



Long-term evaluations of teeth and dental implants during dental maintenance period

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PURPOSE. This study was designed to evaluate the teeth and dental implants during dental maintenance therapy over 3 years in different conditions after periodontal and dental prosthetic treatment. **MATERIALS AND METHODS.** 166 patients received maintenance therapy. 59 patients were treated with 2% minocycline-HCl ointment as local drug delivery (LDD) (L group) and 107 patients were treated without LDD (NL group). Clinical data was collected in maintenance period for evaluation. Patients were classified into groups depending on the application of LDD with maintenance therapy, the type of dental treatment before maintenance period (Pre-Tx), the frequency (F-MT), and regularity (R-MT) of maintenance therapy. **RESULTS.** The numbers of lost teeth (N-teeth, $P=.003$) and newly placed dental implants (N-implants, $P=.022$) are significantly different according to Pre-Tx. F-MT among patients who received surgical dental treatment before maintenance period showed statistical differences in N-teeth ($P=.041$), but not in N-implants ($P=.564$). All of the patients in L group showed high F-MT (F-MT1). In NL group, there were no statistical differences in N-teeth or N-implants according to F-MT or R-MT. In F-MT1 group, application of LDD made N-teeth significantly different from both Pre-Tx groups while no significant difference could be found in N-implant. Independent t-test and one-way ANOVA were selected for statistical analysis. **CONCLUSION.** The regular maintenance therapy and LDD can be effective for teeth during maintenance period. It is not only pharmacological efficacy in decreasing bacterial species that makes LDD a useful adjunct. Application of LDD also motivates patients to take adequate check-ups in the aspects of both frequency and regularity. [J Adv Prosthodont 2017;9:224-31]

KEYWORDS: Long-Term Care; Minocycline; Tooth Loss

INTRODUCTION

There are many researches supporting the idea that maintenance therapy is essential for dental health care in long term

follow up.¹ It is known that clinical diagnosis during maintenance period has to be based on the health status obtained from successful active dental treatment. Lang and Tonetti² suggests the new parameters for evaluating the maintenance of dental health that makes maintenance therapy useful: 1) percentage of bleeding on probing, 2) prevalence of residual pockets greater than 4 mm, 3) loss of teeth from a total of 28 teeth, 4) loss of supporting tissue in relation to the patient's age, 5) systemic and genetic conditions, and 6) environmental factors such as cigarette smoking.

It is generally accepted that bacteria play the most important role in the pathogenesis of human dental diseases.^{3,4} Since many of dental pathogens are anaerobic species, most forms of periodontitis can be considered and treated as anaerobic infections.⁵⁻⁷

It has been shown that scaling and root planing is an effective way to reduce the number of bacteria under threshold values and at the same time to suppress the progression of periodontal disease. Although scaling and root planing is

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considered as useful approach in many cases, there is a certain limitation of this treatment due to the fact that there could be the restriction in retaining adequate access and visibility to the operative sites. This limitation makes complete removal of subgingival plaque and calculus hard to be achieved and sometimes makes treatment itself ineffective.⁸ Also, it may not exterminate some bacterial species that can reach connective tissues of the periodontium.^{9,10}

It has been shown that the adding chemotherapeutic agent to conventional dental treatment has an adjunctive effect in interrupting further dental disease progression.¹¹ According to some *in vitro* studies, it has shown that minocycline can act against several bacteria commonly found in subgingival plaque.^{12,13} One of the studies showed that more than 98% of the total bacteria isolated in periodontitis were inhibited by 5 µg/mL of minocycline.¹⁴ Other studies have evaluated the effect of subgingivally administered 2% minocycline in addition to mechanical debridement.^{15,16} In these studies, patients were randomly chosen into two groups, and patients in treatment group with subgingivally administered minocycline had better response than patients in the placebo group. In the 18-week clinical trial, the results suggested that scaling & root planing with adjunctive subgingival administration of minocycline ointment had a significantly better outcome with prolonged effect compared to scaling & root planing alone on reduction of probing depth, clinical attachment loss, gingival index, and interleukin-1 β content, but not on bleeding on probing.¹⁷

In order to evaluate the success of periodontal and dental prosthetic treatment and years of maintenance, assessment of tooth loss, true sequelae of dental disease, should be preceded since numerical value of increased pocket depth and clinical attachment loss is only the alternative parameter describing progression of disease toward tooth loss. Thus, clinicians may benefit from probing assessment after active dental treatment and during maintenance period, which enables the prediction of further progression of dental disease and subsequent tooth loss.¹⁸

This study is designed to evaluate the natural teeth and dental implants conditions of patients who were treated with maintenance therapy over 3 years after periodontal and dental prosthetic treatment.

