# Patterns of Periodontal Destruction among Smokeless Tobacco Users in a Central Indian Population

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**Research Article**

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# Abstract

**Background:** Findings of studies testing the association between smokeless tobacco (SLT) use and periodontal health have shown varying results in different populations. Considering the high prevalence of SLT use in India, the present study was conducted to understand the pattern of periodontal destruction within different areas of the dentition among SLT users.

**Methods:** Age, gender, oral hygiene habits, the frequency and duration of SLT consumption, the type of SLT product used, and the site of retention of the SLT product in the oral cavity were recorded among 90 SLT users. Mean probing depth (PD), recession (REC), and clinical attachment loss (CAL) at SLT-associated and non SLT-associated teeth of the mandibular arch were compared based on the site of retention of the SLT product, the type of product used, and the duration of the habit.

**Results:** Mean REC and CAL were significantly higher at the SLT-associated zones compared to non SLT-associated zones and at both inter-proximal and mid-buccal sites of SLT-associated teeth. Among individuals who had the habit for >5 years and also among those who had the habit for 5-10 years, mean PD, REC, and CAL were significantly higher at SLT-associated teeth than at non SLT-associated teeth. Significantly greater periodontal destruction was observed at SLT-associated teeth among khaini users and gutkha users.

**Conclusion:** Patterns of periodontal destruction among SLT users varied significantly between SLT-associated and non-SLT-associated sites, and the severity of periodontal destruction at SLT-associated sites differed among individuals depending upon the type of SLT product used, the site of retention of the SLT product, and the duration of the habit.


# Background

Tobacco smoking has been shown to be an important risk factor for poor oral health, including periodontal disease. Although studies have shown that tobacco smoking is strongly associated with increased severity of periodontal destruction, the role of smokeless tobacco (SLT) in periodontal disease is still being investigated. Findings of studies testing the association between SLT use and periodontal health have shown varying results in different populations. While earlier studies conducted in the United States and Sweden have demonstrated that SLT use was associated with increased prevalence of gingival recession [1-7], other studies failed to show any association between the use of SLT and the severity of periodontitis [8-11].

Studies conducted among Asian populations have shown that SLT use is associated with an increased risk for destructive periodontal disease. SLT users in India [12] and Bangladesh [13] have been shown to have an increased risk for tooth loss. Probing depth and attachment loss have been reported to be higher among SLT users when compared to non-users in India,[14-17] Bangladesh,[13] and Thailand [18], SLT use was reported to be associated with increased prevalence and severity of gingival recession and attachment loss at mandibular teeth[16] and with higher scores of the community periodontal index,

gingival index and simplified oral hygiene index as well as increased odds for the presence of periodontal disease, pockets and clinical attachment loss[15, 17] among Indian populations. In their study among tobacco users in north India, Singh et al.[19] reported an increased occurrence of recession, attachment loss, mobility, and furcation lesions among SLT users. An epidemiological study conducted among Bangladeshi subjects also showed that SLT use was associated with poor periodontal health as evidenced by increased mean pocket depth, mean attachment loss, and number of missing teeth [13].

These differences in the observations among Asian and Western populations may be due to several factors such as the differences in the trends in SLT practices and types of SLT products used by the respective populations [20]. The prevalence of the SLT habits is high among both men and women in Asian countries, such as India and Bangladesh.[21] In India, the habit of tobacco consumption is highly prevalent across the country. While urban areas have shown increased prevalence of smoking, in rural areas, the consumption of SLT is high. In the central Indian state of Madhya Pradesh, where the present study was conducted, SLT consumption is very high and prevalent even among females. The high prevalence of these habits may be due to a general misconception, particularly among Asian populations, that oral SLT habits are generally less harmful than smoking. Moreover, such habits are deeply entrenched in the culture of these populations, which consider SLT products as relatively acceptable forms of tobacco consumption when compared to smoking, and individuals, considering it as a part of their life style, are introduced to such habits at a very young age. While smoking by women in India is considered socially unacceptable, SLT use is common, with easy availability and low cost of SLT being key factors promoting SLT use by women. Disadvantaged women also tend to use SLT products to suppress hunger during performance of laborious tasks. Moreover, compared to SLT products available in western countries that are considered to be less harmful than smoking, the products available in Asian countries are more harmful and contain more toxic ingredients [22, 23].

