Role of mechanical curettage with and without adjunct antimicrobial photodynamic therapy in the treatment of peri-implant mucositis in cigarette smokers: A randomized controlled clinical trial

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ABSTRACT

Objective: The aim of the present 12-weeks follow-up randomized clinical trial was to investigate the outcome of mechanical curettage (MC) with or without adjunct antimicrobial photodynamic therapy (aPDT) in the treatment of peri-implant mucositis in cigarette smokers.

Methods: Therapeutically, subjects with peri-implant mucositis were divided into 2 groups: (a) Group-A: MC + aPDT; and (b) Group-B: MC alone (control group). In both groups, peri-implant plaque index (PI), bleeding on probing (BOP) and probing pocket depth (PPD) were gauged at baseline and after 12-weeks follow-up. Group comparisons were performed using the Kruskal-Wallis test. P-values less than 0.05 were considered statistically significant.

Results: Fifty-four male patients (28 in Group-A and 26 in Group-B) were included. The mean age of individuals in groups A and B were 50.6 ± 0.8 and 52.2 ± 0.5 years, respectively. In groups A and B the participants were smoking 16.5 ± 2.7 and 14.2 ± 1.7 cigarettes daily since 25.2 ± 6.5 and 24.6 ± 4.3 years, respectively. Periimplant PI, BOP and PPD were comparable among individuals in both groups at baseline. At 12-weeks follow-up, there was a significant reduction in PI (P < 0.001) and PPD (P < 0.001) among patients in groups A and B compared with their respective baseline values. At 12-weeks follow-up, PI (P < 0.001) and PPD (P < 0.001) were significantly higher among patients in Group-B compared with Group-A (P < 0.001). BOP was comparable in both groups at baseline and at 12-weeks follow-up.

Conclusion: In cigarette smokers, MC with adjunct aPDT is more effective in the treatment of peri-implant mucositis compared with MC alone.

1. Introduction

Dental implants are a modern treatment strategy for the oral rehabilitation of partially and completely edentulous individuals. Although dental implants have been shown to have success and survival rates of up to 100% [1,2]; periimplant diseases (such as peri-implant mucositis) may occur as a post-therapy complication. Amongst the risk-factors that have been associated with the etiology of peri-implant diseases, poor oral hygiene status, history of periodontal disease, poorly-controlled diabetes mellitus and tobacco smoking are well acknowledged [3–5]. Studies have shown that cigarette smoking induces a state of oxidative stress in the gingival and periodontal tissues by escalating the production of proinflammatory cytokines such as interleukins and matrix metalloproteinases [6,7]. Other mechanisms through which smoking impairs periodontal healing response include: (a) increased production and accumulation of advanced glycation end products (AGEs) in tissues (including periodontal tissues) [8]; (b) increased interactions between AGEs and their receptors [8]; (b) compromised function of neutrophils [9]; (c) decreased immunoglobulin (Ig) A, IgG and IgM production in saliva [10] and (d) impaired proliferation and function of periodontal fibroblasts [11]. Moreover, from a clinical perspective, smokers exhibit lower scores of bleeding on probing (BOP), which occurs as a result of a vasoconstrictive effect of nicotine on gingival blood vessels [12]. Therefore, smokers may remain unaware of their compromised periodontal health status and present for diagnosis and consequent therapy at a more advanced stage of periodontal disease. Furthermore, habitual tobacco smoking has also been reported to jeopardize the outcomes of oral surgical interventions...
The traditional therapy for the management of peri-implant diseases involves the detoxification of implant surfaces and peri-implant tissues through mechanical curettage (MC) [15,16]. However, studies [17–19] have shown that MC when performed with adjuvant therapies such as antimicrobial photodynamic therapy (aPDT) is more effective in the treatment of peri-implant diseases compared with MC alone. aPDT involves interactions between a light source of a specific wavelength (630 nm to 830 nm) and a photosensitizer (such as methylene blue or toluidine blue (TBO)) in an aerobic environment [20,21]. This interaction causes the production of reactive oxygen species [21,22], facilitate healing by destroying the cell walls of pathogenic microbes and reducing the levels of proinflammatory cytokines in the body fluids (including the gingival crevicular fluid and peri-implant crevicular fluid) [18,23]. Results from recent clinical studies [16,24] have also shown that MC with adjunct aPDT is more effective in the management of peri-implant diseases in immunocompromised patients compared with MC alone.

