Journal of Orthodontic and Periodontal Biomaterials Research

2024, Volume 4, Issue 2, Page No: 55-65

Available online at: https://galaxypub.co/

Galaxy Publication

Clinical Outcomes of Local Minocycline and Doxycycline Therapy in Acute Periodontal Abscess Management: A Retrospective Study

Lucas Meyer[1]*, Anna Schmid[2]

[1]Department of Orthodontic Materials Science, Faculty of Dentistry, University of Zurich, Zurich, Switzerland.
[2]Department of Periodontal Biomaterials Engineering, Faculty of Dentistry, University of Bern, Bern, Switzerland.

***E-mail** ✉ lucas.meyer@gmail.com

Received: 19 April 2024; **Revised:** 28 August 2024; **Accepted:** 03 September 2024

ABSTRACT

The objective of this retrospective clinical study was to provide evidence supporting the adjunctive local application of doxycycline solution or minocycline ointment, in conjunction with drainage, for the treatment of acute periodontal abscesses. The study included 63 patients who had received treatment for acute periodontal abscesses through drainage supplemented with 1 of 3 types of adjunctive medications during their initial visit (visit 1; baseline): 1) saline irrigation (the control group), 2) 2% minocycline ointment (the TM group), or 3) 300 mg/mL doxycycline irrigation (the TD group). The same adjunctive medication was administered at visit 2, which took place 1 week after visit 1. Probing depth (PD), bleeding on probing (BOP), plaque index, gingival recession, clinical attachment level, and tooth mobility were clinically evaluated at visits 1, 2, and a third visit (visit 3; 4 weeks after visit 1). Statistical significance was considered to be indicated by P values <0.05. By visit 3, all clinical indices and tooth mobility had significantly decreased in each group. At this visit, PD and BOP on the abscess side were significantly lower in the TM and TD groups compared to the control group. The TD group showed a significantly greater improvement than the TM group, with mean PD reductions of 1.09 mm in the control group, 1.88 mm in the TM group, and 2.88 mm in the TD group. Similarly, mean BOP reductions were 45% in the control group, 73.02% in the TM group, and 95.45% in the TD group. Local and adjunctive administration of doxycycline and minocycline in combination with drainage exhibited clinical advantages over drainage alone in improving PD and BOP. Notably, a doxycycline solution of 300 mg/mL was more effective than a 2% minocycline ointment.

Keywords: Doxycycline, Drainage, Minocycline, Periodontal abscess, Retrospective study

How to Cite This Article: Meyer L, Schmid A. Clinical Outcomes of Local Minocycline and Doxycycline Therapy in Acute Periodontal Abscess Management: A Retrospective Study. J Orthod Periodontal Biomater Res. 2024;4(2):55-65. https://doi.org/10.51847/gHZDzZwN47

Introduction

Acute periodontal abscess with rapid destruction of periodontal tissues is accompanied by pus discharge, gingival edema, pain on palpation, purulent exudate, and an increased depth of the periodontal pocket [1-3]. Additionally, the sudden loss of periodontal attachments, vertical destruction of the alveolar bone, and worsening of furcation involvement may produce heightened sensitivity to percussion and increased tooth mobility, potentially leading to tooth loss [4]. This condition accounts for roughly 10% of dental emergencies, making it the third most common after dentoalveolar abscess and pericoronitis [2]. A long-term study found that 53% of patients who had undergone periodic checkups over a 7-year period continued to be affected by this disease [5].

An acute periodontal abscess can appear at a site with a pre-existing pathological deep periodontal pocket or at a healthy site without prior lesions. In the former case, the pressure in the periodontal pocket increases because of the accumulation of purulent exudate as the entrance of the pocket becomes blocked, which may be associated with inappropriate periodontal treatment or superinfection due to systemic antibiotic use. The latter involves the introduction of foreign materials into the healthy gingival sulcus or dysplasia of 1 or more roots. Patients with periodontitis who do not receive appropriate treatment exhibit significant vulnerability to periodontal abscesses. The lesions in these patients typically contain periodontal pathogens such as *Porphyromonas gingivalis*, *Tannerella forsythia*, and *Treponema denticola* [6].

Numerous studies have assessed the effectiveness of pharmacologically reducing bacterial pathogen activity as a supplement to traditional inflammation relief methods such as drainage, surgery, or tooth extraction. Some of these studies have employed systemic or local antibiotics without any mechanical intervention [5, 7]. While the use of systemic antibiotics has been demonstrated effective, ongoing limitations and concerns exist regarding potential superinfection and the lack of evidence supporting the choice of antibiotics [5, 7]. Consequently, most studies suggest prescribing systemic antibiotics to patients with periodontal abscesses only when systemic symptoms are present [4, 5].

The local application of antibiotics appears to be both advantageous and safer than systemic administration, with many antibiotics from the tetracycline family gaining widespread use [8-11]. Both minocycline and doxycycline not only have antibacterial properties but also exhibit additional functions, such as anti-inflammatory activity and resistance to alveolar bone resorption. These attributes have led clinicians to predict their efficacy in treating periodontal abscesses [12, 13].

