Abstract: We investigated the outcome of conventional periodontal treatment in mouth breathing patients with chronic periodontitis, and compared the efficacy of applying salivary substitute to the anterior sextants as an adjunct to conventional treatment in such patients. In this randomized, investigator-blind, clinical study involving parallel groups, 40 mouth breathing patients were divided into two groups: a control group (CG, \( n = 20 \)) comprising patients who received scaling and root planing (SRP), and a test group (TG, \( n = 20 \)) who received salivary substitute as an adjunct to SRP for treatment of chronic periodontitis. The patients were followed up at various time intervals, and improvement of the gingival index (GI) was examined as the primary outcome. Student’s \( t \)-test, repeated-measures ANOVA and Mann-Whitney \( U \) test were applied for statistical analysis. Although periodontal parameters were improved in both groups after 8 weeks of follow-up, the test group showed better improvement in terms of GI and percentage bleeding on probing. Within the limits of this study, our results suggest that the use of salivary substitute has a beneficial adjunctive effect for improvement of periodontal parameters in mouth breathing patients with chronic periodontitis.

(Keywords: chronic periodontitis; mouth breathing; salivary substitute; scaling and root planing.)

Introduction

Mouth breathing has long been perceived as an exacerbating factor in persistent marginal gingivitis (1-4). Prolonged or continuous exposure of tissues in the anterior areas of the mouth to the drying effects of inspired air can lead to significant alteration of the normal homeostatic hydration state of periodontal tissues. There is considerable uncertainty about the pathogenesis of the gingival inflammatory response in mouth breathers because of the paucity of relevant epidemiological data.

There have been various explanations for the biological mechanisms underlying the periodontal inflammatory response. Some authors have claimed that a lack of natural lip friction against the gingiva may lead to accumulation of plaque (3). Others have considered that the loss of continuous salivary flow over marginal tissues in mouth breathers would reduce the antibacterial effect of saliva and the oral pH, thus compromising salivary cleansing of the area, and thereby either increasing the amount of plaque or altering its composition towards a predominantly pathogenic flora (2-5). Another school of thought that precludes the association of mouth breathing with plaque alteration has emphasized that prolonged, intermittent gingival drying itself causes an inflammatory reaction (3,5).

It remains unclear whether this inflammation in gingival tissue is initiated by plaque or by the dehydrated tissues themselves in an attempt to protect the deeper strata. The conventional perspective of a higher gingo-
Gingivitis score in mouth breathers being correlated with an increased amount of plaque is merely speculative. Drying itself may irritate soft tissues in the mouth, making them more susceptible to infections. There is some evidence to support this hypothesis, since a dryness-perpetuated inflammatory response has been observed in various other pathological entities such as dry eye syndrome (keratoconjunctivitis sicca) (6), dry age-related macular degeneration (7), and dermatitis or eczema (8).

Like other mucosal biofluids, saliva lubricates tissues and protects them against dessication and environmental insults, as well as exerting antimicrobial effects against potential pathogens (9). Without the shielding effects of adequate salivary flow, periodontal tissues would become more vulnerable to disease.

Salivary substitutes are agents that are considered to ameliorate mouth dryness through their lubricating and moistening action. Although they cannot cure dryness, they can provide temporary relief of symptoms. There is an increasing body of evidence to indicate that gingivitis is more common in individuals who breathe through the mouth, have an open lip posture, or have reduced coverage of the upper incisor teeth by the upper lip (10). However, there are few reports in the English literature on the efficacy of conventional periodontal treatment in mouth breathers. Accordingly, the present clinical trial was undertaken to evaluate the use of salivary substitute as an adjunct to scaling and root planing for management of gingival inflammation in mouth breathing patients.

**Materials and Methods**

**Study design and patient enrollment**

The present pilot study was designed as a randomized, single blind, parallel group, non-crossover clinical trial. The study population comprised 40 patients (21 males and 19 females) with a mean age of 29.97 ± 3.04 years, recruited from the outpatient section of the Department of Periodontics and Oral Implantology, Post Graduate Institute of Dental Sciences, Rohtak. The study was conducted in agreement with the principles embodied in the 1964 Declaration of Helsinki, as revised in 2008, and was approved by the Institutional Review Board (PGIDS/2013/IEC/94, 2013). The duration of the study was from April 2013 until July 2014, and the trial was ended due to time constraints.

