Influence of Soft Tissue and Crestal Bone Resorption in Moderate Cigarette-Smokers and Nonsmokers: A 5-Year Study

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This study aimed to determine the impact of implant placement depth (bone-level [BL] and subcrestal [SC]) on soft-tissue inflammatory parameters bleeding on probing (BOP), probing depth (PD), and crestal bone resorption (CBR) in moderate cigarette-smokers and nonsmokers at 5 years postplacement. Patient details were recorded, including sex, age, smoking history, duration of implants in function, implant arch location, and daily toothbrushing and flossing habits. Peri-implant BOP, PD, and CBR were measured in all groups, and group comparisons were done; a probability score < .05 was selected as a value for statistical significance. Fifty-three patients (27 smokers, 26 nonsmokers) had BL implants, and 55 patients (28 smokers, 27 nonsmokers) had SC implants. Among all patients, PD was higher in smokers than nonsmokers (P < .05). The peri-implant sites that demonstrated BOP were higher (P < .05) in nonsmokers than smokers. Among smokers, the CBR was higher in those with BL implants than those with SC implants (P < .05). Among nonsmokers, there was a difference in BOP, PD, and CBR at the 5-year follow-up. At 5 years, SC implants demonstrated less CBR than BL implants. Peri-implant PD is higher in smokers than nonsmokers, irrespective of the implant placement depth. Int J Periodontics Restorative Dent 2021;41:895–900. doi: 10.11607/prd.5039

Inflammatory conditions around implants encompass peri-implant mucositis, in which inflammatory reactions are limited to the soft tissues surrounding the implant, or peri-implantitis, where the integrity of the supporting alveolar bone is compromised.1 If the peri-implant diseases are not diagnosed and treated in a timely manner, detrimental outcomes may be encountered, including implant loss. In this context, prevention of inflammation in the peri-implant supporting tissues (including gingiva and supporting bone) plays a role in the long-term stability of implants.2–4 Traditionally, implants are placed at the level of the alveolar crest (bone level [BL]).5 Crestal bone resorption of approximately 1.5 mm within 60 months of placement and loading is considered standard.6,7 Nevertheless, the risk of continued peri-implant bone loss, which may ultimately lead to detrimental outcomes such as infection and implant failure, cannot be disregarded.8 In an experimental study on beagle dogs, Calvo-Guirado et al9 showed that crestal bone resorption (CBR) is minimal when implants are placed 2 mm below the level of the alveolar crest. Similarly, in a recent 24-month follow-up clinical study, Novák et al10 investigated the success rate and alveolar bone response in implants with BL and subcrestal (SC) placements. The
results showed that implants placed 2 mm below the implant-abutment junction demonstrate significantly less CBR than implants placed at BL.\textsuperscript{10} Results from a systematic review reported that studies on BL and SC implants have high risk of bias and have shorter follow-up durations, up to 36 months.\textsuperscript{11} The authors concluded that the significance of BL or SC implant placement towards minimizing CBR remains contentious.\textsuperscript{11}

Several studies\textsuperscript{12–15} have confirmed that habitual use of tobacco products is associated with life-threatening conditions such as cardiovascular diseases, lung cancer, and cerebrovascular disorders. From a molecular perspective, tobacco-smoking increases the production of inflammatory cytokines that accelerate the rate of tissue inflammation in the oral and systemic regions.\textsuperscript{16–18} From an oro-dental perspective, tobacco-smoking increases the production of inflammatory cytokines in the whole saliva and gingival-crevicular fluid, which include interleukin-(IL)-1 beta, tumor necrosis factor-alpha (TNF-\(\alpha\)), and IL-6.\textsuperscript{19–22} These cytokines have been reported to increase periodontal and peri-implant tissue inflammation and enhance bone resorption around natural teeth and implants.\textsuperscript{19–22} In addition, extracts of tobacco smoke have been shown to jeopardize the shape and function of fibroblasts in the lungs and gingiva.\textsuperscript{23–25} Furthermore, according to Pimentel et al.\textsuperscript{26} in comparison to nonsmokers, tobacco-smoking is associated with an increased growth of gram-negative bacteria, such as \textit{Fusobacterium nucleatum} and \textit{Tannerella} types, in the peri-implant plaque. The null hypothesis proposed in the present study is that there is no influence of implant placement depth on peri-implant bleeding on probing (BOP), probing depth (PD), and CBR in moderate cigarette-smokers and nonsmokers. Additionally, it was hypothesized that cigarette-smoking plays a detrimental role in inflammation around implants (increased BOP, PD, and CBR), irrespective of the BL or SC placement. Therefore, the objective of this 5-year follow-up study was to assess the implant placement depth (BL and SC) on the tissue-inflammatory parameters (BOP and PD) and CBR in moderate cigarette-smokers and nonsmokers.