The central Indian state of Madhya Pradesh has a relatively high prevalence of SLT use among both males and females [24, 25]. According to a recent nationwide survey, the SLT habits are prevalent among 28% of the males and 16% of females in the state [25].The common SLT products in India include gutkha and pan masala (powdered tobacco mixed with areca nut, slaked lime, and catechu), betel quid with tobacco, zarda (prepared by boiling pieces of tobacco leaves in water with slaked lime), khaini (tobacco with slaked lime), and mawa (a mixture of areca nut, tobacco, and slaked lime). These products vary in terms of their ingredients and method of preparation. While the harmful effects of tobacco smoking on the periodontal tissues have been extensively studied, the effects of the SLT on the periodontium have received much less attention. Considering the high prevalence of SLT use among the population, it is important to understand the effects of these habits on the periodontium. Therefore, the present study was conducted to understand the pattern of periodontal destruction within different areas of the dentition among SLT users. We also attempted to study the effects of the different types of SLT products and the duration of the habit on the periodontium.

# Materials And Methods

The present study was conducted in the department of Periodontics, People's College of Dental Sciences and Research Centre, Bhopal, Madhya Pradesh state, India. Current oral SLT users above the age of 18 years who had at least five teeth in each quadrant reporting for treatment to the department during the period from January 2012 to December 2012 were enrolled in the study. Individuals who had a history of use of other forms of tobacco (smoking or inhalational), history of use of more than one form of oral SLT product, a history of discontinuation of tobacco use, the presence of any systemic disease, and a history of any form of periodontal treatment or antibiotic therapy during a six-month period prior to the study were excluded from the study. The study protocol was approved by the institutional Human Ethics Committee, and written informed consent was obtained from all of the prospective study participants.

The study variables such as age, gender, oral hygiene habits, frequency, and duration of SLT consumption, type of SLT product used, and site of retention of SLT product in the oral cavity were recorded using a questionnaire. Based on the site of retention of the SLT product in the oral cavity, the participants were categorized into three groups: Group 1-patients who retained the SLT product in the mandibular labial (anterior) vestibule (Zone 1); Group 2- patients who retained the SLT product in the mandibular left buccal vestibule (Zone 2); and Group 3- patients who retained the SLT product in the mandibular right buccal vestibule (Zone 3). SLT users who did not have the habit of retaining the SLT product in any of these regions or who had the habit of retaining it at more than one site were excluded from the study. Based on the duration of the SLT habit, the patients were again grouped into three groups: those who had the habit for <5 years; those who had the habit for 5-10 years; and those who had the habit for >10 years.

Clinical examination was performed to record plaque, calculus, gingival bleeding, probing depth (PD), gingival recession (REC), and clinical attachment loss (CAL). Plaque and calculus scores were recorded on all teeth excluding the third molars in two randomly selected diagonally opposite quadrants. Plaque scores were recorded according to the criteria of the Plaque Index of Sillness and Loe [26], and calculus scores were recorded according to criteria of the calculus component of the Simplified Oral Hygiene Index by Greene and Vermillion[27].

Gingival bleeding, PD, REC, and CAL were recorded on all teeth excluding the third molars in all of the quadrants. Gingival bleeding was recorded as the presence or absence of gingival bleeding within 30 seconds after passing the probe through the gingival sulcus on the buccal and lingual surfaces of all teeth. Gingival bleeding score for each individual was recorded as the ratio of the number of sites with gingival bleeding to the number of sites examined. PD, REC, and CAL were recorded at six points on all teeth using a graduated periodontal probe (UNC-15 probe, Hu-Friedy Manufacturing Co., Chicago, IL), and the measurements were rounded off to the nearest millimeter. All clinical recordings were performed by a single trained examiner (SM).