The efficacy of local antibiotics in treating chronic periodontitis has been evaluated [14, 15]. A recent systematic review concluded that the sustained release of minocycline or doxycycline is superior to mechanical debridement alone for periodontal pocket depth reduction [16]. Numerous studies have involved the administration of tetracycline solutions of varying concentrations in patients with chronic periodontitis [17, 18]. Beyond chronic periodontitis, the local application of minocycline has been shown to be effective in treating acute periodontal abscesses [6]. However, few studies have directly compared the impacts of locally applied tetracycline antibiotics on periodontal abscesses.

The objective of this study was to evaluate the effectiveness of locally administered doxycycline or minocycline, in conjunction with surgical drainage, in the treatment of periodontal abscesses.

Materials and Methods

Study design and population

This retrospective case series involved patients who underwent treatment for acute periodontal abscess between January 1, 2019 and December 31, 2020 at a local dental clinic (Dr. Care's Dental Clinic, Incheon, Korea). All treatments were performed by a single periodontist (D.Y.J.). Of the 83 patients treated for acute periodontal abscess, 63 met the eligibility criteria. This group comprised 33 men and 30 women, with a mean age of 46.2 years (mean ages of 42.1 and 50.3 years for men and women, respectively). The patients were divided into 3 groups according to the type of treatment they received: 1) Control group (n=20): saline irrigation alone after drainage; 2) TM group (n=21): saline irrigation after drainage + minocycline ointment application; and 3) TD group (n=22): saline irrigation after drainage + doxycycline solution irrigation.

All data were collected with the approval of the Human Subject Ethics Institutional Review Board at Yonsei University Dental Hospital (approval No.: 2-2021-0032). This manuscript was prepared in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology guidelines.

Inclusion and exclusion criteria

Inclusion criteria

The inclusion criteria were: 1) Normal body temperature (36.4°C–36.7°C); 2) A first or second maxillary or mandibular molar with acute pain; 3) A periodontal pocket depth ≥6 mm; 4) Pus formation; 5) Alveolar bone loss on a periapical radiograph; and 6) A clinically detectable ovoid swelling in the buccal or lingual gingiva indicative of an acute periodontal abscess [1, 19].

Exclusion criteria

The exclusion criteria included: 1) Use of medications that may induce the signs or symptoms of periodontal disease (e.g., calcium channel blockers, phenytoin, cyclosporine, warfarin, acetylsalicylic acid, or clopidogrel);

2) Presence of uncontrolled hypertension, diabetes, or heart disease; 3) Current smoker or ex-smoker for ≤10 years; 4) Pregnant or lactating; 5) History of allergic reaction to antibiotics in the tetracycline family; 6) Abscess-like lesions caused by factors other than possible periodontal pathogens (i.e., foreign body impaction, endodontic origin, tooth crack, or root fracture); 7) Abscess extending to the adjacent teeth; 8) Antibiotics administered within 1 month before or after the treatment or anti-inflammatory drugs administered post-treatment; 9) Cervical lymphadenitis after treatment; and 10) Difference in prescribed medications between the first and second visits.

Treatment procedure

All patients underwent treatment following a clinical protocol established at a local clinic [1]. A single seasoned periodontist, D.Y.J., carried out all procedures outlined below **(Figure 1)**.

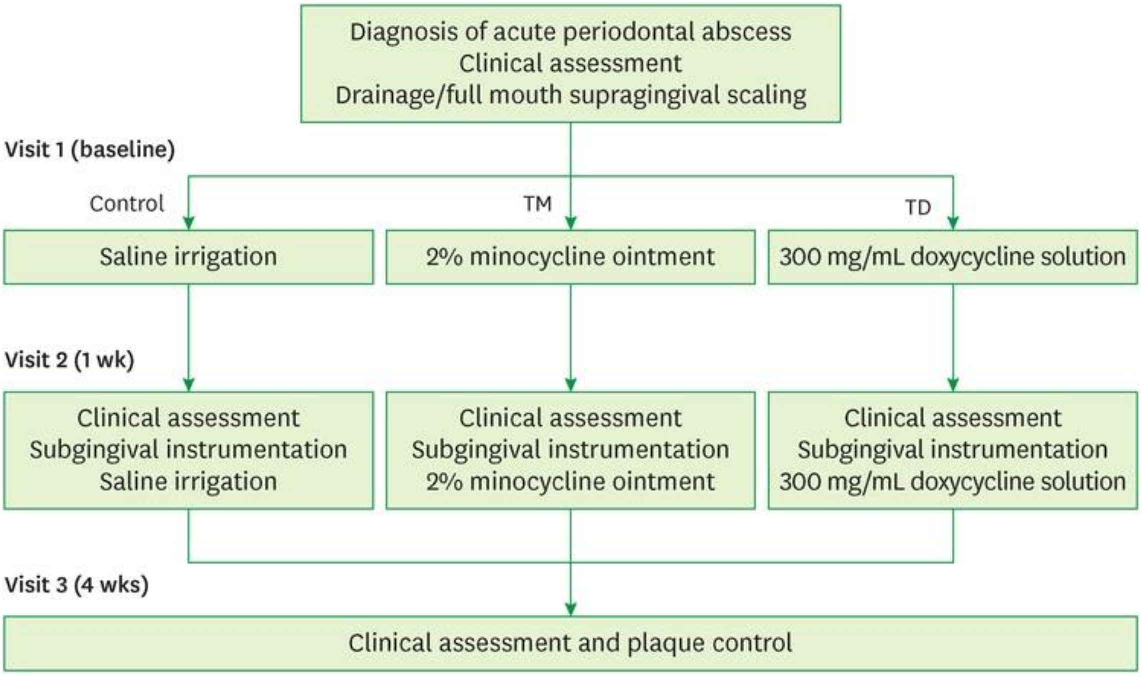

Figure 1. Treatment protocol. Control: saline irrigation alone after drainage, TM: saline irrigation after drainage + minocycline ointment application, TD: saline irrigation after drainage + doxycycline solution irrigation.