**Materials and Methods**

**Ethical Protocol**

This study was performed in accordance with the rules and regulations set by the ethics guidelines of the Declaration of Helsinki as revised in 2000. A consent form, which was written in comprehensible English, was given to consenting subjects.

**Eligibility Standards**

Patients were included in the present study if they were moderate cigarette-smokers (smoking 11 to 15 cigarettes daily)\textsuperscript{27} or nonsmokers (have never used tobacco-containing products)\textsuperscript{28} with implants placed at BL and SC positions. The exclusion criteria were as follows: alcohol users, dual- and heavy smokers, tobacco-chewers, and patients with self-reported medical disorders encompassing but not limited to kidney and liver diseases, immunosuppressed patients (HIV/AIDS and self-reported chronic hyperglycemic conditions including prediabetes and type-1 and type-2 diabetes), and patients who had consumed non-steroidal anti-inflammatory medications, steroids, antibiotics, or probiotics within 60 days.

**Questionnaire**

Self-reported information related to duration of cigarette smoking (pack years), sex, arch location of implants, oral hygiene habits (brushing and flossing), duration of implants in function, and age were collected using a questionnaire. This questionnaire was administered to all patients by a skilled researcher (M.A.).

**Clinical and Radiographic Evaluations**

CBR was calculated as the perpendicular distance from 2 mm under the abutment-implant junction up to the alveolar crestal height. Digital bitewing radiographs were used to assess CBR. All radiographs were taken using the long-cone paralleling technique.\textsuperscript{29} Around all implants, the present author measured the BOP and PD at six sites per implant (three buccal, three palatal/lingual) using a plastic and graded
probe (Hu-Freidy) (intrarater reliability kappa score: 0.9).

**Statistical Analysis**

Statistical comparisons between the groups were done using one-way analysis of variance, Mann-Whitney U test, and Bonferroni post-hoc adjustment tests (SPSS version 20, IBM). Probability values ($P$ values) < .05 were considered significant. With the inclusion of at least 24 smokers and 24 nonsmokers with BL- and SC-positioned implants, the study would achieve a power of 90% with an alpha error of 5%.

**Results**

**General Characteristics**

Altogether, 108 men were assessed. Fifty-three patients (27 smokers, 26 nonsmokers) had BL implants, and 55 (28 smokers, 27 nonsmokers) had SC implants. Smokers with BL and SC implants were both smoking an average of 1.2 packs daily, and smoking patients with BL and SC implants had a smoking history of 24 and 24.4 pack-years, respectively. In smokers and nonsmokers, BL and SC implants were functional for equivalent spans (5 to 5.5 years). All patients had one implant in either the maxilla or mandible. In patients with BL implants, 77.8% of smokers and 73.1% of nonsmokers reported tooth brushing once a day. Among patients with SC implants, 85.7% of smokers and 77.8% of nonsmokers reported tooth brushing once daily. None of the subjects reported use of dental floss (Table 1).

**Implants**

All implants had moderately rough surfaces and were platform-switched. All restorations were screw-retained. The implants were embedded in the areas of missing maxillary and mandibular teeth.
mandibular premolars or molars. The implants diameters ranged from 4.1 to 4.8 mm, and the lengths ranged from 11 to 14 mm. In smokers, the BL and SC implants had been functional for 5.1 and 5.2 years, respectively. In nonsmokers, the BL and SC implants had been functional for 5.3 and 5.3 years, respectively (Table 1).

Clinical and Radiographic Assessments

In contrast to nonsmokers, PD (P < .05) was significantly deep in all smoking patients. BOP scores were markedly lower in smokers than nonsmokers in all patients (P < .05). The CBR was higher in smokers with BL than SC implants. Peri-implant PD and CBR had no significant differences among nonsmokers with BL and SC implants. Compared to smokers with SC implants, CBR was higher in smokers with BL implants (P < .05; Table 2).

Discussion

In the present study, the author formatted a null hypothesis that implant placement depth does not influence peri-implant BOP, PD, and CBR in moderate cigarette-smokers and nonsmokers. It was also hypothesized that cigarette-smoking plays a detrimental role in worsening inflammation around implants, irrespective of BL or SC placement, and would present clinically as increased BOP and PD and present radiographically as increased CBR.