For calibration purposes, intra-examiner reproducibility was determined by the re-examination of a randomly selected quadrant in10 patients who were not part of the study. The participants in the calibration exercise were examined twice on the same visit by the examiner and intra-class correlation

coefficients were determined. Intra-class correlation coefficients for mean PD and mean CAL were 0.916 and 0.902, respectively. Of the replicated measurements, 93.5% were within 1 mm for PD and 91.6% were within 1 mm for CAL. Data collected were tabulated and analyzed statistically using software for statistical analysis (SPSS software version 17, IBM Corporation, Armonk, New York). The mean PD, mean REC, and mean CAL were calculated for the buccal and lingual sites of the mandibular teeth. The mean PD, mean REC, and mean CAL of the buccal sites were calculated separately for the mandibular anterior teeth (incisors and canines), mandibular right posterior teeth (right premolars and first and second molars), and mandibular left posterior teeth (left premolars and first and second molars) for each patient. In each patient, mandibular teeth adjacent to the placement site of the tobacco product were designated as SLT-associated teeth and the remaining mandibular teeth were designated as non SLT-associated teeth. The data did not show a normal distribution (Shapiro-Wilk) and were analyzed using non-parametric tests. Comparisons of the periodontal variables at the SLT-associated sites in a particular group with the corresponding sites in the remaining study participants were performed using the Mann-Whitney U-test. Comparisons of mean PD mean REC, and mean CAL between SLT-associated sites and non SLT-associated sites for the whole population among patient groups stratified based on the type of SLT product used and the duration of the habit were performed using the Wilcoxon Signed Rank test. For all analyses, the statistical significance was fixed at 0.05.

# Results

Among the 90 study participants, there were 74 were males and 16 females. The age of the participants ranged from 19 years to 70 years, with a mean age of 34.02±12.83 years. The mean scores for plaque, calculus, and gingival bleeding for the study population were 1.31±0.55, 1.52±0.65, and 0.80±0.23, respectively. The mean number of mandibular teeth in the study population was 13.53±1.04.

The distribution of the study population in terms of SLT habits is shown in table 1. Among the 90 study participants, there were 21 in group 1, 39 in group 2, and 30 in group 3. In terms of the duration of SLT consumption, 44 participants had the habit for <5 years, 26 had the habit for 5-10 years, and 20 had the habit for >10 years. Regarding the SLT product used, 45 consumed gutkha, 20 used khaini, and 25 consumed zarda.

**Table 1.** Distribution of study participants in terms of the site of retention of the SLT product, the duration of SLT use and the type of SLT product used.

| Variables | | *N* |
|---|---|---|
| Site of retention of SLT products | Zone 1-mandibular labial (anterior) vestibule (Group 1) | 21 |
| | Zone 2-mandibular left buccal vestibule (Group 2) | 39 |
| | Zone 3-mandibular right buccal vestibule (Group 3) | 30 |
| Duration of SLT use | <5 years | 44 |
| | 5-10 years | 26 |
| | >10 years | 20 |
| Type of SLT product used | Khaini | 20 |
| | Gutkha | 45 |
| | Zarda | 25 |

Table 2 shows the periodontal parameters at SLT-associated and non-SLT-associated zones for the study population. Mean PD was significantly higher at the SLT-associated zones compared to the non-SLT-associated zones for all sites ($p<0.001$), buccal sites ($p<0.001$), and lingual sites ($p=0.003$). However, the mean REC and mean CAL were significantly higher at SLT-associated zones compared to non-SLT-associated zones only for all sites ($p=0.027$ and $p<0.001$, respectively) and buccal sites ($p<0.001$ for both mean REC and mean CAL).

**Table 2.** Periodontal variables for mandibular teeth at SLT-associated and non-SLT-associated sites for the study population.

| Variable | Site | SLT-associated | Non SLT-associated | p-value |
|---|---|---|---|---|
| PD | Whole tooth | 3.06±0.81 | 2.79±0.76 | <0.001 |
| | Buccal sites | 3.09±0.81 | 2.79±0.79 | <0.001 |
| | Lingual sites | 3.03±0.96 | 2.79±0.87 | 0.003 |
| REC | Whole tooth | 0.78±1.00 | 0.60±0.96 | 0.027 |
| | Buccal sites | 1.05±1.25 | 0.61±1.03 | <0.001 |
| | Lingual sites | 0.53±1.00 | 0.59±1.00 | 0.322 |
| CAL | Whole tooth | 2.28±2.32 | 1.70±2.24 | <0.001 |
| | Buccal sites | 2.89±2.54 | 1.72±2.36 | <0.001 |
| | Lingual sites | 1.69±2.42 | 1.69±2.29 | 0.328 |