MATERIALS AND METHODS

166 patients who visited the Kyungpook National University Dental Hospital between April 2010 and April 2014 were analyzed in this study. Exclusion criteria were defined as pregnancy, heavy smokers (smoking more than 10 cigarettes per day), and any kind of systemic disease that might influence response of the treatment such as diabetes mellitus, hypertension, cardiovascular disease, arthritis, liver disease, renal disease, malignant tumor, autoimmune disease, and metabolic bone disease.

59 patients received maintenance therapy with 2% minocycline-HCl ointment (Periocline) over 3 years as local drug delivery (LDD) (L group) and 107 patients received maintenance

therapy without LDD over 3 years (NL group). The mean age of L group is 55.60 ± 7.88 years, including 21 males and 38 females. The mean age of NL group is 50.07 ± 8.45 years, including 58 males and 49 females.

Evaluation has been made from the clinical data collected from patients in specific period starting from first maintenance therapy applied after dental treatment (baseline) to the last visit of patients for maintenance therapy, using more than two panoramic radiographs and dental records. Collected data includes the number of lost teeth (N-teeth), the location of lost teeth, the number of newly placed dental implants (N-implants), and the location of newly placed dental implants. Also the type of treatment before maintenance period and the number and intervals of visit in this period were also recorded for evaluation.

All of data were classified into following 6 criteria.

- 1) Application of 2% minocycline-HCl ointment (Appl-LDD): Yes (L group), No (NL group)
- 2) Type of treatment before maintenance period (Pre-Tx): surgical, non-surgical periodontal and dental prosthetic treatment
- 3) Frequency of maintenance therapy (F-MT): F-MT1, more than once in 6 months / F-MT2, once in a year / F-MT3, less than once in 2 years
- 4) Regularity of maintenance therapy (R-MT): R-MT1, the intervals of each visit are distinguished within 6 months / R-MT2, the intervals of each visit are distinguished over 6 months
- 5) Sex: male (M), female (F)
- 6) Age: A1, 20 to 39 years old / A2, 40 to 49 years old / A3, 50 to 59 years old / A4, over 60 years old

Additional data such as smoking habit and the frequency of tooth brushing in a day were also collected for more information.

The study protocol was reviewed and accepted by Research Ethics Committee, Kyungpook National University (Ethics Reference No. KNUH 2014-07-050-001).

Data were expressed as mean and standard deviation. Comparisons between groups or within groups were performed by independent t-test and one-way ANOVA. Kruskal-Wallis test and Mann-Whitney U test were used for analysis. It was assumed to be statistically significant when *P* value is below .05.

RESULTS

We analyzed collected data from two main points of view. The first point of view is Pre-Tx since initial dental condition can make the result quite differently. Table 1 shows average, total number of patients and standard deviation of age, N-teeth, N-implants, and number of visit for maintenance therapy according to Pre-Tx (Table 1).

Table 2 represents crosstabulations of sex, F-MT and Appl-LDD to Pre-Tx. In sex criteria, no significant difference could be noticed according to the type of pre-treatment. In case of frequency of maintenance therapy criteria, it could be assumed that most of patients received maintenance therapy

more than once a year since F-MT1 showed the highest frequency of visit. Surgical/nonsurgical pre-treatment rate among each frequency of maintenance therapy groups were similar. Seeing Appl-LDD criteria, pre-treatment rate between each group was similar in L group while surgical pre-treatment was higher in NL group. In total, there were more patients treated with surgical pre-treatment compared to the patients with nonsurgical pre-treatment (Table 2).

N-teeth ($P = .003$) and N-implants ($P = .022$) were significantly different according to Pre-Tx (Table 3). A number of lost teeth and newly placed dental implants were higher in patients treated with surgical pre-treatment.

