefore, definite treatment outcomes and
significant prognostic factors might be more apparent after the further recall.

The outcome interpretation by two examiners with almost perfect intra-observer and inter-observer agreement showed that the healed rate of orthograde retreatment was 65.70%, whereas other studies were in the range of 44.10–90.90%. The lower healed rates might be because 11.40% of cases were in the healing process. Since most of the healing cases will be healed after further review, it can be assumed that the success rate after continuing recall will be 77.10%, similar to the outcome of previous studies.

Regarding 56 of the disease cases, 20 teeth with asymptomatic smaller lesions after a 4-year recall could be scar tissue healing. Seven teeth were asymptomatic and had unchanged periapical lesions within 4 years of follow-up. Therefore, only 11.80% of the sample needed further treatment. Even though the presence of periapical lesions after a 4-year recall was classified as diseased, if the patient’s expectation was pain-relieving, the outcome could be classified as functional, which was 97.10%. Therefore, orthograde retreatment could be a treatment of choice for post-treatment apical periodontitis since a high success rate has been reported.

The bivariate and multivariate analyses revealed the pre-operative lesions to be the most dominant prognostic factor, which corresponded with previous studies. A systematic review of the orthograde retreatment by Ng et al. also showed the significance of pre-operative lesions to treatment outcomes and the other was the length of root canal filling and quality of restoration. However, solvent usage was not mentioned in the systematic review, although our study indicated the association of gutta-percha solvent with the healed rate.

### Table 1: Distribution of teeth in relation to prognostic factors and treatment outcome of orthograde retreatment

| Prognostic factors | Overall | Healed | Healing | Disease |
|--------------------|---------|--------|---------|---------|
| Age (n = 245) | | | | |
| < 45 years | 71 (29) | 42 (59.2) | 9 (12.7) | 20 (28.2) |
| ≥ 45 years | 174 (71) | 119 (68.4) | 19 (10.9) | 36 (20.7) |
| Gender (n = 245) | | | | |
| Male | 87 (35.5) | 52 (59.8) | 13 (14.9) | 22 (25.3) |
| female | 158 (64.5) | 109 (69.0) | 15 (9.5) | 34 (21.5) |
| Tooth type (n = 245) | | | | |
| Anterior teeth | 72 (29.4) | 47 (65.3) | 16 (22.2) | 9 (12.5) |
| Premolar | 74 (30.2) | 52 (70.3) | 2 (2.7) | 20 (27.0) |
| Molar | 99 (40.4) | 62 (62.6) | 10 (10.1) | 27 (27.3) |
| Pre-op lesion (n = 245) | | | | |
| Absent | 107 (43.7) | 90 (84.1) | 1 (0.9) | 16 (15.0) |
| Present | 138 (56.3) | 71 (51.5) | 27 (19.6) | 40 (29.0) |
| Pre-op lesion size (n = 138) | | | | |
| < 5 mm | 72 (52.2) | 43 (59.7) | 9 (12.5) | 20 (27.8) |
| ≥ 5 mm | 66 (47.8) | 28 (42.4) | 18 (27.3) | 20 (30.3) |
| Pre-op root canal filling quality (n = 245) | | | | |
| Adequate | 48 (19.6) | 27 (56.3) | 6 (12.5) | 15 (31.3) |
| Inadequate | 197 (80.4) | 134 (68.0) | 22 (11.2) | 41 (20.8) |
| Pre-op perforation (n = 245) | | | | |
| Absent | 231 (94.3) | 154 (66.7) | 28 (12.1) | 49 (21.2) |
| Present | 14 (5.7) | 7 (50.0) | 0 (0.0) | 7 (50.0) |
| Intra-op access opening through the crown (n = 245) | | | | |
| No | 234 (95.5) | 158 (67.5) | 24 (10.3) | 52 (22.2) |
| Yes | 11 (4.5) | 3 (27.3) | 4 (36.4) | 4 (36.4) |
| Intra-op chlorhexidine usage (n = 245) | | | | |
| No | 213 (86.9) | 146 (68.5) | 21 (9.9) | 46 (21.6) |
| Yes | 32 (13.1) | 15 (46.9) | 7 (21.9) | 10 (31.3) |
| Intra-op solvent usage (n = 189) | | | | |
| No | 92 (48.7) | 53 (57.6) | 16 (17.4) | 23 (25.0) |
| Yes | 97 (51.3) | 72 (74.2) | 6 (6.2) | 19 (19.6) |

n = number, pre-op = pre-operative, intra-op = intra-operative
The presence of apical radiolucency indicates residual bacteria resistance to primary root canal treatment, most often in the form of biofilm residing in the area of dentinal tubules, isthmuses, or apical ramification or the treatment-resistant species. It might have been unable to eradicate by the chemo-mechanical technique of retreatment, resulting in persistent apical periodontitis.[4,28,29]