Comparison of periodontal parameters at the three different zones of the mandibular arch between individuals who retained the SLT product at the zone and individuals who did not retain it at that particular zone is shown in table 3. For zone 1, mean PD, mean REC, and mean CAL were higher among the 21 individuals in group 1 compared to the 69 individuals in groups 2 and 3 for buccal, lingual, and all

sites. However, none of the differences for mean PD were statistically significant. Statistically significant differences were observed for the mean REC for all sites (p=0.042) and buccal sites (p=0.004) and for the mean CAL for buccal sites (p=0.009). For zone 2, compared to 51 individuals in groups 1 and 3, significantly higher values were observed among 39 individuals in group 2 for mean PD at buccal sites (p=0.029), mean REC at all sites (p=0.052) and buccal sites (p=0.006), and mean CAL at buccal sites (p=0.002). Regarding zone 3, significantly higher values were observed for mean REC at buccal sites (p=0.018) and mean CAL at all sites (p=0.027) and buccal sites (p=0.007) among the 30 individuals in group3 compared to the 60 participants in groups 1 and 2.

**Table 3.** Periodontal variables for mandibular teeth at different zones among participants who did (SLT-associated) and did not (non-SLT-associated) retain the SLT product at the zone.

| **Zone 1 (Anterior)** | **Variable** | **Site** | **SLT-associated(n=21)** | **Non-SLT-associated(n=69)** | **p-value** |
|---|---|---|---|---|---|
| | PD | Whole tooth | 2.62±0.77 | 2.51±0.71 | 0.477 |
| | | Buccal sites | 2.83±0.90 | 2.66±0.80 | 0.538 |
| | | Lingual sites | 2.41±0.75 | 2.35±0.82 | 0.525 |
| | REC | Whole tooth | 1.35±1.27 | 0.84±1.28 | 0.042 |
| | | Buccal sites | 1.55±1.39 | 0.75±1.25 | 0.004 |
| | | Lingual sites | 1.16±1.41 | 0.94±1.46 | 0.510 |
| | CAL | Whole tooth | 2.79±2.50 | 1.91±2.52 | 0.070 |
| | | Buccal sites | 3.37±2.44 | 1.86±2.57 | 0.009 |
| | | Lingual sites | 2.22±2.77 | 1.97±2.69 | 0.853 |
| **Zone 2 (Left posterior)** | Variable | Site | SLT-associated(n=39) | Non-SLT-associated (n=51) | p-value |
| | PD | Whole tooth | 3.19±0.76 | 3.11±0.93 | 0.186 |
| | | Buccal sites | 3.25±0.76 | 2.99±0.94 | 0.029 |
| | | Lingual sites | 3.14±0.86 | 3.22±1.03 | 0.929 |
| | REC | Whole tooth | 0.61±0.95 | 0.34±0.69 | 0.052 |
| | | Buccal sites | 0.83±1.11 | 0.37±0.82 | 0.006 |
| | | Lingual sites | 0.40±0.88 | 0.32±0.70 | 0.853 |
| | CAL | Whole tooth | 2.06±2.40 | 1.49±2.14 | 0.058 |
| | | Buccal sites | 2.59±2.60 | 1.49±2.23 | 0.002 |
| | | Lingual sites | 1.54±2.38 | 1.48±2.26 | 0.621 |
| **Zone 3 (Right posterior)** | Variable | Site | SLT-associated(n=30) | Non-SLT-associated(n=60) | p-value |
| | PD | Whole tooth | 3.19±0.82 | 2.94±0.72 | 0.164 |
| | | Buccal sites | 3.03±0.75 | 2.80±0.78 | 0.055 |
| | | Lingual sites | 3.31±1.05 | 3.08±0.84 | 0.387 |
| | REC | Whole tooth | 0.61±0.76 | 0.46±0.86 | 0.060 |
| | | Buccal sites | 0.97±1.24 | 0.56±1.06 | 0.018 |
| | | Lingual sites | 0.25±0.54 | 0.32±0.73 | 0.742 |
| | CAL | Whole tooth | 2.24±2.13 | 1.61±2.22 | 0.027 |
| | | Buccal sites | 2.88±2.55 | 1.69±2.43 | 0.007 |
| | | Lingual sites | 1.53±2.23 | 1.49±2.19 | 0.571 |