At the initial appointment (visit 1), after clinical and radiographic examinations, the abscess site was drained through the periodontal pocket under local anesthesia with 2% lidocaine containing epinephrine at a 1:100,000 ratio (Huons, Seoul, Korea). Supragingival calculus was removed using an ultrasonic scaler and a hand instrument. Following detailed explanations of the treatments, patients were instructed to select their preferred therapeutic modality.

- For the control group, the periodontal pocket was irrigated with normal saline at room temperature (15°C–25°C) for 5 minutes.
- For the TM group, after irrigation of the periodontal pocket with normal saline, a 2% minocycline ointment was applied. Any ointment that overflowed onto the gingival margins was subsequently removed.
- For the TD group, a 300 mg/mL solution of doxycycline was prepared by dissolving the powder from a doxycycline capsule (100 mg of doxycycline per capsule) in normal saline at 40°C using a water bath. The chosen concentration was based on findings from previous studies, which reported the use of up to 40% hydroxypropyl methylcellulose doxycycline [17, 20, 21]. This solution was then applied to the periodontal pocket for 5 minutes, after which it was irrigated with normal saline.

At visit 2, which took place 1 week after visit 1, a clinical examination was conducted and full-mouth root planing was performed, with local anesthesia administered if required. The abscess sites were then treated repeatedly, following the assigned treatment protocol [22]. At visit 3 (4 weeks after visit 1), a clinical examination was performed, and plaque control measures were implemented.

Outcome variables

The primary outcome was probing depth (PD). We also considered several secondary outcomes, which included various clinical parameters such as bleeding on probing (BOP), plaque index (PI), gingival recession (GR), clinical attachment level (CAL), and tooth mobility as represented by the Periotest value (PTV; Periotest M; Medizintechnik Gulden, Modautal, Germany).

Outcome measurements

Clinical parameters (PD, BOP, PI, GR, and CAL) were measured at 6 sites around the tooth at each visit prior to treatment. A single examiner (D.Y.J.) measured PD and BOP. PD was measured on 6 surfaces (mesiobuccal, mid-buccal, distobuccal, mesiolingual, mid-lingual, and distolingual) of the tooth with an approximate value of 1 mm using a UNC-15 periodontal probe (Hu-Friedy, Chicago, IL, USA), as described below.

- Average PD, BOP, PI, GR, and CAL (abbreviated as avrPD, etc.): the average values of the indices measured at the 6 sites, serving as representative values for each tooth
- Abscess-side PD (sidePD) and BOP (sideBOP): the average PD and BOP measured at the 3 sites on the buccal or lingual side on which the abscess is located
- Deepest PD (deepPD) for each tooth: the deepest PD among the PDs measured at different tooth sites

After every PD measurement, BOP was noted. A score of 0 was assigned if bleeding occurred within 10 seconds of probing, while a score of 1 was given if no bleeding was observed [23]. The PI was determined on a scale of 0 to 3, depending on the quantity and location of plaque accumulation [24]. GR was measured from the cementoenamel junction to the gingival margin, and CAL was calculated as the sum of the PD and GR measurements.

Tooth movement was quantified as the PTV, displayed by a device measuring the damping capacity from −8 to +50 and measured in compliance with the manufacturer's instructions. To reduce errors and optimize measurement consistency, an oil-based pen was used to mark the center of the buccal surface of the tooth with a red dot, and the PTV was measured at that position by the examiner responsible for all PD measurements (D.Y.J.).

Statistical analysis

All statistical analyses were performed using standard computer software (SPSS version 23.0; IBM, Armonk, NY, USA). As each patient was treated at a single site, the clinical data obtained at each visit were analyzed at the patient level. Normally distributed data were compared using the Shapiro–Wilk test and expressed as mean ± standard deviation. Paired *t*-tests were used to compare all indices between the first and subsequent visits within a group, and 1-way analysis of variance (ANOVA) was used for comparing the 3 groups at visit 1 (baseline). Repeated-measures ANOVA was used to compare changes over time among the 3 groups. A linear mixed model was used for intergroup comparisons of the correlations between time and changes in PD (sidePD) and BOP (sideBOP) on the abscess side (buccal or lingual). Additionally, 1-way ANOVA was used for intergroup comparisons of the PD change at the deepest site (deepPD) between visits 1 and 2 (the first period) and between visits 2 and 3 (the second period). For all statistical analyses, the significance cutoff was 5%, and a *post hoc* test with Bonferroni correction was applied when necessary.

Results and Discussion

Patient characteristics

Generalized stage 3 periodontitis was identified in most patients. **Table 1** summarizes the demographic information.