**Diagnosis of mouth breathing**

Diagnosis of mouth breathing was made on the basis of patient history and clinical examination. Patients were asked whether, in their opinion, they were mouth breathers, and also whether they had dry mouth on awakening. The examination comprised observation coupled with various diagnostic tests for mouth breathing. Patient reaction was observed when one of the nostrils was closed and the lips sealed. Nose breathers usually demonstrate good control of the alar muscle, and this is lacking in mouth breathers. Also, the following diagnostic tests were performed to confirm the diagnosis of mouth breathing.

For the mirror test (11), patients were instructed to breathe normally while a double sided mirror was held horizontally below the nostrils. Fogging on the upper surface of the mirror indicated nasal breathing, whereas fogging on lower surface suggested mouth breathing.

In the water holding test (11), patients were instructed to fill the mouth with water and hold it in the mouth for three minutes. Mouth breathers found this task difficult whereas nasal breathers achieved it with relative ease.

**Inclusion criteria**

All of the patients were selected according to the following criteria: 1) aged 20-35 years, 2) possessing ≥16 natural teeth, and 3) fulfilling the criteria for chronic periodontitis (12), i.e. at least two or more inter-proximal sites with clinical attachment loss (CAL) ≥4 mm, or two or more inter-proximal sites with pocket depths (PD) of ≥5 mm, not on the same tooth. All patients had lip seal incompetence at rest along with signs of gingival inflammation in the anterior sextants.

**Exclusion criteria**

Patients with a history of any systemic condition that might alter the course of disease and/or wound healing, such as diabetes mellitus, immunologic disorders, hepatitis, human immunodeficiency virus infection, nephrotic syndrome, cardiovascular disease and blood dyscrasias were excluded, as were pregnant and lactating women and those taking oral contraceptive drugs. None of the participants had received anti-inflammatory drugs or antibiotics within the previous 3 months or treatment for periodontal disease within the last 6 months prior to study commencement. Patients who were current or former smokers or who had been receiving treatment with statins, glucocorticoids, bisphosphonates or any other host modulatory drugs were also excluded. Additional exclusion criteria included systemic conditions with gingival manifestations, e.g. muco-cutaneous lesions and allergic reactions, as well as non-plaque-induced gingival inflammation. Patients with xerostomia or patients taking any drugs reported to cause it, were also excluded.
Study groups
Patients were randomly assigned to one of two treatment groups: a control group comprising of mouth breathers who received conventional periodontal treatment, i.e. scaling and root planing (SRP), and a test group treated by SRP in addition to local application of salivary substitute. The latter were advised to apply salivary substitute (Wet Mouth, ICPA, Gujrat, India), available in solution form, with a cotton swab to the area of the mouth being studied every 3-4 h throughout the day. After each application, the patients were instructed to refrain from water-rinsing for at least half an hour.

After carefully explaining the nature and objectives of the study, written informed consent was obtained from each patient.

Randomization
The 40 participants were randomly assigned to either of the two groups using a computer-generated table. Restricted randomization with a random permuted block approach (four block size) was used in order to achieve equal numbers of participants in the two groups. Group allocation was done by one of the authors (SCN) not directly involved in either recording of parameters or provision of treatment, and allocation was concealed from the principal author (AB) until the completion of statistical analysis.

Clinical measurement
All of the study participants underwent maxillary and mandibular anterior sextant examination and the following parameters were recorded: plaque index (PI), gingival index (GI), bleeding on probing (BOP), PD, and CAL. Teeth were assessed at four sites for PI and GI, and at six sites for PD, CAL, and BOP during examination with a calibrated University of North Carolina (UNC)-15 periodontal probe. BOP was assessed as a dichotomous measure within 30 s of probing to full pocket depth. GI was set as the primary outcome variable, whereas BOP, PD, and CAL were regarded as secondary outcomes. All patients received oral hygiene instructions and full-mouth SRP after the initial readings had been recorded. Patients were re-examined on a weekly basis and reinforcement of oral hygiene was carried out until the 3rd week. PI and GI were recorded after 1, 2, 3, and 8 weeks of treatment. The other parameters were measured only at the 8th week after SRP.