Table 4 shows the comparison of periodontal parameters of inter-proximal and mid-buccal sites at the three different zones of the mandibular arch between individuals who retained the SLT product at the zone and individuals who did not retain it at that particular zone. For zone 1, mean REC and mean CAL were significantly higher at both the inter-proximal (p=0.002 and p=0.009, respectively) and mid-buccal (p=0.004 and p=0.010, respectively) sites among individuals in group 1 compared to the remaining study population. A similar trend was observed for zones 2 and 3, where individuals who retained the SLT product at these sites exhibited significantly higher mean REC and mean CAL scores at these sites

compared to individuals who did not retain the SLT product at these sites. While mean PD was higher at SLT-associated sites in all zones compared to non-SLT-associated sites, statistically significant differences were observed only for inter-proximal sites in zone 3 (p=0.030). Periodontal destruction in terms of mean REC and mean CAL at inter-proximal and mid-buccal sites were more severe in zone 1 than in the remaining areas.

**Table 4.** Periodontal variables for inter-proximal and mid-buccal sites of mandibular teeth at different zones among participants who did (SLT-associated) and did not (non-SLT-associated) retain the SLT product at the zone.

| | | **Zone 1 (Anterior)** | | | **Zone 2 (Left posterior)** | | | **Zone 3 (Right posterior)** | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Site | Variable | SLT-associated (*n*=21) | Non-SLT-associated (*n*=69) | *p*-value | SLT-associated (*n*=39) | Non-SLT-associated (*n*=51) | *p*-value | SLT-associated (*n*=30) | Non-SLT-associated(*n*=60) | *p*-value |
| Inter-proximal | PD | 3.03±1.00 | 2.91±0.92 | 0.735 | 3.44±0.84 | 3.18±0.99 | 0.052 | 3.34±0.85 | 3.00±0.83 | 0.030 |
| | REC | 1.44±1.36 | 0.70±1.23 | 0.002 | 0.80±1.09 | 0.35±0.79 | 0.017 | 0.96±1.25 | 0.59±1.08 | 0.028 |
| | CAL | 3.43±2.46 | 1.91±2.70 | 0.009 | 2.68±2.60 | 1.56±2.30 | 0.002 | 3.11±2.58 | 1.84±2.52 | 0.008 |
| Mid-buccal | PD | 2.43±0.85 | 2.17±0.68 | 0.188 | 2.87±0.86 | 2.62±0.96 | 0.069 | 2.55±0.82 | 2.39±0.74 | 0.397 |
| | REC | 1.76±1.50 | 0.84±1.33 | 0.004 | 0.90±1.19 | 0.39±0.89 | 0.005 | 0.99±1.32 | 0.58±1.04 | 0.043 |
| | CAL | 3.26±2.48 | 1.77±2.38 | 0.01 | 2.41±2.71 | 1.34±2.15 | 0.009 | 2.63±2.60 | 1.50±2.32 | 0.025 |

Periodontal variables at buccal sites of mandibular teeth of SLT-associated and non SLT-associated zones for the study population stratified by the duration of SLT use are shown in table 5. Among individuals who had the habit for < 5 years (n=44) and also among individuals who had the habit for 5-10 years (n=26), mean PD (p=0.002 and p=0.014, respectively), mean REC (p=0.023 and p=0.003, respectively), and mean CAL (p=0.003 and p<0.001, respectively) were significantly higher at SLT-associated teeth than at non-SLT-associated teeth. However, among individuals who had the SLT habit for > 10 years (n=20), although all of the periodontal parameters were higher at SLT-associated teeth than at non-SLT-associated teeth, statistically significant differences were observed only for mean CAL (p=0.017). Individuals who had the habit for > 10 years demonstrated more severe periodontal destruction (higher mean PD, mean REC, and mean CAL) even at non-SLT-associated teeth compared to the remainder of the study population.