Since aPDT when used as an adjunct to MC is more effective in the treatment of oral soft tissue inflammation compared with MC alone [17,18,23,25]; it is hypothesized that the outcomes of the treatment of peri-implant mucositis are significantly compromised among cigarette smokers that receive MC alone as compared to smokers that receive MC with adjunct aPDT. With this background, the aim of the present 12-weeks follow-up randomized controlled clinical trial was to investigate the outcome of MC with or without adjunct aPDT in the treatment of peri-implant mucositis in cigarette smokers.

2. Materials and methods

2.1. Ethical guidelines

After taking the Ethical clearance from the Institutional Ethical Committee and delivering all the information regarding the study, a written consent from the volunteering individuals was obtained. All consenting participants were given the liberty to withdraw from the study at any stage of the investigation without any form of penalty.

2.2. Eligibility criteria

The inclusion criteria were as follows: (a) patients with peri-implant mucositis (probing pocket depth [PPD] of at least 4 millimeters [mm] at least east 30% sites; (b) self-reported cigarette-smokers (individuals smoking at least 1 cigarette daily since at least 1 year were defined as smokers [26–29]). Self-reported non-smokers, smokeless tobacco chewers, individuals with systemic diseases such as acquired immune deficiency syndrome, cancer, diabetes mellitus, prediabetes, hepatic disorders, and renal disorders were excluded. Moreover, individuals that reported to have used antibiotics, steroids and/or non-steroidal anti-inflammatory drug within the past 3-months were also excluded.

2.3. Questionnaire

Data regarding age, gender, duration of smoking and daily frequency of smoking was collected using a questionnaire.

2.4. Grouping and randomization

Therapeutically, subjects with peri-implant mucositis were randomly divided into 2 groups: (a) Group-A: MC with a single session of adjunct aPDT therapy; and (b) Group-B: a single session of MC alone (control group). In both groups, MC was performed using plastic curettes (Implant Prophy + ™ Plastic Dental Instrument System Kit, Tess Corporation, WI, USA). Randomization was done by tossing a coin.

2.5. Assessment of peri-implant clinical parameters

In both groups, peri-implant plaque index (PI) and BOP were measured at 6 sites per implant (mesiobuccal, mid-buccal, distobuccal, distopalatal, mid-palatal, and mesiopalatal) and presented as mean percentages per individual. PPD was also measured at the sites per implant and presented as mean PPD in millimeters (mm). These parameters were assessed at baseline (one hour before therapy) and at 12-weeks of follow-up by a trained and calibrated investigator (Kappa 0.88).

2.6. Photodynamic therapy protocol

In Group-A, aPDT was performed immediately after MC. aPDT performed using a standardized protocol (HELB0®, Photodynamic Systems GmbH, Wels, Austria) as described elsewhere [17]. In summary, a 660 nm diode laser with a power density of 100 milliwatts (HELB0® TherLite Laser, HELBO® 3D Pocket Probe; Photodynamic Systems GmbH) was used. The photosensitizer used in this study was Phenothiazine chloride (HELB0® Blue Photosensitizer; Photodynamic Systems GmbH). The photosensitizer was applied submucosally from the bottom to the top of the peri-implant pockets and was left in situ for 2 min. Each peri-implant pocket was exposed to the laser light for 10 s.

2.7. Statistical analysis

Statistical analysis was performed using a software program (SPSS Version 18, Chicago, IL, USA). Means and standard deviations were computed and intergroup comparisons were performed using the Kruskal-Wallis test. P-values less than 0.05 were considered statistically significant.

3. Results

3.1. General characteristics of the study population

In total, 54 male individuals (28 in Group-A and 26 in Group-B) with peri-implant mucositis were included. The mean age of individuals in groups A and B were 50.6 ± 0.8 and 52.2 ± 0.5 years, respectively. In groups A and B, the participants were smoking 16.5 ± 2.7 and 14.2 ± 1.7 cigarettes daily since 25.2 ± 6.5 and 24.6 ± 4.3 years, respectively. These results are summarized in Table 1.