The results are partially in agreement with the null hypothesis, as peri-implant PD was significantly higher among BL and SC implants placed in smokers than in nonsmokers. Inflammatory cytokines (for instance, TNF-α and IL-1β) are commonly expressed in the sulci around implants placed in smokers; this increases inflammation on soft tissues, such as gingivae, and accelerate the activity of bone-resorbing cells. In situations where gingival inflammation is left untreated, peri-implant mucositis and peri-implantitis can occur as potential complications.

A state of oxidative stress in gingival tissues is also associated with tobacco-smoking, forming advanced glycation end-products in the gingivae.

Akram et al analyzed and compared the levels of advanced glycation end-products (AGEs) expressed in the gingival crevicular fluid (GCF) of patients experiencing periodontal inflammation. The comparison results showed that patients with inflamed periodontal tissues had raised levels of AGES in the GCF compared to patients with a healthy periodontal status. Likewise, Alrabiah et al reported raised levels of AGES in the peri-implant sulcular fluid of patients suffering from peri-implant diseases. The results of the

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Bone-level implants</th>
<th>Subcrestal implants</th>
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<tbody>
<tr>
<td></td>
<td>Smokers</td>
<td>Nonsmokers</td>
</tr>
<tr>
<td>Bleeding on probing, %</td>
<td>11.1 (8.2–17.2)</td>
<td>39.4 (30.6–46.8)</td>
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<tr>
<td>Probing depth, mm</td>
<td>4.3 (3.5–4.5)</td>
<td>1.9 (1.5–2.3)</td>
</tr>
<tr>
<td>Crestal bone resorption, mm</td>
<td>2.9 (2.2–3.5)</td>
<td>0.5 (0.4–1)</td>
</tr>
</tbody>
</table>

Data are presented as mean (range).

aCompared with nonsmokers with bone-level (P < .05) and subcrestal implants (P < .05).
bCompared with nonsmokers with subcrestal implants (P < .05).
cCompared with smokers with subcrestal implants (P < .05).
proximately 80% of patients stated CBR in smoking patients specifically. Therefore, the SC position cannot be lower around SC implants (2.9 mm). mm, which would be similar to the CBR in SC implants is around 2.3 mm. In this context, the implant placement depth does not seem to minimize CBR and instead merely seems to mask the ongoing inflammatory process for a limited duration. With reference to BOP, the current outcomes are incongruous with the null hypothesis, as BOP was more commonly observed in nonsmoking patients than in smokers. One explanation is that nicotine constricts the gingival vessels, thereby masking BOP in smokers.36 Thus, tobacco consumers (such as cigarette smokers) often spend prolonged periods being oblivious to the ongoing and augmenting peri-implant inflammation.19,37

The present results demonstrated that, in smokers, CBR was greater around BL implants than SC implants. Examining this result is critical, as it might suggest that SC implant placement decreases CBR. It is important to note that the SC implants were placed 2 mm beneath crestal bone. At the 5-year follow-up, the bone resorption around SC implants in smokers was 0.3 mm (estimated as the vertical distance from the implant interface to the greatest vertical stature of crestal bone). Therefore, if the CBR was measured from the bone level instead of from the subcrestal location, the genuine CBR in SC implants is around 2.3 mm, which would be similar to the CBR noted in BL implants (2.9 mm). Therefore, the SC position cannot be suggested as a means to reduce CBR in smoking patients specifically.

In the present investigation, approximately 80% of patients stated that brushing their teeth was something they did once a day, and none of the patients used dental floss. That been said, one should keep in mind the role played by poor oral hygiene in the instigation and progression of peri-implant diseases in smokers and nonsmokers alike. In this situation, it is a basic requirement to inform and educate patients about the negative impacts of poor oral hygiene and tobacco-smoking on oral wellbeing and peri-implant tissues.

It is important to mention that the present investigation was only performed in cigarette smokers vs nonsmokers. Studies32,37,38 have demonstrated that patients using waterpipes are just as susceptible to peri-implant diseases, including peri-implantitis, as cigarette smokers. This suggests that PD and CBR are higher around BL implants than SC implants in waterpipe-using patients than in nonsmoking patients. In addition, a vast majority of implants were located in the mandible. Because bone thickness varies between the maxilla and the mandible, with the latter comprised of thicker bone, it is theorized that CBR is higher around BL and SC implants in the maxilla than in the mandible.

Conclusions

Five years after implant placement, SC implants demonstrated significantly less CBR than BL implants. Peri-implant PD is higher in smokers than nonsmokers, irrespective of the implant placement depth.

Acknowledgments

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References