Table 1. Demographic information of the patients at baseline

Variables	Control group	TM group	TD group
Number of patients	20	21	22
Sex			
Female	8	10	12
Male	12	11	10
Age (yr; mean ± standard deviation)	48.7±9.4	43.6±7.7	46.3±10.0

Past dental history regarding periodontal disease			
Having periodontitis never treated	17	19	20
Under periodic maintenance after treatment	3	2	2
Location			
Anterior/Posterior	0/20	0/21	0/22
Maxilla/Mandible	6/14	6/15	4/18
Buccal/Lingual	18/2	16/5	20/2

Control group: saline irrigation alone after drainage, TM group: saline irrigation after drainage + minocycline ointment application, TD group: saline irrigation after drainage + doxycycline solution irrigation.

All patients showed clinical improvement after the first treatment. Most patients experienced a significant subjective reduction in pain. At visit 2, 5 patients in the control group and 3 and 4 patients in the TM and TD groups, respectively, reported mild spontaneous pain and/or pain on biting; none of them reported pain at visit 3.

Measurements of clinical parameters and tooth mobility

At visit 1, before treatment, none of the clinical parameters (PD, BOP, PI, GR, or CAL) differed significantly among the groups. **Tables 2-4** summarize all clinical data.

Table 2. Average values of clinical parameters and tooth mobility (PTV) measured at each time point (mean ± standard deviation)

Clinical parameter	Group	Visit 1 (baseline)	Visit 2 (1 wk)	Visit 3 (4 wks)	*P*(rmA) Control vs. TM vs. TD	*P*(LMM) Control vs. TM Control vs. TD TD vs. TM
avrPD (mm)	Control	6.97±1.20	6.74±1.19[c)]	6.22±1.14[c)]	*P*<0.001[a)]	*P*=0.008[b)]
	TM	6.66±1.41	6.34±1.29[c)]	5.41±1.24[c)]		*P*<0.001[b)]
	TD	7.03±1.23	6.46±1.35[c)]	5.29±1.31[c)]		*P*=0.010[b)]
avrBOP (%)	Control	80.83±22.47	74.17±24.46[c)]	39.17±24.94[c)]	*P*=0.007[a)]	*P*=0.047[b)]
	TM	83.33±22.36	74.60±24.05[c)]	20.63±25.22[c)]		*P*=0.004[b)]
	TD	78.79±22.57	63.64±26.54[c)]	6.82±8.38[c)]		*P*=0.368
avrPI	Control	1.76±0.84	0.57±0.46[c)]	0.81±0.49[c)]	*P*=0.479	*P*=0.743
	TM	1.80±0.76	0.61±0.38[c)]	0.96±0.62[c)]		*P*=0.401
	TD	1.91±0.87	0.63±0.35[c)]	1.24±0.73[c)]		*P*=0.606
avrGR (mm)	Control	0.45±0.67	0.64±0.60[c)]	0.80±0.58[c)]	*P*=0.854	*P*=0.638
	TM	0.24±0.55	0.42±0.49[c)]	0.64±0.38[c)]		*P*=0.451
	TD	0.35±0.57	0.54±0.51[c)]	0.78±0.52[c)]		*P*=0.778
avrCAL (mm)	Control	7.43±1.52	7.40±1.49[c)]	7.03±1.39[c)]	*P*<0.001[a)]	*P*=0.125
	TM	6.91±1.56	6.76±1.50[c)]	6.05±1.37[c)]		*P*<0.001[b)]
	TD	7.38±1.14	7.01±1.20[c)]	6.07±1.24[c),]		*P*=0.002[b)]
PTV	Control	28.28±10.12	25.20±9.60[c)]	18.50±9.69[c)]	*P*=0.312	*P*=0.777
	TM	27.04±9.82	23.58±9.40[c)]	17.74±8.96[c)]		*P*=0.260
	TD	25.25±10.41	21.72±9.35[c)]	13.57±7.46[c)]		*P*=0.154

avr: an average value of the indices measured at the six sites around the tooth, PTV: Periotest value, Control: saline irrigation alone after drainage, TM: saline irrigation after drainage + minocycline ointment application, TD: saline irrigation after drainage + doxycycline solution irrigation, PD: probing depth, BoP: bleeding on probing, PI: plaque index, GR: gingival recession, CAL: clinical attachment level, rmA: repeated-measures analyses of variance, LMM: linear mixed model.

[a)] Statistically significant (*P*<0.05).

[b)] Statistically significant (*P*<0.05).

[c)] Statistically significant decrease found when compared to the visit 1 within each group (*P*<0.05).

Table 3. Linear mixed model for the intergroup comparison of PD and BOP over time on abscess side of tooth

	Group					
	Control		**TM**		**TD**	
	sidePD (mm)	**sideBOP (%)**	**sidePD (mm)**	**sideBOP (%)**	**sidePD (mm)**	**sideBOP (%)**
Visit 1 (baseline)	9.40±1.19	100.00±0.00	8.98±1.39	100.00±0.00	9.51±1.52	100.00±0.00
Visit 2 (1 week)	9.08±1.27	96.67±10.26	8.41±1.31	93.65±17.05	8.56±1.71	87.88±28.25
Visit 3 (4 weeks)	8.31±1.32	55.00±36.31	7.10±1.46	26.98±35.93	6.63±1.81	4.55±11.70
	Effect over time					
	Control vs. TM		Control vs. TD		TD vs. TM	
P value (PD)	0.024[a)]		<0.001[a)]		<0.001[a)]	
P value (BOP)	0.009[a)]		<0.001[a)]		0.031[a)]	

Values are presented as mean ± standard deviation.