**Table 5.** Periodontal variables for mandibular teeth at SLT-associated and non-SLT-associated sites for the study population according to the duration of SLT use.

| Duration of habit | Variable | SLT-associated | Non-SLT-associated | p-value |
|---|---|---|---|---|
| <5 years (n=44) | PD | 2.84±0.62 | 2.54±0.56 | 0.002 |
| | REC | 0.62±0.96 | 0.38±0.89 | 0.023 |
| | CAL | 1.79±2.05 | 0.99±1.91 | 0.003 |
| 5-10 years (n=26) | PD | 3.08±0.86 | 2.75±0.80 | 0.014 |
| | REC | 1.04±1.13 | 0.34±0.61 | 0.003 |
| | CAL | 2.86±2.24 | 1.22±1.64 | <0.001 |
| >10 years (n=20) | PD | 3.69±0.84 | 3.40±0.90 | 0.070 |
| | REC | 1.98±1.50 | 1.45±1.30 | 0.121 |
| | CAL | 5.36±2.24 | 3.99±2.71 | 0.017 |

**Table 6.** Periodontal variables for mandibular teeth at SLT-associated and non-SLT-associated sites for the study population according to the type of SLT product used.

| Type of ST product | Variable | SLT-associated | Non-SLT-associated | p-value |
|---|---|---|---|---|
| Khaini (n=20) | PD | 3.18±0.75 | 2.90±0.84 | 0.100 |
| | REC | 1.47±1.47 | 0.75±1.20 | 0.015 |
| | CAL | 3.87±2.38 | 2.05±2.46 | 0.002 |
| Gutkha (n=45) | PD | 2.89±0.75 | 2.52±0.59 | <0.001 |
| | REC | 0.72±1.04 | 0.28±0.67 | 0.002 |
| | CAL | 1.96±2.21 | 0.81±1.61 | <0.001 |
| Zarda (n=25) | PD | 3.39±0.89 | 3.19±0.89 | 0.150 |
| | REC | 1.30±1.30 | 1.07±1.22 | 0.248 |
| | CAL | 3.79±2.71 | 3.11±2.75 | 0.081 |

Table 6 shows the comparison of periodontal variables at buccal sites of mandibular teeth of SLT-associated and non-SLT-associated zones for the study popula tion stratified by the type of SLT product used. Generally, irrespective of the type of SLT product used, mean PD, mean REC, and mean CAL were higher at SLT-associated teeth than at non-SLT-associated teeth. However, statistically significant differences were observed only for mean REC (p=0.015) and mean CAL (p=0.002) among khaini users (n=20) and for mean PD (p<0.001), mean REC (p=0.002), and mean CAL (p<0.001) among gutkha users (n=45).

# Discussion

The present study was performed to determine the pattern of periodontal destruction at SLT-associated teeth and non-SLT-associated teeth among different types of SLT users in a central Indian population. The results of the present study indicate that the patterns of periodontal destruction among SLT users were significantly different between SLT-associated and non-SLT-associated sites. The findings in the present study also showed that the severity of periodontal destruction at SLT-associated sites varied among individuals depending upon the type of SLT product used, the site of retention of the SLT product, and the duration of the habit. Although studies have suggested that the habit of SLT use may be associated with increased severity of periodontal destruction [15, 28] the patterns of periodontal destruction among SLT users are not fully understood. The results reported by different investigators indicate that there are considerable variations in the association of the SLT habit with periodontal disease [7, 13]. While a study conducted among Swedish adolescents [7] reported that the prevalence of gingival recession was significantly greater without significant differences in mean CAL among SLT users compared to controls, studies conducted among Indian subjects [15] and Bangladeshi subjects [13] have shown that SLT use is associated with increased PD and loss of periodontal attachment. Several factors, such as patterns of SLT habits and types of products, may account for these variations [20].

Nationwide studies conducted in India have shown that SLT habits are highly prevalent and more common than smoking among both males and females in rural as well as in urban areas [25, 29, 30]. Considering the prevalence of SLT habits among Indians, it is important to understand the harmful effects of such habits on the periodontium. In the present study, it was observed that the mean PD was significantly higher at SLT-associated teeth at the level of the whole tooth, buccal sites, and lingual sites, while significantly higher mean REC and mean CAL at SLT-associated sites were observed only at the level of the whole tooth and buccal sites. In a similar study conducted among SLT users in a US population, significant differences between SLT-associated and non-SLT-associated teeth were reported only for attachment level at the level of the whole tooth and buccal sites and not for PD or REC [31].The participants were categorized into three groups depending on the site of retention of the SLT product in relation to the mandibular arch. Periodontal parameters at each individual zone were compared between individuals who did and who did not retain the SLT product at the particular zone. It was observed that for all zones, mean REC and mean CAL were significantly greater at buccal sites among individuals who retained the SLT product at the respective zone when compared to individuals who did not retain it at that particular zone. Of the three zones, the maximum difference in scores of mean REC and mean CAL was observed at the mandibular anterior teeth, suggesting a more severe destruction at these sites on account of the SLT habits. Very few studies reported the periodontal destruction patterns with reference to the site of retention of the SLT product in the oral cavity. While some of these studies have mentioned that the participants retained the SLT product in the lower right or left buccal vestibule [31] or the maxillary anterior tooth region, [6, 7] one study conducted among professional baseball players in the US reported that the majority of the SLT-associated mucosal lesions occurred in the mandibular incisor region with a greater prevalence of gingival recession in these zones [4]. In the present study, it was observed that the SLT habit was associated with the retention of the SLT product by the participants in the mandibular right

