Outcome of Orthograde Retreatment after Failed Apicoectomy: Use of a Mineral Trioxide Aggregate Apical Plug

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Abstract

Introduction: This controlled, single-center historic cohort study project evaluates treatment outcomes of a nonsurgical treatment approach after failed apicoectomy. Methods: The treatment outcomes of nonsurgical retreatment after a failed apicoectomy were evaluated clinically and radiographically. The study cohort consisted of teeth that had received primary root canal treatment and subsequent apicoectomy elsewhere before the patients presented with post-treatment disease. Orthograde retreatment and obturation using an apical mineral trioxide aggregate plug was performed by postgraduate students and endodontic specialists in 25 cases between 2004 and 2012. Pre-, intra-, and postoperative information and the potential effect on the retreatment outcome were evaluated and statistically analyzed using the chi-square test. Results: Twenty-two patients with 23 teeth attended the follow-up examinations (recall rate = 92%). The follow-up periods ranged from 12 to 102 months (median = 35 months). Twenty teeth (87%) were classified as “success,” and 3 teeth were considered (17%) “failure.” The chi-square test confirmed that the preoperative factor “number of roots” had a statistically significant effect on treatment outcome (odds ratio = 0.08; 95% confidence interval, 0–1.76; \( P = .03 \)). The factor “tooth location” was of borderline significance (odds ratio = 0.1; 95% confidence interval, 0–2.14; \( P = .05 \)). Conclusions: The results of the present study suggest that orthograde retreatment combined with orthograde placement of an apical mineral trioxide aggregate plug is a promising long-term treatment option for teeth with postsurgical pathosis. The success rates were higher for single-rooted teeth. The use of cone-beam computed tomographic imaging in cases of inconclusive periapical radiographs is recommended to minimize the risk of misinterpretation when assessing treatment outcome. (J Endod 2015;41:613–620)

Key Words

Failed apicoectomy, mineral trioxide aggregate, orthograde retreatment, treatment outcome

Apical surgery is a valuable treatment option to maintain a tooth with persistent posttreatment apical periodontitis (1–3), but there is an evidence-based rationale for when to perform this procedure. Regardless of the clinical performance, root-end resection cannot compensate for poor orthograde endodontic treatment (4). In a retrospective evaluation, Abramowitz et al (5) found that only 45% of the teeth that were referred for apical surgery were adequately selected. In addition, 83% of the teeth from this evaluation were found to be inadequately obturated and required nonsurgical retreatment instead of apical surgery. Thus, teeth that present with postsurgical pathosis often lack proper orthograde endodontic treatment. In these cases, surgical retreatment with a traditional technique is unlikely to be successful (6, 7). The first clinical results regarding the treatment outcome after microresurgery are promising. However, the number of cases is rather small, and the observation periods are relatively short (8). After failed primary root canal treatment, orthograde retreatment should always be considered first instead of apical surgery (3, 9, 10). When a patient presents with post-treatment disease in a tooth in which apicectomy had already been performed instead of orthograde retreatment, the endodontist must still come up with a treatment plan. However, current data regarding the treatment outcome of nonsurgical retreatment after failed apicoectomy are limited. There are only a small number of case reports that describe a nonsurgical treatment approach after failed apicoectomy. The first step is the complete removal of the root canal filling material and adequate cleaning and shaping of the root canal system. Next, the root canal is obturated by orthograde placement of an apical mineral trioxide aggregate (MTA) plug (11–13). Despite the low level of evidence from case series based on the criteria of the Centre for Evidence-Based Medicine, Oxford, England (14), the reported treatment outcome appears favorable. Thus, it is important to further evaluate the clinical data regarding this treatment option. The present study is part of a recently published clinical trial (15). The treatment outcome of MTA in open apex teeth was evaluated based on clinical and radiographic findings. In contrast to the clinical trial published in 2013, in the present study, the only reason for the open apex was apicoectomy. Primary root canal treatment and apicoectomy had been completed elsewhere before these patients presented with post-treatment disease at the Division of Endodontics, University Hospital of Heidelberg, Heidelberg, Germany. Usually, the former treatment providers have only offered the...
Inclusion and Exclusion Criteria

recorded based on the well-established criteria described by Rud et al (16) and Molven et al (17). In addition, cone-beam computed tomographic (CBCT) imaging was used as a diagnostic tool in uncertain cases.