PD: probing depth, BOP: bleeding on probing, side: Abscess-side, Control: saline irrigation alone after drainage, TM: saline irrigation after drainage + minocycline ointment application, TD: saline irrigation after drainage + doxycycline solution irrigation.

[a)] Statistically significant (P<0.05).

Table 4. Deepest PD and the difference (Δ) between the visits (mm)

Group	**Visit 1 (baseline)**		**Visit 2 (1 wk)**		**Visit 3 (4 wks)**
Control	9.99±1.25		9.37±1.28		8.35±1.33
Δ between the visits		0.52±0.44		1.02±0.66	
TM	9.47±1.50		8.69±1.30		7.34±1.33
Δ between the visits		0.77±0.43		1.35±0.69	
TD	10.13±1.61		8.83±1.76		6.90±1.76
Δ between the visits		1.30±0.79		1.92±0.86	
		First period		Second period	
Control vs. TM		*P*=0.528		*P*=0.488	
Control vs. TD		*P*<0.001[a)]		*P*=0.001[a)]	
TD vs. TM		*P*=0.015[a)]		*P*=0.049	

Values are presented as mean ± standard deviation.

Values are presented as mean ± standard deviation.

PD: probing depth, Control: saline irrigation alone after drainage, TM: saline irrigation after drainage + minocycline ointment application, TD: saline irrigation after drainage + doxycycline solution irrigation.

[a)] Statistical significance observed in *post hoc* comparison under Bonferroni correction (P<0.017).

PD

The avrPD was ≥6 mm in all groups at the first visit and showed mean decreases of 0.75 (control), 1.25 (TM), and 1.74 (TD) mm, respectively, at visit 3. The change in avrPD was significantly larger in the TD group than in the other 2 groups (TD vs. control, P<0.001; TD vs. TM, P=0.010) **(Table 2)**.

When focusing on the abscess-side PD, the mean decreases in sidePD for the 3 visits were 1.09 (control), 1.88 (TM), and 2.88 (TD) mm, with statistical significance in the linear mixed model analysis between the control and TM groups (P=0.024), between the control and TD groups (P<0.001) and between the TD and TM groups (P<0.001) **(Table 3)**.

A comparison of the changes in deepPD observed between visits 1 and 2 (the first period) revealed that the decrease was the largest in the TD group (mean, 1.30 mm), followed by the TM (mean, 0.77 mm) and control (mean, 0.52 mm) groups; the differences were statistically significant between the control and TD groups and between the TM and TD groups (control vs. TD, P<0.001; control vs. TM, P=0.528; TM vs. TD, P=0.015) **(Table 4)**. All 3 groups exhibited significantly larger decreases during the second period, between visits 2 and 3 (mean values: control, 1.02 mm; TM, 1.35 mm; TD, 1.92 mm) compared to between visits 1 and 2. On comparing the 3 groups between visits 2 and 3, only the difference between the control and TD groups was significant (P=0.001).

BOP

The avrBOP decreased significantly to 39.17%±24.94%, 20.63%±25.22%, and 6.82%±8.38% relative to the baseline in the control, TM, and TD groups, respectively (*P*<0.05) **(Table 2)**. The change in avrBOP over time was significantly greater in the TD and TM groups than in the control group. The mean decrease in sideBOP for the overall period was significantly larger in the TD group (mean, 95.45%) than in the control (mean, 45.00%; *P*<0.001) and TM (mean, 73.02%; *P*=0.031) groups. Further, the decrease was significantly greater in the TM group than in the control group (*P*=0.009) **(Table 3)**.

avrPI, avrGR, and avrCAL

The avrPI showed significant improvement at visits 2 and 3 relative to visit 1 in within-group comparisons (*P*<0.05); however, no significant change was observed in intergroup comparisons. The avrGR also increased significantly over time within each group (*P*<0.05), with no significant intergroup differences. The avrCAL showed significant improvement at visit 3 compared to visit 1 in each group (*P*<0.05). When comparing the CAL change over time between groups, the improvement in CAL was significantly greater in the TD group (mean, 1.31 mm) than in the control (mean, 0.40 mm, *P*<0.001) and TM (mean, 0.86 mm, *P*=0.002) groups **(Table 1)**.

Tooth mobility

An intergroup comparison of the PTV change over time revealed no significant differences. When the PTV measured at visit 3 was compared to that measured at visit 1 within each group, all groups showed significantly lower values (control, 18.50±9.69; TM, 17.74±8.96; TD, 13.57±7.46) at visit 3 than at visit 1 (control, 28.28±10.12; TM, 27.04±9.82; TD, 25.25±10.41; *P*<0.05) **(Table 1)**.

This retrospective study was conducted to verify whether the adjunctive use of minocycline ointment or doxycycline solution provided clinical benefits over drainage with saline irrigation alone. The symptoms of acute periodontal abscesses typically decrease within 1 month when appropriate treatment is administered [25]. As such, we designed a 3-visit protocol spanning 4 weeks. All clinical parameters significantly decreased over the course of the study in each group, suggesting that all 3 treatment modalities were effective regardless of the use of local antibiotics. However, the degree of improvement varied significantly among the groups. Additional irrigation using the doxycycline solution was more effective than the other 2 treatment methods in improving PD, CAL, and BOP.