### Table 2: Bivariate analysis of the relation between prognostic factors and healed rate of orthograde retreatment

| Prognostic factors | Number of teeth (% within factor) | Crude OR (95% CI) | P-value |
|--------------------|-----------------------------------|-------------------|---------|
| Healed Healing, disease | | | |
| Pre-op lesion (n = 245) | | | |
| Absent | 90 (84.1) | 17 (15.9) | 1 |
| Present | 71 (51.4) | 67 (48.6) | 4.99 (2.70–9.26) | <0.01* |
| Pre-op lesion size (n = 138) | | | |
| < 5 mm | 43 (59.7) | 29 (40.3) | 1 |
| ≥ 5 mm | 28 (42.4) | 38 (57.6) | 2.01 (1.02–3.97) | 0.04* |
| Pre-op root canal filling quality (n = 245) | | | |
| Adequate | 27 (56.3) | 21 (43.8) | 1.65 (0.87–3.15) | 0.13 |
| Inadequate | 134 (68.0) | 63 (32.0) | 1 |
| Pre-op perforation (n = 245) | | | |
| Absent | 154 (66.7) | 77 (33.3) | 1 |
| Present | 7 (50.0) | 7 (50.0) | 2.00 (0.68–5.91) | 0.21 |
| Pre-op perforation size (n = 245) | | | |
| < 5 mm | 43 (59.7) | 29 (40.3) | 1 |
| ≥ 5 mm | 28 (42.4) | 38 (57.6) | 2.01 (1.02–3.97) | 0.04* |
| Pre-op root canal filling quality (n = 245) | | | |
| Adequate | 27 (56.3) | 21 (43.8) | 1.65 (0.87–3.15) | 0.13 |
| Inadequate | 134 (68.0) | 63 (32.0) | 1 |
| Pre-op perforation (n = 245) | | | |
| Absent | 154 (66.7) | 77 (33.3) | 1 |
| Present | 7 (50.0) | 7 (50.0) | 2.00 (0.68–5.91) | 0.21 |

*n = number, pre-op = pre-operative, intra-op = intra-operative, OR = odds ratio, CI = confidence interval

*Statistically significant difference

### Table 3: Univariable and multivariable binary logistic regression of prognostic factors and healed rate of orthograde retreatment

| Prognostic factors | Univariable | Multivariable |
|--------------------|-------------|---------------|
|                  |             |                |
|                  | Crude OR (95% CI) | Adjusted OR (95% CI) | P-value |
| Pre-op lesion | | | |
| Absent | 1 | 1 | |
| Present | 4.99 (2.70–9.26) | 6.30 (2.72–14.63) | <0.01* |
| Pre-op root canal filling quality | | | |
| Adequate | 1.65 (0.87–3.15) | 2.23 (0.90–5.49) | 0.08 |
| Inadequate | 1 | 1 | |
| Pre-op perforation | | | |
| Absent | 1 | 1 | |
| Present | 2.00 (0.68–5.91) | 3.63 (0.84–15.69) | 0.08 |
| Pre-op perforation size (n = 245) | | | |
| < 5 mm | 43 (59.7) | 29 (40.3) | 1 |
| ≥ 5 mm | 28 (42.4) | 38 (57.6) | 2.01 (1.02–3.97) | 0.04* |
| Pre-op root canal filling quality (n = 245) | | | |
| Adequate | 27 (56.3) | 21 (43.8) | 1.65 (0.87–3.15) | 0.13 |
| Inadequate | 134 (68.0) | 63 (32.0) | 1 |
| Pre-op perforation (n = 245) | | | |
| Absent | 154 (66.7) | 77 (33.3) | 1 |
| Present | 7 (50.0) | 7 (50.0) | 2.00 (0.68–5.91) | 0.21 |
| Pre-op perforation size (n = 245) | | | |
| < 5 mm | 43 (59.7) | 29 (40.3) | 1 |
| ≥ 5 mm | 28 (42.4) | 38 (57.6) | 2.01 (1.02–3.97) | 0.04* |
| Pre-op root canal filling quality (n = 245) | | | |
| Adequate | 27 (56.3) | 21 (43.8) | 1.65 (0.87–3.15) | 0.13 |
| Inadequate | 134 (68.0) | 63 (32.0) | 1 |
| Pre-op perforation (n = 245) | | | |
| Absent | 154 (66.7) | 77 (33.3) | 1 |
| Present | 7 (50.0) | 7 (50.0) | 2.00 (0.68–5.91) | 0.21 |
| Pre-op perforation size (n = 245) | | | |
| < 5 mm | 43 (59.7) | 29 (40.3) | 1 |
| ≥ 5 mm | 28 (42.4) | 38 (57.6) | 2.01 (1.02–3.97) | 0.04* |
| Pre-op root canal filling quality (n = 245) | | | |
| Adequate | 27 (56.3) | 21 (43.8) | 1.65 (0.87–3.15) | 0.13 |
| Inadequate | 134 (68.0) | 63 (32.0) | 1 |
| Pre-op perforation (n = 245) | | | |
| Absent | 154 (66.7) | 77 (33.3) | 1 |
| Present | 7 (50.0) | 7 (50.0) | 2.00 (0.68–5.91) | 0.21 |