The first aim of this clinical study was to systematically assess the 1- to 5-year treatment outcomes in teeth that had undergone orthograde retreatment and reobturation with MTA apical plugs after失败apicectomy. The second aim of this study was to investigate the association of potential prognostic factors with the treatment outcome of this nonsurgical treatment approach for teeth that present with post-treatment disease after the apicectomy has already been performed.

Materials and Methods

The study protocol of this historical cohort study was approved by the Ethics Committee of the University of Heidelberg (ref. 095/2010). The participants were recruited from among the patients of the Department of Conservative Dentistry, University Hospital of Heidelberg. Patients who had undergone nonsurgical retreatment after failed apicectomy between November 2003 and June 2012 were selected for potential inclusion.

Inclusion and Exclusion Criteria

Subjects were selected from among the patients who presented with signs and symptoms after the apicectomy had been performed elsewhere. Because the existing root canal filling was radiographically evaluated to be inadequate in every case included in the study, all patients underwent nonsurgical retreatment followed by orthograde placement of an apical MTA plug. The study sample was confined to teeth with a follow-up period of at least 12 months. A tolerance of 14 days was accepted. A compromised immune status or pregnancy at the time of follow-up resulted in exclusion from the study. Cases with missing pre- and intraoperative information were excluded from the study. Any tooth diagnosed with either a longitudinal root fracture or a periodontal-endodontic lesion on the day of the nonsurgical retreatment was excluded from the study.

Recruitment of Patients

The recruitment of patients has been previously described in detail (15). Briefly, patients who met the previously mentioned inclusion criteria were contacted and invited to attend the follow-up examinations. The potential participants received detailed information about the study. Clinical and radiographic follow-up examinations were performed only after written informed consent had been given.

Endodontic Treatment Intervention

The treatment providers were either postgraduate students or endodontic specialists. A dental operating microscope (Zeiss, Oberkochen, Germany) was used during the entire root canal treatment in every case. A rubber dam was applied, and the access cavity was then prepared. The root canal filling material was removed using nickel-titanium rotary instruments or hand files. The treatment providers were free to choose from various types of endodontic files. The following nickel titanium rotary instruments were available for use: File Master and Reciproc files (VDW, Munich, Germany), ProTaper retreatment files (Dentsply Maillefer, Ballaigues, Switzerland), and GT rotary files (Dentsply Maillefer). The following hand files were available for use: nickel-titanium Hedström files and nickel titanium K-type files (Brasseler, Lemgo, Germany), stainless steel Hedström files and K-type files (VDW), and GT hand instruments (Dentsply Maillefer). When necessary, posts were carefully removed using ultrasound vibration (P5 XS; Acteon Group, Mérignac Cedex, France). There were no complications, such as root perforation or instrument fracture, during the retreatments. The working length was established with the aid of an apex locator (Raypex 4, VDW) and was confirmed radiographically. The root canals were intermittently irrigated with ultrasonically activated 3% sodium hypochlorite (Hedinger GmbH, Stuttgart, Germany) and 2% chlorhexidine (Engelhard Arzneimittel GmbH, Niederdorfelden, Germany) using a 27-G needle (Transcoject, Neumünster, Germany).

When switching from sodium hypochlorite to chlorhexidine or vice versa, root canals were irrigated with ethyl alcohol to prevent the precipitate formation of parachloroaniline. After completion of root canal instrumentation, the canals were irrigated with the EDTA containing Smear Clear (Sybron Endo, Orange, CA) for 60 seconds. The canals were finally flushed with chlorhexidine and dried with sterile paper points (VDW). The nonsurgical retreatment was performed in 1 or multiple sessions. In cases of multiple sessions, calcium hydroxide powder was mixed with chlorhexidine to form a pasty consistency, and the paste was applied with a Lentulo spiral (VDW) to form the intracanal dressing. The access cavities were temporarily sealed with zinc oxide–eugenol cement (IRM; Dentsply, Konstanz, Germany).