The largest improvements in avrPD and avrCAL outcomes were observed in the TD group, followed by the TM and control groups. The changes in PD observed in this study align with the results of previous research on the effectiveness of locally applied minocycline ointment or doxycycline solution. Eguchi *et al*. reported an average PD reduction of 0.56 mm 1 week after the application of a 2% minocycline ointment among patients with periodontal abscess, compared to an average decrease of only 0.18 mm with saline irrigation alone [6]. Similarly, Stabholz *et al*. [17] found that a diseased site with a PD greater than 6 mm showed a mean 1.3-mm PD reduction 4 weeks after scaling and root planing, combined with 50 mg/mL tetracycline irrigation. This is comparable to the decrease in PD observed at the final visit in our study.

In this study, we observed a greater mean decrease over a 4-week period on the abscess side in both the TM and TD groups (1.88 and 2.88 mm, respectively) compared to the control group (1.09 mm). This decrease was also larger than the reductions of 1.1 to 1.38 mm noted 1 month after the topical application of tetracycline to deep pockets greater than 5 mm in several previous studies [26, 27].

Given that the avrGR value showed no significant differences among the groups at the third visit, the changes in avrCAL during the treatment period could be attributed to the repair of periodontal attachment, rather than the reduction of diseased gingiva. Antibiotics in the tetracycline group, such as minocycline and doxycycline, create a conducive environment for the regeneration of periodontal tissue. They achieve this by removing the smear layer on the root surface, leading to the opening of the dentinal tubules. This process ultimately enhances the adhesion of fibroblasts by triggering an increase in fibronectin levels [28]. Therefore, this phenomenon may have also occurred in the TM and TD groups in this study, as both groups demonstrated significantly greater improvements in CAL over time relative to the control group.

A decrease in BOP has been observed following the local administration of tetracycline. However, in the current study, the extent of this decrease was particularly pronounced in the TD and TM groups, particularly at the 4-week mark. Drisko *et al*. documented a mean BOP reduction of 65% and a clinical attachment increase of 1 mm 1 month after tetracycline application [29]. Similarly, Stabholz *et al*. [17] reported a 40% decrease at 2 weeks post-tetracycline irrigation, and both of those results align with the BOP reduction findings reported in this study. However, the mean BOP assessed by Stabholz *et al*. [17] 4 weeks after the initial treatment increased by 32% relative to the 2-week mark, a finding that contradicts the present study (TM, 62.70% and TD, 71.97% decrease in average BOP). This discrepancy is likely due to the additional administration of local medication (either minocycline ointment or doxycycline solution) 1 week after initial treatment, a practice supported by previous studies highlighting the efficacy of repeated tetracycline applications in reducing PD and BOP [20, 30]. This suggests that repeated local applications of antibiotics could offer clinical advantages in managing periodontal infections [31, 32].

The TD group demonstrated superior performance in infection control and periodontal attachment restoration compared to the TM group. This result may be attributed to the high concentration of the doxycycline solution used (300 mg/mL; 30%). The therapeutic impact of locally administered tetracycline is known to vary based on the concentration of the drug. Isik *et al*. found that dentin demineralization was more pronounced when tetracycline solutions of 50–150 mg/mL were applied to the root surface for 5 minutes, compared to solutions of 10–25 mg/mL [33]. Sterrett *et al*. also observed this concentration-dependent effect [34]. Consistent with these findings, other studies have reported a significant decrease in PD when a higher concentration of tetracycline solution (50 and 100 mg/mL) was used for 5-minute irrigation in periodontal pockets deeper than 5 mm [17, 18]. Given the notable differences in mechanical properties, such as viscosity, an ointment tends to remain on an abscess longer than a solution. However, the doxycycline solution used in this study may have produced a therapeutic effect comparable to that of the minocycline ointment. This is because a higher concentration of the tetracycline solution may enhance the local drug dosage in the gingival crevicular fluid by increasing its substantivity [35]. This is supported by a previous study, which demonstrated that 100 mg/mL of a tetracycline solution in gingival crevicular fluid remained significantly above the 90% minimum inhibitory concentration (1 µg/mL) at 2 (23 µg/mL) and 3 (8 µg/mL) weeks [36]. Furthermore, the findings of this study are supported by the improved control of certain resistant bacteria (e.g., *Staphylococcus aureus*, *Streptococcus pneumoniae*, *Escherichia coli*, and *Acinetobacter* spp.) associated with high concentrations of doxycycline [37]. The decrease in deepPD in the first and second periods was greater in the TD group than in the other groups **(Table 4)**. Presumably, the decrease in the first period was due to the relatively rapid resolution of inflammation, resulting from the potent antibacterial effect of high concentrations of doxycycline. The reduction in the second period can be attributed to the sustained beneficial effects of the additional application of high-concentration doxycycline following the mechanical treatment on the root surface.

The use of high local concentrations of antibiotics reportedly exerts minimal systemic effects. Maze *et al*. [38] applied a 35% tetracycline gel, a concentration higher than that used in our study, and discovered that the concentration in the gingival sulcus fluid was 293 µg/mL after 8 days. Stoller *et al*. [35] found that tetracycline was barely detectable in the serum, even when its concentration in the gingival fluid was 309 µg/mL at 1 week. Therefore, it can be inferred that the antibiotics and concentrations used in our study (2% minocycline gel and 300 mg/mL doxycycline solution) had minimal systemic effects.