No significant statistical difference could be found on N-teeth and N-implants in both surgical and nonsurgical pre-treatment group according to age. Thus, it is possible to rule out age as an influential factor (Table 4). In case of sex,

Table 1. Means and standard deviations of age, number of lost teeth, number of newly placed dental implants and number of visit for maintenance therapy according to the type of treatment before maintenance period (Pre-Tx)

Pre-Tx		Age	N-teeth	N-implants	No. of visit for maintenance therapy
Surgical (No. of patients : 92)	Mean	51.989	.880	.663	8.924
	Std. Deviation	8.9461	1.9826	1.4771	3.7977
Nonsurgical (No. of patients : 74)	Mean	52.095	.216	.243	8.743
	Std. Deviation	8.3160	.5305	.8245	3.8537
Total (No. of patients : 166)	Mean	52.036	.584	.476	8.843
	Std. Deviation	8.6451	1.5498	1.2441	3.8122

Number of visit for maintenance therapy is similar in both pre-treatment group, but number of lost teeth (N-teeth) and number of newly placed dental implants (N-implants) are higher in surgical pre-treatment group than in nonsurgical pre-treatment group.

Table 2. Crosstabulation of sex, frequency of maintenance therapy (F-MT) and application of 2% minocycline-HCl ointment as local drug delivery (LDD) (Appl-LDD) to type of treatment before maintenance period (Pre-Tx)

		Pre-Tx		Total
		Surgical	Nonsurgical	
Sex	F	43 ^a (25.9%) ^b	44 (26.5%)	87 (52.4%)
	M	49 (29.5%)	30 (18.1%)	79 (47.6%)
F-MT ^c	1	65 (39.1%)	51 (30.7%)	116 (69.9%)
	2	19 (11.4%)	17 (10.2%)	36 (21.7%)
	3	8 (4.8%)	6 (3.6%)	14 (8.4%)
Appl-LDD ^d	L group	30 (18.1%)	29 (17.5%)	59 (35.5%)
	NL group	62 (37.3%)	45 (27.1%)	107 (64.5%)
Total		92 (55.4%)	74 (44.6%)	166 (100.0%)

No significant difference could be found among groups on sex criteria. F-MT1 (more than once in 6 months) shows the highest percentage on frequency of maintenance therapy criteria and surgical/nonsurgical pre-treatment rate among each frequency of maintenance therapy groups were similar. Seeing Appl-LDD criteria, pre-treatment rate between each group was similar in L group while surgical pre-treatment was higher in NL group.

^a No. of patients, ^b Percentage share of total patients.

^c F-MT1, more than once in 6 months / F-MT2, once in a year / F-MT3, less than once in 2 years.

^d L group, LDD applied / NL group, LDD not-applied.

Table 3. Independent t-test of number of lost teeth (N-teeth) and number of newly placed dental implants (N-implants) according to the type of treatment before maintenance period (Pre-Tx)

Pre-Tx	Surgical	Nonsurgical	P value
N ^a	92	74	
N-teeth ^b	0.88 ± 1.9826	0.216 ± 0.5305	.003
N-implants ^b	0.663 ± 1.4771	0.243 ± 0.8245	.022

Both N-teeth and N-implants show significant differences between surgical and nonsurgical pre-treatment group ($P < .05$).

^a Sample size, ^b Mean ± Std. Deviation

no significant statistical difference could be found on N-teeth and N-implants in both surgical and nonsurgical pre-treatment groups (Table 5).

F-MT among patients who were treated with surgical dental treatment before maintenance period showed statistical differences in N-teeth ($P = .041$, Fig. 1A), but not in N-implants ($P = .564$, Fig. 1B). Among patients who were treated with non-surgical dental treatment before maintenance period, there were no differences in N-teeth ($P = .124$, Fig. 1C) and N-implants ($P = .305$, Fig. 1D) according to F-MT.

The second point of view is the application of LDD. All

of the patients in L group showed high F-MT (F-MT1, Table 6). Thus, N-teeth and N-implants according to the application of LDD could be compared only in F-MT1 group and differences according to F-MT or R-MT could be analyzed only in NL group.

In F-MT1 group, N-teeth was significantly different according to application of LDD, both in surgical Pre-Tx group ($P = .000$, Fig. 2A) and in non-surgical Pre-Tx group ($P = .036$, Fig. 2C). However, N-implant was not significantly different according to application of LDD, both in surgical Pre-Tx group ($P = .523$, Fig. 2B) and in non-surgical Pre-Tx group ($P = .709$, Fig. 2D).