Orthograde Obturation and Application of Apical MTA Plug

Small portions of MTA were inserted with an MTA delivery carrier (Dentsply Maillefer) and compacted apically with Machtou pluggers of sizes 0, ½, and ¾ (Dentsply Maillefer). The minimum thickness of the apical MTA plug was 4 mm. The correct position and the adequate extent of the apical MTA plug were confirmed radiographically. If the MTA plug was poorly placed and was too short or exhibited voids, then the MTA was removed with a small ultrasonic tip (S 25, Acion Group) coupled with irrigation and subsequently replaced.

The residual root canal space was backfilled immediately after placement of the MTA plug. It was filled with injectable gutta-percha (Obtura III; Obtura Spartan, Fenton, MO) and AH Plus sealer (Dentsply) with ProRoot MTA (Dentsply Maillefer) or with bonded composite resin (Tetric EvoCeram bleach; Vivadent, Schaan, Liechtenstein). After completion of the root canal filling, the access cavities were sealed with composite resin (Tetric Ceram, Vivadent). Post-treatment radiographs were taken immediately using the parallel technique with an RWT film holder (KKD GmbH, Elwangen, Germany) and 30 × 40 mm ISO classification E dental film (Kodak Ekta-Speed Plus; Carestream Health Inc, New York, NY).

Pre- and Intraoperative Data

The acquisition of pre- and intraoperative information from the patients’ records and data entry into a specifically designed database spreadsheet were previously described in detail (15).

Calibration

Clinical Calibration. Given the high interexaminer reliability achieved during the calibration process in phase 1 of the present study (18), we simplified the clinical calibration process for further similar study projects. The clinical calibration was performed using study models (A1 and B1; KaVo, Biberach Germany). The step-by-step procedure of this clinical calibration has recently been described in detail (19).

Radiographic Calibration. Radiographs were independently interpreted by 2 experienced endodontists using the criteria and classification described by Rud et al (16) and Molven et al (17). Before the
interpretation of the study radiographs, both examiners assessed sample radiographs using the schematic depiction of different healing categories published by Molven et al (17). The procedure has been previously described elsewhere (2). The interexaminer agreement was computed according to Rud et al (16) and Molven et al (17).

Follow-up Examination

Two calibrated examiners (M.L. and T.P.) performed the follow-up examinations at least 12 and up to 109 months after treatment. A detailed description of the follow-up examination was previously published (15).

Outcome Assessment

The treatment outcome was evaluated based on clinical and radiographic findings. Periapical radiographs were taken using the parallel technique to ensure high reproducibility. The preoperative and follow-up radiographs were assessed independently and in a random sequence by 2 experienced endodontists (T.P. and J.M.). All radiographs were viewed in a darkened room using an illuminated viewer box (Kentzler-Kaschner Dental GmbH, Ellwangen, Germany) with 2× magnification.

Any radiographically visible pathological changes, such as persistence and recurrence of radiolucent lesions, root resorption, and apical extrusion of MTA, were recorded. Postoperative periapical healing was assessed radiographically using the well-established classification introduced by Rud et al (16) and Molven et al (17). The classification distinguishes between the following 4 groups of healing:

1. Complete healing
2. Incomplete healing (scar tissue)
3. Uncertain healing
4. Unsatisfactory healing

The treatment outcomes were recorded as “success” in cases of “complete healing” or “incomplete healing (scar tissue)” (20). Furthermore, the tooth had to be free of clinical signs or symptoms and had to remain functional. The treatment outcome was recorded as “failure” in cases of “uncertain healing” or “unsatisfactory healing.” If a tooth presented with clinical signs or symptoms or if it had lost functionality, then the treatment outcome was also recorded as “failure.”

In cases of interobserver disagreement regarding the radiographic interpretation, the 2 examiners discussed their findings and reached a consensus. To minimize the risk of misinterpretation in cases in which the periapical radiographs were difficult to interpret, the periapical situation was also assessed by CBCT imaging. The results of this additional advanced 3-dimensional imaging method were then used to decide between “success” and “failure.”

CBCT scans were obtained with the Veraviewepocs 3D (J Morita Mfg Corp, Kyoto, Japan). The imaging settings were as follows: small field of view (40 × 40 mm), high resolution (0.125-mm voxels), 80 kV, and 7 mA. The CBCT images were viewed with i-dixel software (J Morita). Two experienced observers (H.G. and J.M.) evaluated the CBCT images independently.