All clinical periodontal examinations were carried out by a single investigator (AB) to preclude any inter-examiner variability. The study was conducted in a blinded manner in that the examiner (AB) who recorded the pre- and post-treatment clinical parameters was unaware of the treatment the patients had received. Another clinician (RKS) provided treatment to both groups. Determination of examiner reproducibility was done by carrying out double clinical periodontal data recording on ten patients. Assessment of the mean difference in the PD and CAL scores (with >90% accuracy) indicated that there was no systematic bias in the measurements.

Statistical analysis
We defined a difference of 0.20 in the primary outcome variable, GI, between the groups as clinically significant. With independent sample t-test and $f/\Omega$ set at 0.05 and a fixed effect size of 1, 17 patients per group were required in order to achieve a power of 80% to detect a true difference of 0.20 (assumed) between the test and control groups using reduction of GI as the primary outcome variable. However, 20 patients per group (40 total) were recruited in order to compensate for possible attrition.

The upper and lower anterior sextants, taken together, in each patient served as the unit for statistical analysis. The mean values of study variables were obtained from each patient at each visit and subjected to statistical analysis. The normality of the data distribution was examined using Shapiro-Wilk W test. Since all the parameters did not show a vigorous normal distribution, parametric statistics were applied to PI, GI, PD, and CAL whereas non-parametric statistics were applied to age and BOP. Descriptive analysis was carried out and variables were described as mean ± SD and 95% CI. Subsequently, differences between the groups were analyzed using independent sample Student’s t-test at various time points. Within each group, comparison of PI and GI was performed using repeated measures analysis of variance with time as the within-subject factor and 5 as the number of levels. If a statistically significant difference was observed, post hoc tests were performed to determine its source. The remaining parameters were analyzed using paired sample t-test, as these were examined only at the baseline and the 8th week. For BOP and age, Mann-Whitney test was applied. All statistical analyses were two-tailed at a significance level of 0.05.

Results
Study population
Among the 40 participants, 37 completed the study. No adverse reaction was reported in any of the participants in the test group. One patient in the test group was not included in the study analysis due to erratic compliance with follow-up visits. Two participants in the control group dropped out due to family commitments. None of
the drop-out patients reported any complaints or complications related to the trial.

**Age**
The mean age of the participants was 29.66 ± 2.80 years in the control group and 30.26 ± 3.29 years in the test group. There was no significant difference between the two groups at the baseline with regard to the periodontal parameters under consideration. Table 1 shows the clinical parameters of the control and test groups at the baseline and at 8 weeks, respectively. At 8 weeks, all of the parameters had improved significantly in both groups. The control group and test group were further analyzed at various time intervals (0, 1, 2, 3, and 8 weeks) after SRP, and gradual improvement in periodontal parameters was evident in both groups.

**PI**
In the control group, the PI score was reduced significantly from the baseline value of 1.71 ± 0.58 to 0.50 ± 0.22 at 1 week after SRP. At the 2nd week, PI was 0.56 ± 0.27, and at the 3rd week it was reduced further to 0.52 ± 0.22. However, at the 8th week, PI (0.50 ± 0.22) did not differ significantly from that at the 3rd week (0.52 ± 0.22). PI values in the test group were 2.67 ± 0.44 at the baseline and at 8 weeks after SRP, and gradual improvement in periodontal parameters was evident in both groups.

**GI**
The GI score in the control group at 0, 1, 2, 3, and 8 weeks was 2.08 ± 0.20, 1.18 ± 0.27, 0.89 ± 0.29, 0.51 ± 0.18, and 0.50 ± 0.22, respectively. There was a significant improvement in the GI at all time points up to 3 weeks. At the 8th week, GI in the control group did not differ significantly from that at the 3rd week. The corresponding GI scores in the test group were 2.10 ± 0.21, 0.51 ± 0.18, and 0.50 ± 0.22, respectively. Again, there was a significant improvement in the GI at all time points up to 3 weeks. However, GI at the 8th week was significantly lower than that at the 3rd week in the test group.