Despite the significant difference in the reduction of PD over time among the 3 groups, the PTV at 4 weeks and its decrease over time showed no significant differences in the intergroup comparison. This suggests that tooth mobility is influenced by PD and other factors, such as occlusion, the extent of alveolar bone resorption, and parafunctional habits [39]. Concurrently, the pattern of change in tooth mobility over time did not significantly differ among the groups, suggesting that the healing pattern of the periodontal tissue in this study was similar to that observed previously [40]. PTV exhibited a slight decrease between visits 1 and 2, which may be due to atrophy of the periodontal tissue caused by pus removal. The reduction in tooth mobility was more pronounced between visits 2 to 3, which could be due to the proliferation, remodeling, and maturation of the newly formed fibers following root planing. Additionally, the improvement in PTV was greater in the TD group. However, no statistically significant differences were found. This could be because the initial healing period was brief before the improvement in CAL led to an enhancement in PTV. Further studies with extended observation periods are recommended.

This study had certain limitations. First, the follow-up period was brief. Second, we did not conduct any microbiological investigations, which could have offered a deeper understanding of shifts in bacterial distribution. Future studies should address these limitations to corroborate our findings.

Conclusion

In conclusion, within the limitations of this study, the local administration of 300 mg/mL doxycycline solution or 2% minocycline ointment could potentially serve as an effective adjunctive treatment for acute periodontal abscesses when used in conjunction with drainage. The use of a 300 mg/mL doxycycline solution for irrigation yielded superior results, as evidenced by improvements in PD, CAL, and BOP.

Acknowledgments: None

Conflict of interest: None

Financial support: This work was supported by a grant from the National Research Foundation of Korea (NRF) funded by the Korean government (MSIT) (grant No. 2020R1A2C2008053).

Ethics statement: None

References

1. Herrera D, Roldán S, Sanz M. The periodontal abscess: a review. J Clin Periodontol. 2000;27(6):377-86.
2. Corbet EF. Diagnosis of acute periodontal lesions. Periodontol 2000. 2004;34(1):204-16.
3. Herrera D, Retamal-Valdes B, Alonso B, Feres M. Acute periodontal lesions (periodontal abscesses and necrotizing periodontal diseases) and endo-periodontal lesions. J Clin Periodontol. 2018;45(Suppl 20):S78-94.
4. Olsen I, van Winkelhoff AJ. Acute focal infections of dental origin. Periodontol 2000. 2014;65:178-89.
5. Herrera D, Alonso B, de Arriba L, Santa Cruz I, Serrano C, Sanz M. Acute periodontal lesions. Periodontol 2000. 2014;65(1):149-77.
6. Eguchi T, Koshy G, Umeda M, Iwanami T, Suga J, Nomura Y, et al. Microbial changes in patients with acute periodontal abscess after treatment detected by PadoTest. Oral Dis. 2008;14(2):180-4.
7. Lewis MA, McGowan DA, MacFarlane TW. Short-course high-dosage amoxycillin in the treatment of acute dento-alveolar abscess. Br Dent J. 1986;161(6):299–302.
8. Wilder RS. A new option for local delivery. Antimicrobials, such as minocycline microspheres, can enhance the effectiveness of mechanical therapy in treating chronic periodontitis. Tex Dent J 2003;120(12):984-7.
9. Lee SB, Lee BA, Choi SH, Kim YT. Long-term outcomes after peri-implantitis treatment and their influencing factors: a retrospective study. J Periodontal Implant Sci. 2022;52(3):194-205.
10. Chadha VS, Bhat KM. The evaluation of doxycycline controlled release gel versus doxycycline controlled release implant in the management of periodontitis. J Indian Soc Periodontol. 2012;16(3):200–6.
11. Jung DY, Park JC, Kim YT, Yon JY, Im GI, Kim BS, et al. The clinical effect of locally delivered minocycline in association with flap surgery for the treatment of chronic severe periodontitis: a split-mouth design. J Clin Periodontol. 2012;39(8):753-9.
12. Jain R, Mohamed F, Hemalatha M. Minocycline containing local drug delivery system in the management of chronic periodontitis: a randomized controlled trial. J Indian Soc Periodontol. 2012;16(3):179-83.
13. Ranch KM, Maulvi FA, Koli AR, Desai DT, Parikh RK, Shah DO. Tailored doxycycline hyclate loaded in situ gel for the treatment of periodontitis: optimization, in vitro characterization, and antimicrobial studies. AAPS PharmSciTech. 2021;22:77.
14. Kalsi R, Vandana KL, Prakash S. Effect of local drug delivery in chronic periodontitis patients: a meta-analysis. J Indian Soc Periodontol. 2011;15(4):304–9.
15. Abraham A, Raghavan R, Joseph A, Devi MP, Varghese M, Sreedevi PV. Evaluation of different local drug delivery systems in the management of chronic periodontitis: a comparative study. J Contemp Dent Pract. 2020;21(5):280-4.
16. Matesanz-Pérez P, García-Gargallo M, Figuero E, Bascones-Martínez A, Sanz M, Herrera D. A systematic review on the effects of local antimicrobials as adjuncts to subgingival debridement, compared with subgingival debridement alone, in the treatment of chronic periodontitis. J Clin Periodontol. 2013;40(3):227-41.