Statistical Analysis

The interexaminer agreement regarding radiographic examination was quantified using the Kappa-Cohen test. The median, first and third quartile, minimum and maximum, and relative and absolute frequencies were calculated for descriptive analyses. The chi-square test was applied to investigate the effect of potential outcome predictors. The data were analyzed using the SAS statistical package (Version 9.3; SAS Institute Inc, Cary, NC). There were no adjustments made for multiple testing because of the exploratory nature of the study. All tests were performed at a significance level of 0.05.

Results

Calibration Process

The clinical calibration resulted in a high level of consensus with the “authorized measurements.” There were 1008 measurements of probing depths and 144 measurements of furcation involvement.

| TABLE 1. Outcome Distribution by Preoperative Factors and Estimated Relative Rates of Success |
|-----------------------------------|--------|--------|
| Factor                            | Teeth Healed | Disease |
| Age                               | n      | %      | N      | %      | P value* | OR† (95% CI) |
| ≤45 y                             | 18     | 78     | 15     | 83     | 3       | 17       | .33 2.48 (0.1–56.18) |
| >45 y                             | 5      | 22     | 5      | 100    | —       | 0        | .83 1.33 (0.1–17.29) |
| Sex                               | Female | 14     | 61     | 12     | 86     | 2        | 14       | .27 0.32 (0.01–7.11) |
|                                   | Male   | 9      | 49     | 8      | 89     | 1        | 11       | .03 0.08 (0–1.76) |
| No. of roots                      | 1      | 13     | 57     | 13     | 100    | —        | 0        | .05 0.1 (0–2.14) |
|                                   | ≥2     | 10     | 43     | 7      | 70     | 3        | 30       | .59 2 (0.15–25.76) |
| Tooth type                        | Anterior | 6     | 26     | 6      | 100    | —        | 0        | .57 1.06 (0.06–18.01) |
|                                   | Posterior | 17    | 74     | 14     | 82     | 3        | 18       | |
| Tooth location                    | Maxilla | 12     | 52     | 12     | 100    | —        | 0        | |
|                                   | Mandible | 11    | 48     | 8      | 73     | 3        | 27       | |
| Signs or symptoms (preoperative)  | Absent  | 12     | 52     | 10     | 83     | 2        | 17       | |
|                                   | Present | 11     | 48     | 10     | 91     | 1        | 9        | |
| Apical periodontitis (preoperative)| Absent  | 2      | 9      | 2      | 100    | —        | 0        | |
|                                   | Present | 21     | 91     | 18     | 86     | 3        | 14       | |

CI, confidence interval; OR, odds ratio.
Numbers in parentheses denote the lower and upper limits of the 95% CI. Bold denotes statistical significance at a 5% confidence level. Healing classification according to Rud et al (16); in cases in which radiographic findings at follow-up were unclear, outcome was assessed using cone-beam computed tomographic imaging.

*Chi-square test.
†Mantel-Haenszel odds ratio (the logit estimator was used if a cell contains a zero).
reviewed by each examiner and statistically analyzed for concordance with the "authorized measurements." The interexaminer agreement regarding probing depth measurements was 95% and 96%, respectively. The interexaminer agreement regarding the assessment of furcation involvement was 93% for both examiners. The intraexaminer reliability regarding probing depth measurements was 96.5% and 98%, respectively. The intraexaminer reliability regarding furcation involvement measurements was 91.5% for both examiners. The radiographic calibration according to revealed "substantial agreement" \( k = 0.774 \).

### Study Group

Twenty-four patients were initially identified for potential inclusion in the study. There were 22 patients with a total of 23 teeth in the follow-up examinations. The time of follow-up ranged from 12 to 102 months (median = 35 months, 92% recall rate). The patient ages ranged from 23–60 years, and the median age was 36 years (first quartile = 30 years, third quartile = 44 years). The reasons for study dropout were recorded, and there were 2 patients (8%) who refused to participate in the recall.

The reasons why patients had been referred to the Division of Endodontics, University Hospital of Heidelberg and why nonsurgical orthograde retreatment after failed apicoectomy was considered were as follows: a persistent or increasing periapical lesion of more than 1 year after apicoectomy (21/23 teeth, 91%); clinical signs and symptoms 11 and 98 months after an apicoectomy, respectively (2/23 teeth, 9%); and persistent or increasing periapical radiolucency combined with clinical signs and symptoms (9/23 teeth, 39%).