![Figure 1](image_url)

Figure 1 shows the gradual reduction in PI (mean ± SD) and GI (mean ± SD) at various time intervals (0, 1, 2, 3, and 8 weeks) in the control group and test groups. In both groups, there was a significant improvement in PI at 1 week. Significant improvement in GI was noticed up to the 3rd week in the control group, whereas in the test group this was evident up to the 8th week. An inter-group comparison of improvements in periodontal parameters is shown in Table 2. Reduction in GI was significantly more evident in the test group than in the control group.

**BOP**
The improvement in BOP% was 62% in the test group, as compared to 50% in the control group (Table 2).

**PD**
In the control group, PD showed a reduction from 2.67 ± 0.44 mm at the baseline to 2.12 ± 0.32 mm at the 8th week, whereas in the test group it was reduced from 2.65 ± 0.41 mm to 2.04 ± 0.32 mm, respectively. The difference in the degree of improvement between the two groups was not significant (Table 2).

**Table 1** Clinical parameters of the control group and test group at the baseline and at 8 weeks, and inter-group comparison of improvements in test parameters (mean ± SD)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Control group (n = 18)</th>
<th>Test group (n = 19)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline 8 weeks</td>
<td>Baseline 8 weeks</td>
</tr>
<tr>
<td>PI</td>
<td>1.71 ± 0.58 0.50 ± 0.22*a</td>
<td>1.75 ± 0.78 0.45 ± 0.21*a</td>
</tr>
<tr>
<td>ΔPI</td>
<td>1.21 ± 0.53 1.29 ± 0.70</td>
<td></td>
</tr>
<tr>
<td>GI</td>
<td>2.08 ± 0.20 0.89 ± 0.29*a</td>
<td>2.10 ± 0.21 0.51 ± 0.18*a</td>
</tr>
<tr>
<td>ΔGI</td>
<td>1.18 ± 0.27 1.58 ± 0.15*</td>
<td></td>
</tr>
<tr>
<td>BOP (%)</td>
<td>87.50 ± 12.59 43.61 ± 11.08*</td>
<td>88.42 ± 13.52 33.31 ± 9.44*</td>
</tr>
<tr>
<td>ΔBOP</td>
<td>43.88 ± 9.17 55.10 ± 11.78*</td>
<td></td>
</tr>
<tr>
<td>PD (mm)</td>
<td>2.67 ± 0.44 2.12 ± 0.32*a</td>
<td>2.65 ± 0.41 2.04 ± 0.32*a</td>
</tr>
<tr>
<td>ΔPD</td>
<td>0.55 ± 0.17 0.61 ± 0.23</td>
<td></td>
</tr>
<tr>
<td>CAL (mm)</td>
<td>1.87 ± 0.46 1.25 ± 0.47*</td>
<td>1.90 ± 0.30 1.04 ± 0.55*</td>
</tr>
<tr>
<td>ΔCAL</td>
<td>0.61 ± 0.22 0.85 ± 0.38*</td>
<td></td>
</tr>
</tbody>
</table>

a, paired t-test; b, wilcoxon-signed rank test; * P < 0.05 indicates significance
CAL in the control group was 1.86 ± 0.46 mm at the baseline, and was reduced to 1.25 ± 0.47 mm at the 8th week. In the test group, by comparison, there was a corresponding reduction from 1.90 ± 0.30 mm to 1.04 ± 0.55 mm. The difference in the degree of improvement between the two groups was significant (Table 2).

**Discussion**

Mouth breathing is a common habit among children of school age (13), and is often accompanied by morphological alterations in the normal growth pattern of the face and various harmful effects on physiological health (14). If continued over a long period of time, this abnormal mode of respiration may have detrimental effects on gingival health in the presence of dental plaque. If left untreated, this may progress to chronic periodontal disease. The aim of the present study was to assess the effects of root surface debridement in mouth breathing patients with periodontitis, and represented the first reported attempt to test the effectiveness of local application of salivary substitute as an adjunct to SRP on periodontal status in such patients.

The impact of mouth breathing in individuals over 14 years old is still largely unexplored. As our present study included patients older than this (up to 35 years old), our findings may be applicable to a larger proportion of the general population. The male:female ratio was well distributed within the two groups, and the study population was derived from same ethnic background and sampled from middle class families.