Table 4. One-way ANOVA of number of lost teeth (N-teeth) and number of newly placed dental implants (N-implants) according to age, in patients who received surgical and nonsurgical pre-treatment

Age ^c		A1	A2	A3	A4	P value
Surgical Pre-tx	N ^a	9	30	37	15	
	N-teeth ^b	1.222 ± 1.302	0.867 ± 1.907	0.568 ± 1.692	1.533 ± 2.973	.431
	N-implants ^b	0.667 ± 1.000	0.700 ± 1.466	0.514 ± 1.170	0.933 ± 2.344	.833
Nonsurgical Pre-tx	N ^a	6	20	35	13	
	N-teeth ^b	0.000 ± 0.000	0.350 ± 0.587	0.143 ± 0.355	0.308 ± 0.855	.35
	N-implants ^b	0.000 ± 0.000	0.300 ± 0.979	0.086 ± 0.374	0.692 ± 1.378	.123

No significant difference can be found ($P < .05$).

^a Sample size, ^b Mean ± Std. Deviation.

^c A1, 20 to 39 years old / A2, 40 to 49 years old / A3, 50 to 59 years old / A4, over 60 years old.

Table 5. Independent t-test of number of lost teeth (N-teeth) and number of newly placed dental implants (N-implants) according to sex, in patients who received surgical and nonsurgical pre-treatment (Pre-Tx)

Sex		Female	Male	P value
Surgical Pre-tx	N ^a	43	49	
	N-teeth ^b	0.488 ± 0.8273	1.224 ± 2.5680	.063
	N-implants ^b	0.558 ± 1.2966	0.755 ± 1.6270	.526
Nonsurgical Pre-tx	N ^a	44	30	
	N-teeth ^b	0.159 ± 0.4283	0.300 ± 0.6513	.303
	N-implants ^b	0.091 ± 0.4214	0.467 ± 1.1666	.1

No significant difference can be found ($P < .05$).

^a Sample size, ^b Mean ± Std. Deviation.

Table 6. Crosstabulation of the frequency of maintenance therapy (F-MT) to application of 2% minocycline-HCl ointment (LDD)

F-MT ^b		F-MT1	F-MT2	F-MT3	Total
L group ^a	Surgical Pre-tx	30	0	0	30
	Nonsurgical Pre-tx	29	0	0	29
NL group ^a	Surgical Pre-tx	35	19	8	62
	Nonsurgical Pre-tx	22	17	6	45
Total		116	36	14	166

All of the patients in L group (LDD applied) shows high frequency of maintenance therapy (F-MT1).

^a L group, LDD applied / NL group, LDD not-applied.

^b F-MT1, more than once in 6 months / F-MT2, once in a year / F-MT3, less than once in 2 years.