### Success Rate

The treatment outcome relative to recorded pre-, intra-, and postoperative variables is shown in Tables 1–3. There were 20 teeth (87%)
classified as “success” and 3 teeth (13%) classified as “failure.” One tooth had been extracted at the time of follow-up because the patient presented with persistent clinical signs and symptoms 4 months after nonsurgical retreatment. One tooth was extracted because of a symptomatic longitudinal root fracture 21 months after nonsurgical retreatment. The third failed tooth showed decreased, albeit still present, periapical radiolucency 5 years after nonsurgical retreatment. The CBCT analysis confirmed the persistent periapical lesion in this case (Fig. 1B–D).

Influence of Potential Prognostic Factors

We identified 2 preoperative variables that were associated with higher healing rates. The success rates were higher in anterior (6/6 teeth healed, 100%) than in posterior teeth (14/17 teeth healed, 82%). Additionally, the healing rates of single-rooted teeth (13/15 teeth healed, 100%) were higher than those of multirooted teeth (7/10 teeth healed, 70%). The healing rates differed by more than 15% with regard to 2 intraoperative factors (root canal backfill technique coronal to MTA plug and experience of treatment provider). The data are described in detail in Table 2. Postoperatively, only the type of restoration was associated with notable differences in treatment outcome (Table 3). The chi-square test found that “number of roots” was a statistically significant influence on treatment outcome (odds ratio [OR] = 0.08; 95% confidence interval [CI], 0–1.76; P = .03). The variable “tooth location” was borderline between significant and not significant (OR = 0.1; 95% CI, 0–2.14; P = .05). Because of the relatively small sample size, a multivariate analysis was not performed.

Discussion

This single-center, historic cohort study project is part of a recently published clinical trial (15). In this study, clinical interventions were assessed retrospectively, whereas treatment outcome was assessed prospectively. The treatment outcomes of nonsurgical retreatment after failed apicoectomies that were reobturated by orthograde placement of MTA apical plugs were evaluated independently by calibrated examiners. The patient follow-up periods ranged from 12 to 102 months after treatment. The radiographic evidence of periapical healing requires a follow-up period of at least 1 year (22, 23). Longer follow-up periods are particularly important in the case of persistent lesions after surgical endodontic treatment (24). These requirements were met with the relatively long follow-up periods in this study. Despite the low number of cases, the high recall rate of 92% increases the level of evidence (25, 26).

The treatment outcome was successful in 86% of the cases (Table 1). This result compares with the success rates reported for conventional orthograde root canal retreatment of previously nonsurgically
treated teeth (3, 9, 10) and is superior to the healing rates reported for surgical retreatment using a traditional technique (6, 7). In addition, these results are slightly below the healing rates for endodontic microsurgery of teeth with post-treatment disease (8).

Data of the present study suggest that the decision for endodontic surgery is sometimes made independent of the factors responsible for postendodontic apical periodontitis. The presence of persistent contamination of the root canal system because of coronal or apical leakage (27, 28), untreated root canals (29), inadequate root canal disinfection during primary root canal treatment (30), and poor quality of the root canal filling (31, 32) respond very well to conventional orthograde retreatment (3, 9). Thus, after failed primary root canal treatment, orthograde retreatment should always be considered first and ideally performed by an endodontist using a dental operating microscope (3). The majority of teeth treated in this manner would have been healed without additional therapy (9, 10). However, apical surgery is still performed ignoring the factors that lead to apical pathosis in the first place. Importantly, clinicians might be able to offer these patients a reasonable treatment approach in addition to extraction. The statistical analysis in this study identified 1 outcome factor (ie, “number of roots” [OR = 0.08; 95% CI, 0–1.76; \( P = 0.03 \)]) out of all of the potential prognostic factors evaluated within this study (Tables 1–3). All failures occurred in multirupted teeth (Table 1). This result was consistent with findings obtained by other studies that showed worse healing rates for multirupted teeth (33, 34). The root canal system of multirupted teeth is generally more complex than in single-rooted teeth (35), which may account for the difference in success rates.