17. Stabholz A, Nicholas AA, Zimmerman GJ, Wikesjö UM. Clinical and antimicrobial effects of a single episode of subgingival irrigation with tetracycline HCl or chlorhexidine in deep periodontal pockets. J Clin Periodontol. 1998;25(10):794–800.
18. Christersson LA, Norderyd OM, Puchalsky CS. Topical application of tetracycline-HCl in human periodontitis. J Clin Periodontol. 1993;20(1):88-95.
19. Parameter on acute periodontal diseases. American Academy of Periodontology. J Periodontol. 2000;71(7):863-6.
20. Heijl L, Dahlen G, Sundin Y, Wenander A, Goodson JM. A 4-quadrant comparative study of periodontal treatment using tetracycline-containing drug delivery fibers and scaling. J Clin Periodontol. 1991;18(2):111-6.
21. Ozcan G, Taner IL, Doğanay T, Iscanoğlu M, Taplamacioğlu B, Gültekin SE, et al. Use of membranes containing 20% chlorhexidine and 40% doxycycline for treatment of chronic periodontal pockets. J Nihon Univ Sch Dent. 1994;36(2):191–8.
22. Ahl DR, Hilgeman JL, Snyder JD. Periodontal emergencies. Dent Clin North Am. 1986;30(4):459-72.
23. Meitner SW, Zander HA, Iker HP, Polson AM. Identification of inflamed gingival surfaces. J Clin Periodontol. 1979;6(2):93-7.
24. Löe H. The gingival index, the plaque index and the retention index systems. J Periodontol. 1967;38(8):610-6.
25. Nabers JM. Treatment of the symptomatic periodontal lesions. Dent Clin North Am. 1969;13(1):169-80.
26. Paquette D, Oringer R, Lessem J, Offenbacher S, Genco R, Persson GR, et al. Locally delivered minocycline microspheres for the treatment of periodontitis in smokers. J Clin Periodontol. 2003;30(9):787-94.
27. Goodson JM, Gunsolley JC, Grossi SG, Bland PS, Otomo-Corgel J, Doherty F, et al. Minocycline HCl microspheres reduce red-complex bacteria in periodontal disease therapy. J Periodontol. 2007;78(9):1568-79.
28. Madison JG 3rd, Hokett SD. The effects of different tetracyclines on the dentin root surface of instrumented, periodontally involved human teeth: a comparative scanning electron microscope study. J Periodontol. 1997;68(8):739–45.
29. Drisko CL, Cobb CM, Killoy WJ, Michalowicz BS, Pihlstrom BL, Lowenguth RA, et al. Evaluation of periodontal treatments using controlled-release tetracycline fibers: clinical response. J Periodontol. 1995;66(8):692–9.
30. van Steenberghe D, Rosling B, Söder PO, Landry RG, van der Velden U, Timmerman MF, et al. A 15-month evaluation of the effects of repeated subgingival minocycline in chronic adult periodontitis. J Periodontol. 1999;70(6):657-67.
31. McColl E, Patel K, Dahlen G, Tonetti M, Graziani F, Suvan J, et al. Supportive periodontal therapy using mechanical instrumentation or 2% minocycline gel: a 12 month randomized, controlled, single masked pilot study. J Clin Periodontol. 2006;33(2):141-50.
32. Bonito AJ, Lux L, Lohr KN. Impact of local adjuncts to scaling and root planing in periodontal disease therapy: a systematic review. J Periodontol. 2005;76(8):1227-36.
33. Isik AG, Tarim B, Hafez AA, Yalçin FS, Onan U, Cox CF. A comparative scanning electron microscopic study on the characteristics of demineralized dentin root surface using different tetracycline HCl concentrations and application times. J Periodontol. 2000;71(2):219-25.
34. Sterrett JD, Simmons J, Whitford G, Russell CM. Tetracycline demineralization of dentin: the effects of concentration and application time. J Clin Periodontol. 1997;24(6):457-63.
35. Stoller NH, Johnson LR, Trapnell S, Harrold CQ, Garrett S. The pharmacokinetic profile of a biodegradable controlled-release delivery system containing doxycycline compared to systemically delivered doxycycline in gingival crevicular fluid, saliva, and serum. J Periodontol. 1998;69(10):1085-91.
36. Kulik EM, Thurnheer T, Karygianni L, Walter C, Sculean A, Eick S. Antibiotic susceptibility patterns of Aggregatibacter actinomycetemcomitans and Porphyromonas gingivalis strains from different decades. Antibiotics (Basel). 2019;8(4):253.
37. Cunha BA, Baron J, Cunha CB. Similarities and differences between doxycycline and minocycline: clinical and antimicrobial stewardship considerations. Eur J Clin Microbiol Infect Dis. 2018;37(1):15–20.
38. Maze GI, Reinhardt RA, Payne JB, Maze C, Baker RA, Bouwsma OJ, et al. Gingival fluid tetracycline release from bioerodible gels. J Clin Periodontol. 1996;23(13):1133-6.

39. Anderegg CR, Metzler DG. Tooth mobility revisited. J Periodontol. 2001;72(8):963-7.
40. Kerry GJ, Morrison EC, Ramfjord SP, Hill RW, Caffesse RG, Nissle RR, et al. Effect of periodontal treatment on tooth mobility. J Periodontol. 1982;53(8):635-8.