or left buccal vestibule or the labial vestibule, and this was associated with greater periodontal destruction at these sites, particularly at the mandibular anterior region.

Comparison of periodontal parameters at inter-proximal and mid-buccal sites at the three different zones between individuals who did and who did not retain the SLT product at the particular zone showed that both mean REC and mean CAL were significantly higher at both inter-proximal and mid-buccal sites among individuals who retained the SLT product at the respective zone when compared to individuals who did not retain it at that particular zone. It was also observed that at each zone, mean REC was higher at mid-buccal sites compared to the inter-proximal sites, whereas for mean CAL, the trend was reversed. Moreover, among the three zones, higher scores of mean REC and mean CAL for both inter-proximal and mid-buccal sites were observed at the mandibular anterior region, suggesting greater periodontal destruction at these teeth. An earlier study comparing periodontal destruction patterns at inter-proximal and mid-buccal sites at SLT-associated and non-SLT-associated sites among SLT users in the US showed significant differences only for mean CAL at mid-buccal sites with no significant differences in mean REC at mid-buccal and inter-proximal sites and mean CAL at inter-proximal sites [31]. The greater scores of mean REC and CAL observed at both inter-proximal and mid-buccal sites of SLT-associated teeth among participants in the present study may be due to the different practices in SLT habits among participants in the present study compared to individuals in the US.

Comparison of the periodontal parameters between SLT-associated and non SLT-associated sites in the study population stratified by the duration of habit showed that mean PD, mean REC, and mean CAL at SLT-associated sites were significantly higher among participants who had the habit for ≤10 years, while the differences in the mean values of PD, REC, and CAL between SLT-associated sites and non-SLT-associated sites among SLT users who had the habit for >10 years, though greater at SLT-associated sites, were not statistically significant, except for mean CAL. In a similar study among SLT users in the US, significantly greater REC and attachment loss were reported, particularly at buccal sites, at SLT-associated teeth among SLT users who had the habit for ≥10 years, while significant differences were not observed among users who had the habit for <10 years [31]. The lack of significant differences between SLT-associated and non-SLT-associated teeth among participants in the present study who had the habit for >10 years may be because the longer duration of SLT use can result in generalized changes in the periodontium, a finding similar to that observed in our earlier study among SLT users [16]. This may be explained by the fact that during the habit of tobacco chewing, the harmful ingredients contained in the SLT may be moved around from one region of the oral cavity to the other, thus exposing all areas of the dentition to the deleterious effects of the tobacco contents. Although these products are not retained at all locations for a significant length of time, persistence of the habit over a long period of time may have a cumulative effect, resulting in generalized damage to the periodontium.

The different types of SLT products used in India and other Asian countries vary in their composition (besides tobacco, they include other ingredients such as betel quid, areca nut, slaked lime, catechu, and spices) and method of preparation, which may result in an alteration of the properties of the individual components. Therefore, the effects of the various SLT products on the periodontium may be different. To