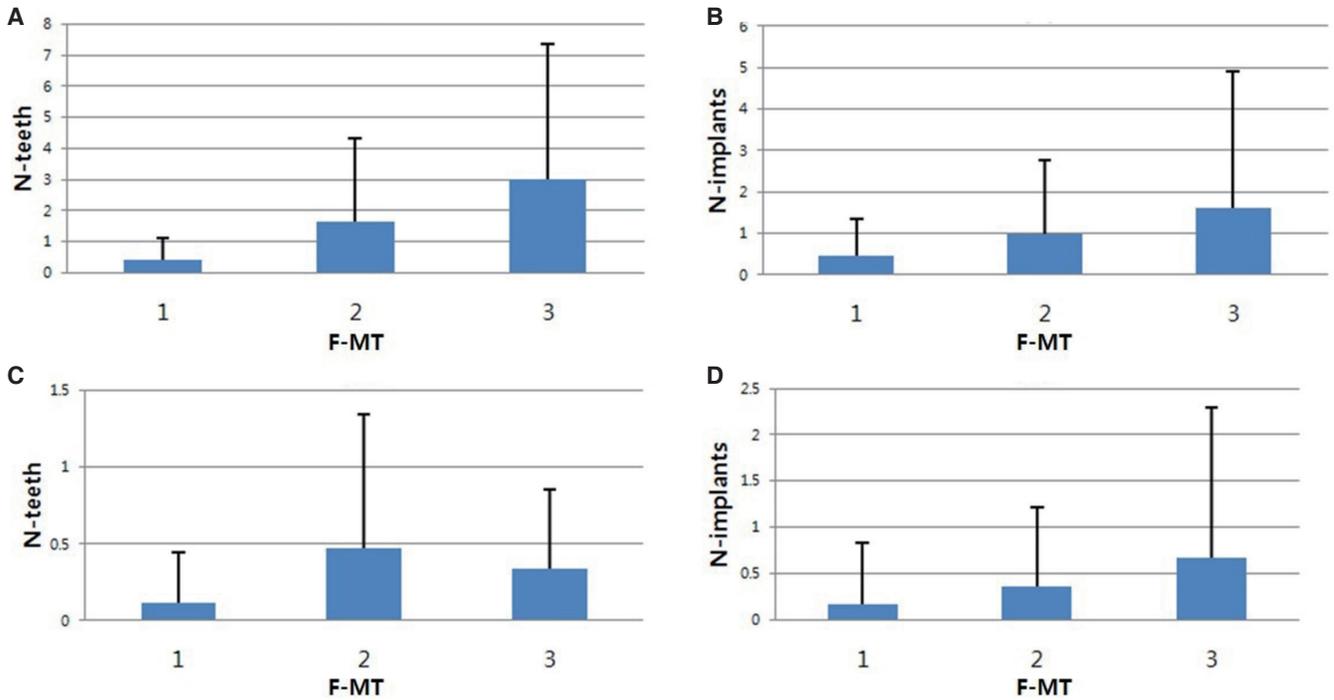


Fig. 1. Independent-Samples Kruskal-Wallis test of number of lost teeth (N-teeth) and number of newly placed dental implants (N-implants) according to the frequency of maintenance therapy (F-MT), in patients who received surgical and nonsurgical pre-treatment (F-MT1, more than once in 6 months / F-MT2, once in a year / F-MT3, less than once in 2 years). (A) N-teeth according to F-MT, in patients who received surgical pre-treatment (B) N-implants according to F-MT, in patients who received surgical pre-treatment (C) N-teeth according to F-MT, in patients who received nonsurgical pre-treatment (D) N-implants according to F-MT, in patients who received nonsurgical pre-treatment. Significant statistical difference can be solely noticed in N-teeth of patients who received surgical pre-treatment (A, $P = .041$).