Pre-op = pre-operative, intra-op = intra-operative, OR = odds ratio, CI = confidence interval

*Statistically significant difference
The pre-operative lesion size was statistically significant in binary logistic regression, as corresponded to Eyuboglu et al.\(^5\) Although larger lesions might take a longer time to heal completely after treatment, the healed rate of larger lesions over 4 years was not statistically higher than the short-term healed rate according to our study. Because larger periapical lesions were correlated with the number of species and density of bacteria, larger lesions might have treatment-resistant traits and cause persistent apical lesions.\(^6,30\)

Chlorhexidine was used as an additional irrigant due to its substantivity and the eradicating effects on *Enterococcus faecalis*.\(^6,31,32\) However, the use of 2% chlorhexidine seemed to be significantly associated with disease in the bivariate analysis, which was consistent with the study of Ng et al.\(^8\) In this study, chlorhexidine was selectively used in the cases of persistent pain, sinus tract opening, or apical exudate after proper chemo-mechanical disinfection and in the cases with pre-operative radiolucency, which were confounding factors that adversely affected the treatment outcomes.\(^2\)

An interesting outcome was that the solvent usage was significant in the multivariate analysis; however, there was no prior orthograde retreatment outcome study that had discussed this factor. Despite the cytotoxicity of any type of solvent, they were mainly used in cases in which the obturation terminated short of the apex, meaning that the chance of solvent extrusion into the periapical tissue and the subsequent irritation may be minimal.

To achieve the best outcome and disinfection, root canal filling material should be completely removed.\(^33\) Various studies have reported that solvents enhanced cleanliness for gutta-percha removal and facilitated the achievement of apical patency.\(^14,33\) Therefore, using solvents might increase the accessibility of irrigants and medicaments to eradicate any remaining microorganisms and cleaning at the apical portion of the root canal, which are significant factors for positively affecting the healed rate.\(^2\) According to this possible mechanism, gutta-percha solvent could be an effective tool in orthograde retreatment protocol to enhance disinfection in the root canal and to improve treatment outcomes. However, according to the limitation of the recall period, the effect of the solvent should be further evaluated by a randomized clinical trial with more than 4 years of follow-up period.

**Conclusion**

The healed rate of orthograde retreatment after 1–12 years of follow-up was 65.70% and 77.10% for the lenient success rate. The pre-operative lesion and solvent usage were the significant prognostic factors with adjusted ORs of 6.30 (CI, 2.72–14.63; \(P < 0.01\)) and 2.54 (CI, 1.24–5.23; \(P = 0.01\)), respectively. The healed rate was higher with the absence of pre-operative lesions and with the usage of the solvent.

**Future Scope/Clinical Significance**

An aseptic technique of orthograde retreatment achieved a favorable outcome and is considered the treatment of choice for post-treatment disease cases. Gutta-percha solvent might be an additional tool for achieving a favorable outcome.

The limitation of our study was the short time recall period, which affected the outcome evaluation due to strict criteria. To clarify the true significant prognostic factors, especially solvent usage should be done by randomized clinical trials with more than 4-year follow-up period.

**Acknowledgements**

The authors are immeasurably grateful to Asst. Prof. Dr. Chulaluk Komoltri and Dr. Sittichoke Osiri for their assistance in the statistical analyses.

**Financial Support and Sponsorship**

Not applicable.

**Conflicts of Interest**

There are no conflicts of interest.

**Authors’ Contribution**

Saranya Ponsri has contributed in conceptualization, literature review, data acquisition, data analysis, statistical analysis, manuscript preparation, editing and review; Titalee Jirathanyanatt, in conceptualization, data analysis, statistical analysis, manuscript editing and review. All authors have read and agreed to the published version of the manuscript.

**Ethical Policy and Institutional Review Board Statement**

The study protocol was approved by the Faculty of Dentistry/Faculty of Pharmacy, Mahidol University, Institutional Review Board (MU-DT/PY-IRB), reference number: COA.No.MU-DT/PY-IRB 2019/038.2006.

**Patient Declaration of Consent**

Not applicable.

**Data Availability Statement**

The data set used in the current study is available on request from Dr. Titalee Jirathanyanatt (E-mail: Titalee.jir@mahidol.ac.th).

**References**

1. Laukkannen E, Vehkalahti MM, Kotiranta AK. Impact of type of tooth on outcome of non-surgical root canal treatment. Clin Oral Investig 2019;23:4011–8.