Dryness-induced inflammation of other body surfaces, such as ocular and cutaneous surfaces, has been reported previously. Factors that adversely affect tear film stability and osmolarity can induce ocular surface damage and initiate an inflammatory cascade that generates innate and adaptive immune responses. These immune-inflammatory responses lead to further ocular surface damage and the development of a self-perpetuating inflammatory cycle (15). In an analogous manner, in the oral milieu, factors that disturb the salivary coating may also harm the underlying tissue.

Evaluation of data in our present control group revealed that non-surgical periodontal treatment in the form of SRP resulted in considerable improvement of all clinical parameters by the 8th week when compared to the baseline values. Analysis of changes in clinical parameters on a weekly basis indicated gradual improvement in GI during the first 3 weeks, attributable to control of local etiological factors in the form of dental plaque and endotoxin. At the 8th week, the improvement in GI did not differ significantly from that in the 3rd week; the mean values of GI at both time points were very similar. This finding suggests that the maximum improvement in gingival inflammation occurred within 3-4 weeks in the control group, or that further reduction of inflammation was hindered by some other influencing factor. This may reflect the fact that mouth breathers are more likely to suffer from the drying effects and frictional action of continuous passage of inspired air over the anterior gingival tissues, thereby leaving the tissues dehydrated.

It has been documented that dermal wound healing occurs more rapidly under moist than under dry conditions (16). Desiccation itself is known to slow epithelial cell migration (17). One of the primary factors affecting the rate of angiogenesis during wound healing is the environment maintained over the surface of the wound bed. Acceleration of angiogenesis has been observed in
Hydration, surface tension and/or antimicrobial functions of saliva such as lubrication, viscosity, tissue function-oriented and have been used to support various non-surgical periodontal therapy. Salivary substitutes are investigated the use of salivary substitute as an adjunct to yet been explored. Therefore, in the present study, we effect on periodontal healing in mouth breathers has not dryness in such patients seems valuable. However, its preserve the hydration status of the underlying investing tissues. Thus, the use of salivary substitute to ameliorate application of salivary substitute might thus have aided resolution of the periodontal inflammatory burden.

The use of saliva substitutes may be helpful for patients complaining of a dry mouth and offer symptomatic relief for those with insufficient salivary function (20). A variety of artificial saliva replacement preparations (e.g., gels, sprays, and mouth rinses) are available. Oral desiccation caused by inspired air may be prevented by the use of a lubricant and moisturizer, which might help to preserve the hydration status of the underlying investing tissues. Thus, the use of salivary substitute to ameliorate dryness in such patients seems valuable. However, its effect on periodontal healing in mouth breathers has not yet been explored. Therefore, in the present study, we investigated the use of salivary substitute as an adjunct to non-surgical periodontal therapy. Salivary substitutes are function-oriented and have been used to support various functions of saliva such as lubrication, viscosity, tissue hydration, surface tension and/or antimicrobial properties. A carboxymethyl cellulose (CMC)-based salivary substitute (Wet Mouth) was used in the present study. Salivary substitutes normally contain cellulose derivatives that increase their stickiness and moistening ability. The glycerine component of this salivary substitute acts as a humectant as well as enhancing lubrication. Although such preparations can be used as often as needed, they are quickly swallowed and therefore repeated application may be necessary as their moistening and lubricating actions have limited duration. Although salivary substitute is not a perfect substitute for saliva, it can moisten oral tissues when used regularly.

Our findings are consistent with those of Lite et al., who observed restoration of inflamed tissues in mouth breathers to a normal healthy state after removal of local irritants and application of petroleum jelly over the affected tissues (21). Our present study had a number of strengths, including stringent inclusion and exclusion criteria, randomization, inclusion of patients older than 14 years, and exclusion of smokers. However, it was limited in being a pilot study with a relatively small sample size, without any analysis of inflammatory markers. Estimation of salivary changes as well as qualitative analysis of plaque might have better supported the results we obtained. Any definitive treatment strategy for mouth breathing patients involves an interdisciplinary approach from ENT specialists, physicians and dentists. There is a need to explore effective and affordable self-care techniques for this population of dental patients.

In conclusion, the results of the present study indicate that use of salivary substitute as an adjunct to conventional periodontal treatment may reduce gingival inflammation and bleeding on probing in anterior oral areas in mouth breathing patients with periodontitis.

Conflict of interest
No potential conflict of interest relevant to this article is reported.

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