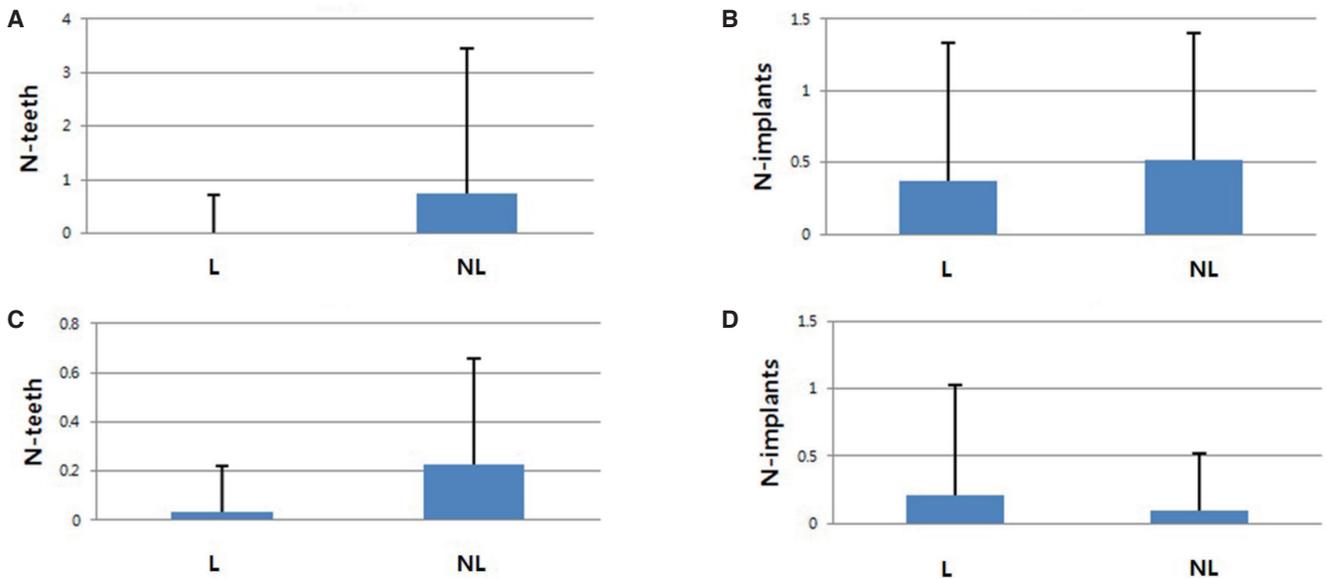


Fig. 2. Independent t-test of number of lost teeth (N-teeth, (A)) and number of newly placed dental implants (N-implants, (B)) according to application of 2% minocycline-HCl ointment as local drug delivery (LDD) (Appl-LDD), in patients who received surgical pre-treatment (L group, LDD applied / NL group, LDD not-applied). Also independent-samples Mann-Whitney U test of N-teeth (C) and N-implants (D) according to application of LDD, in patients who received nonsurgical pre-treatment. This analysis is solely based on the patients in F-MT1 group. Significant statistical differences can be found in N-teeth according to the application of LDD ((A),(C)) regardless of the type of pre-treatment ($P < .05$).

In NL group, there were no statistical differences in N-teeth ($P = .568$, surgical Pre-Tx; $P = .771$, non-surgical Pre-Tx) or N-implants ($P = .847$, surgical Pre-Tx; $P = .389$, non-surgical Pre-Tx) according to F-MT (Table 7).

Similarly, there were no statistical differences in N-teeth ($P = .437$, surgical Pre-Tx; $P = .988$, non-surgical Pre-Tx) or N-implants ($P = .228$, surgical Pre-Tx; $P = .319$, non-surgical Pre-Tx) according to R-MT among the patients in NL group (Table 8).

DISCUSSION

It is generally accepted fact that maintenance therapy is essential for dental health care in long-term follow up. Periodontal disease is the most common cause of tooth loss during maintenance period,¹⁹ and age and smoking habit can be the causes of tooth loss as well.²⁰ Also, there are many factors that can make difference in conditions of patients receiving maintenance therapy. This study is designed to evaluate teeth and dental implants of patients who received

maintenance therapy over 3 years. Collected data are evaluated to identify the factors that have an effect on long-term dental condition with maintenance therapy.

Since the initial dental condition can make differences in establishing prognosis, perception of initial dental condition is important although most patients have received maintenance therapy upon completion of active dental treatment. The initial dental condition of patients can be classified according to the type of treatment before maintenance period: surgical or nonsurgical treatment. Thus, we analyzed data according to the type of treatment before maintenance period. There were no statistical differences in age, sex, and application of 2% minocycline-HCl ointment (LDD) according to the type of treatment before maintenance period; therefore, these factors can be considered as control factors.

The result showed statistical differences in the number of lost teeth and the number of newly placed dental implants according to the type of treatment patients received before maintenance period. There were a larger

Table 7. Independent samples Kruskal-Wallis test of number of lost teeth (N-teeth) and number of newly placed dental implants (N-implants) according to the frequency of maintenance therapy (F-MT), in the patients who received maintenance therapy without the application of 2% minocycline-HCl ointment (LDD) after surgical or nonsurgical pre-treatment (Pre-Tx)

F-MT ^c		F-MT1	F-MT2	F-MT3	P value
Surgical Pre-tx	N ^a	35	19	8	
	N-teeth ^b	0.743 ± 0.817	1.632 ± 2.692	3.000 ± 4.375	.568
	N-implants ^b	0.514 ± 0.887	1.000 ± 1.764	1.625 ± 3.292	.847
Nonsurgical Pre-tx	N ^a	22	17	6	
	N-teeth ^b	0.227 ± 0.429	0.471 ± 0.875	0.333 ± 0.516	.771
	N-implants ^b	0.091 ± 0.426	0.353 ± 0.862	0.667 ± 1.633	.389

No significant statistical difference can be found ($P < .05$).

^a Sample size, ^b Mean ± Std. Deviation.

^c F-MT1, more than once in 6 months / F-MT2, once in a year / F-MT3, less than once in 2 years.

Table 8. Independent t-test of number of lost teeth (N-teeth) and number of newly placed dental implants (N-implants) according to the regularity of maintenance therapy (R-MT), in the patients who received maintenance therapy without the application of 2% minocycline-HCl ointment after surgical or nonsurgical pre-treatment (Pre-Tx)

R-MT ^c		R-MT1	R-MT2	P value
Surgical Pre-tx	N ^a	65	27	
	N-teeth ^b	0.985 ± 2.2534	0.630 ± 1.0795	.437
	N-implants ^b	0.662 ± 1.5839	0.667 ± 1.2089	.988
Nonsurgical Pre-tx	N ^a	57	17	
	N-teeth ^b	0.175 ± 0.5044	0.353 ± 0.6063	.228
	N-implants ^b	0.175 ± 0.7102	0.471 ± 1.1246	.319

No significant statistical difference can be found ($P < .05$).