the best of our knowledge, this is the first study to compare the periodontal destruction patterns among users of different types of SLT products in India. Although in an earlier study among SLT users in north India, Singh et al. reported differences in the severity of periodontal destruction among users of different types of SLT products, the authors mentioned that many of the participants in their study had used more than one type of SLT product [19]. In the present study, we attempted to study the effects of individual types of SLT products on the periodontium by excluding individuals who had used more than one type of product. It was observed that the participants in the present study used gutkha, khaini, or zarda, with about half of the participants using gutkha. When the comparison of periodontal parameters between SLT-associated and non-SLT-associated sites in the study population stratified by the type of product used was performed, it was observed that, while the use of zarda resulted in maximum destruction at SLT-associated sites, statistically significant differences in periodontal destruction between SLT-associated and non-SLT-associated sites were observed in khaini and gutkha users. Gutkha is one of the most widely used forms of SLT in India,[19, 32-34] while other forms such as khaini and zarda are also popular among SLT users. Gutkha is also the most popular form of SLT product among Asian immigrants in Western countries. On account of the aggressive marketing strategies and availability in the form of small sachets, the consumption of SLT in general and gutkha in particular has increased dramatically in recent decades. The various SLT products available in Asian countries, unlike the products available in developed countries, have been shown to contain more than 4000 different types of mutagenic and carcinogenic ingredients [22, 23, 35, 36]. Nicotine, the principal alkaloid in tobacco, is considered to play a major role in causing periodontal destruction, and its absorption from SLT products through the oral mucosa is higher from products that have a higher pH and higher unionized nicotine content. SLT products available in Asian countries have higher values of pH, total nicotine, and unionized nicotine, thereby facilitating increased absorption through the oral mucosa [36]. In addition to nicotine, these products contain other toxic components that may also contribute to tissue destruction, and this needs to be considered, particularly because a recent animal study has shown that components other than nicotine in gutkha can exert adverse effects on living tissues [37].

# Conclusions

In conclusion, the findings of the present study suggest that periodontal destruction among SLT users is higher at SLT-associated teeth with variations in the patterns of destruction depending on the location of retention of the product, the duration of the habit, and the type of product used. One major limitation of the study is the limited sample size, which was further curtailed when the participants were stratified by the duration of the habit and the type of SLT product used. Moreover, only three types of SLT products were compared in the present study, while at least 10 different types of products are used by different populations in India alone. As large numbers of people tend to use more than a single product as well as a combination of smoking and SLT, the effects of such habits on the periodontium also need to be evaluated. Influence of oral hygiene practices and etiologic factors such as plaque and calculus also need to be considered in evaluating the role of SLT products on periodontal destruction. Therefore, further studies utilizing larger samples need to be carried out among different populations in Asian countries to

better understand the effects of SLT on the periodontium among these populations. Once these associations are better understood, the new information thus generated may be used to better design the public health programs among these populations to tackle periodontal diseases and improve the oral health status among these populations. Moreover, emphasis should also be placed on improving the awareness of members of these populations regarding the health hazards of SLT to reduce the health problems caused by these habits and thus improve the quality of life among these populations.

# Abbreviations

SLT-smokeless tobacco

PD-probing depth

REC-gingival recession

CAL-clinical attachment loss

# Declarations

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**Availability of data and materials**

The datasets during and/or analyzed during the current study available from the corresponding author on reasonable request

**Authors' contributions**

**SM-**was involved in collection of data, drafting the manuscript, approval of the final version of the manuscript for submission, and is accountable for all aspects of the work, **DN-**was involved in collection of data, drafting the manuscript, approval of the final version of the manuscript for submission, and is accountable for all aspects of the work, **NK-**was involved in **s**tudy conception and design, drafting the manuscript and revising it critically for important intellectual content, approval of the final version of the manuscript for submission, and is accountable for all aspects of the work, **KK-** was involved in study conception and design, statistical analysis and interpretation of data, drafting the manuscript and revising it critically for important intellectual content, approval of the final version of the manuscript for submission, and is accountable for all aspects of the work, **PA-** was involved in study conception and

design, data collection, statistical analysis and interpretation of data, drafting the manuscript and revising it critically for important intellectual content, approval of the final version of the manuscript for submission, and is accountable for all aspects of the work, **SA-** was involved in study conception and design, drafting the manuscript and revising it critically for important intellectual content, approval of the final version of the manuscript for submission, and is accountable for all aspects of the work

### Competing interests

The authors declare that they have no competing interests

### Ethics approval and consent to participate

The study protocol was approved by the institutional Human Ethics Committee, and written informed consent was obtained from all of the prospective study participants. Ethics Committee, People's College of Dental Sciences & Research Centre, Bhopal, Madhya Pradesh State, India

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### Consent for Publication

Not applicable

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