The potential prognostic factor “tooth location” was of borderline significance (OR = 0.1; 95% CI, 0–2.14; \( P = 0.05 \)) and should be re-evaluated in further clinical studies with a larger sample size. The “apical extrusion of MTA” did not negatively affect treatment outcome (OR = 0.59; 95% CI, 0.03–6.44; \( P = 0.5 \)). MTA is a material suited for areas in which there is a physical communication between the root canal system and the periodontium (15, 19, 36, 37). MTA sets in moist environments, including blood (38, 39). This material shows excellent sealing properties (40–42). Given the favorable characteristics of MTA, it is not surprising that the “apical extrusion of MTA” did not significantly affect treatment outcome. When recording treatment outcome, all examiners should be calibrated clinically and radiographically before the examinations (26). Outcome in endodontics should always be assessed using a combination of clinical and radiographic findings. The radiographic appearance of teeth after periapical surgery differs somewhat from teeth after...
nonsurgical endodontic treatment. Thus, periapical radiographs were not interpreted using the periapical index (PAI) (43). The examiners used the well-established radiographic classifications of Rud et al (16) and Molven et al (17), which are particularly suited for assessing periapical healing after endodontic surgery (2, 44–48).

The authors suspect that the additional evaluation of periapical tissues by CBCT in cases of inconclusive periapical radiographs resulted in less misinterpretations concerning periapical healing. CBCT images are known to show periapical bone loss as a sign of apical pathosis more accurately than periapical radiographs (49–53).

In the present study, several cases exemplify the diagnostic value of CBCT imaging in detecting periapical pathosis. A mandibular first molar 7.5 years after apicoectomy is shown in Figure 1A. Radiographically, periapical pathosis is evident both on the mesial and distal root. The follow-up radiograph 5 years after the orthograde retreatment showed a substantial reduction in periapical radiolucency (Fig. 1B) compared with the preoperative radiograph (Fig. 1A). The examiners found that the periapical radiographs did not provide sufficient data to determine whether the tooth should be classified as a “success” or “failure.” Periapical pathosis is expected to resolve within 4 to 5 years after treatment (20). Thus, it was particularly important to accurately assess treatment outcome. The CBCT images revealed persisting periapical pathosis (Fig. 1C and D). The usefulness of additional CBCT imaging can also be seen in another case, which is shown in Figure 2A–D. A mandibular first molar before and 4.5 years after orthograde retreatment is shown in Figure 2A and B. The follow-up radiograph shows that the bone bordering the periapical area is less dense than the surrounding bone. The 3-dimensional assessment of periapical tissue confirmed complete periapical healing with bone tissue present in direct contact with the resected root tips (fig. 2C and D). Although the bone bordering the apical area still does not consistently have the same radiopacity as the surrounding bone that was not involved in the apical surgery, this case would still be considered a “success.” In contrast, CBCT imaging was not considered necessary in the case presented in Figure 3. The preoperatively existing periapical pathosis is radiographically visible (Fig. 3A). In addition, the patient reported that he had felt pain originating from this tooth. Furthermore, a fracture of the distal part of the coronal restoration was evident before orthograde retreatment was performed. The follow-up radiograph 16 months after orthograde retreatment still showed small defects in the lamina dura adjacent to notable amounts of apically extruded root MTA (Fig. 3B). After 45 months, complete regeneration of the periodontal ligament space around the resected root tip and the extruded MTA was visible (Fig. 3C). In this case, additional CBCT imaging was not considered necessary to confirm complete healing of the periapical tissues. Despite the advantages of CBCT images in assessing periapical pathosis, the general use of CBCT scans instead of or in combination with periapical radiographs cannot be recommended. Because of the comparatively high radiation dose (54), the risks might outweigh the benefits. The authors advise using CBCT imaging when the periapical status cannot be clearly assessed using 2-dimensional periapical radiography.

Conclusions

The results of the present study indicate that orthograde nonsurgical retreatment after failed apicoectomy may present a treatment option with favorable prognosis if the orthograde revision is performed using a dental operating microscope and orthograde inserted MTA apical plugs are used for reobturation. The authors recommend the use of CBCT imaging in cases of inconclusive periapical radiographs to minimize the risk of misinterpretation when assessing treatment outcome.

Despite the promising results reported in the present study, further clinical research is necessary to confirm the reported success rates and to clarify the effect of potential factors on treatment outcome.

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The authors deny any conflicts of interest related to this study.
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