^a Sample size, ^b Mean ± Std. Deviation.

^c R-MT1, the intervals of each visit are distinguished within 6 months / R-MT2, the intervals of each visit are distinguished over 6 months.

number of lost teeth and newly placed dental implants in surgical pre-treatment group compared to nonsurgical pre-treatment group. It could be considered that patients who needed surgical dental treatment were more susceptible to dental disease like periodontitis, while Lindhe and Nyman²¹ stated that patients with more susceptibility to periodontitis are more likely to have a relapse of periodontitis. Hence, it is important that dentists classify patients who can be more susceptible to dental disease and make sure to offer them long-term maintenance therapy.

In addition, the patients receiving maintenance therapy with more frequency had a smaller number of lost teeth in surgical pre-treatment group. It coincides with the results from previous studies that revealed regular maintenance therapy is important for longevity of natural teeth. The number of newly placed dental implants had no statistically significant difference in surgical pre-treatment group. Direct correlation between effectiveness of maintenance therapy and the changed number of dental implants is hard to be evaluated since dental implant placement can be influenced in greater value by the other factors like necessity of replacement of missing tooth, proper dental condition for successful implant surgery, and financial condition of patient, etc. There were no statistically significant differences in the number of lost teeth and the number of newly placed dental implants according to the frequency of maintenance therapy in non-surgical pre-treatment group. It also coincides with the results from the previous studies. Rosén *et al.*²² and Bragger *et al.*²³ studied about the effects of different frequencies of maintenance therapy and their results showed that maintenance therapy shared similar effect when the frequency was more than once a year in mild to moderate periodontitis patients. It can be understood that the patient with more severe periodontitis initially responds to maintenance therapy more definitely.

There are many studies that supported that applying local drug delivery (LDD) system can help maintenance of patients' oral hygiene. Nakagawa *et al.*¹⁵ and van Steenberghe *et al.*^{16,24} evaluated the effect of subgingivally administered 2% minocycline in addition to mechanical debridement. In this study, it could be confirmed that the loss of natural teeth was lower in patients who received maintenance therapy with LDD irrespective of pre-treatment type, among F-MT1 (visit for maintenance therapy more than once in 6 months) group.

In the statistical analysis according to application of LDD, all of the patients treated with LDD maintenance therapy also made more frequent and regular visits for maintenance therapy, more than once in 6 months. It supports that applying LDD also motivates patients to visit for maintenance therapy, in addition to its pharmacological effectiveness for reducing the number of bacteria. This motivational effect is significant since active patient participation can affect outcome of treatment considerably. Ng *et al.*²⁵ studied about tooth loss in both compliant and non-compliant group of patients with dental treatment, 7 years after active dental treatment. The result showed that tooth

loss was 7 times higher in non-complier group compare to complier group. König *et al.*¹⁹ also concluded that long-term maintenance of compliant patients was effective over 10 years of observation.

The changed number of dental implants showed significant difference in surgical pre-treatment group, but not in nonsurgical pre-treatment group with application of LDD. Additional analysis of the number of lost teeth and the number of newly placed dental implants according to the frequency and regularity of maintenance therapy showed no statistical significant difference in the patients who got maintenance therapy without LDD.

It can be concluded that maintenance therapy is effective in maintenance of natural teeth especially in surgical pre-treatment group. The frequency and regularity of maintenance therapy can affect dental condition as well. The local application of 2% minocycline-HCl ointment (Periocline) as local drug delivery (LDD) can be effective for maintenance of the natural teeth by its pharmacological efficacy of decreasing bacterial species and by motivating patients to take adequate check-ups. The further long term researches with more patients are required.

CONCLUSION

The regular maintenance therapy and local application of 2% minocycline-HCl ointment (LDD) can be effective for the natural teeth during maintenance period after periodontal and dental prosthetic treatment. It is not only pharmacological efficacy in decreasing bacterial species that makes LDD as a useful adjunct. It also motivates patients to take adequate check-ups in the aspects of both frequency and regularity.

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