3.2. Peri-implant clinical parameters

At baseline, peri-implant PI, BOP and PPD were comparable among individuals in groups A and B. At 12-weeks of follow-up, there was a statistically significant reduction in PI (P < 0.001) and PPD (P < 0.001) among patients in groups A and B compared with their respective baseline values. At 12-weeks follow-up, PI (P < 0.001) and PPD (P < 0.001) were significantly higher among patients in Group-B compared with Group-A (P < 0.001). BOP was comparable in both groups at baseline and at 12-weeks follow-up. These results are summarized in Table 2.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Group-A</th>
<th>Group-B</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of participants (n)</td>
<td>28</td>
<td>26</td>
</tr>
<tr>
<td>Gender (male)</td>
<td>28</td>
<td>26</td>
</tr>
<tr>
<td>Mean age ± SD</td>
<td>50.6 ± 0.8 years</td>
<td>52.2 ± 0.5 years</td>
</tr>
<tr>
<td>Duration of smoking habit</td>
<td>16.5 ± 2.7 years</td>
<td>14.2 ± 1.7 years</td>
</tr>
<tr>
<td>Number of cigarettes smoked daily (n)</td>
<td>25.2 ± 6.5/day</td>
<td>24.6 ± 4.3/day</td>
</tr>
</tbody>
</table>
The present study was based on the hypothesis that the outcomes of the treatment of peri-implant mucositis are significantly compromised among cigarette smokers that receive MC alone (Group-B) as compared to smokers that receive MC with adjunct aPDT (Group-A). The results are in accordance with this hypothesis as scores of PI and PD were statistically significantly higher among patients in Group B compared with Group A at 12-weeks follow-up. These results indicate that aPDT when used as an adjunct to MC augments the overall anti-inflammatory compared with MC alone thereby reducing soft tissue inflammation. In aPDT, interactions between a light source and a photosensitizer occur in the presence of oxygen. This reaction results in the formation of free oxygen radicals, which destroy target cells such as tumor and bacterial cells [30]. aPDT has also been shown to help reduce the levels of proinflammatory cytokines in the gingival crevicular fluid of patients with periodontitis [31]; and also kill pathogenic bacteria associated with the etiology of periodontal and periimplant disease such as Aggregatibacter actinomycetemcomitans (A. actinomycetemcomitans), Prevotella intermedia, and Porphyromonas gingivalis (P. gingivalis) [25].

It is noteworthy that the methodology of the present study was different in contrast to traditional clinical trials that assessed the efficacy of aPDT when used as an adjunct to conventional MC. It has already shown that aPDT when performed as an adjunct to MC is more effective in the treatment of peri-implant diseases compared with MC alone in non-smokers [32]. However, there are no studies in indexed literature that compared the efficacy of MC with or without adjunct aPDT in the treatment of peri-implant diseases among exclusively smokers. For this reason, the patient population included in the present investigation comprised solely of smokers that underwent MC with and without adjunct aPDT. Another interesting finding in the present study was that scores of BOP remained unchanged throughout the study period on both groups. One explanation in this regard could be associated with the fact that nicotine exerts a vasoconstrictive effect on gingival blood vessels thereby demonstrating lower scores of BOP in smokers compared with non-smokers [33]. In this regard, smokers may remain unaware of their periodontal and peri-implant inflammatory status for prolonged durations.

There are a number of limitations associated with the present study. First of all, the present study had a relatively short term follow-up duration, that is 3 months. It is hypothesized that the peri-implant parameters (PI, BOP and PD) would have been comparable among both study groups in case these patients were followed up for a longer duration (at least 6-months). Next, stringent eligibility criteria were imposed in the present study. It has been reported that peri-implant soft tissue inflammation and alveolar bone loss are significantly higher among immunosuppressed patients, such as those with acquired immune deficiency syndrome and poorly-controlled diabetes mellitus compared with systemically healthy subjects [34–36]. It is likely that the outcomes of MC (either with or without aPDT) would have been compromised in case the smokers were immunocompromised. Furthermore, it is well-known that habitual use of smokeless tobacco products is a significant risk factors for oral soft tissue inflammatory conditions such as periodontitis [37–41]. It is therefore hypothesized that the outcomes of MC with or without adjunct aPDT are compromised in smokers that also habitually use smokeless tobacco product users compared with smokers not using other forms of tobacco products. Further studies are needed to test these hypotheses.

4. Discussion

Within the limits of the present study, it is concluded that MC with adjunct aPDT is more effective in the treatment of peri-implant mucositis in smokers compared with MC alone. It is noteworthy that the methodology of the present study was different in contrast to traditional clinical trials that assessed the efficacy of aPDT when used as an adjunct to conventional MC. It has already shown that aPDT when performed as an adjunct to MC is more effective in the treatment of peri-implant diseases compared with MC alone in non-smokers [32]. However, there are no studies in indexed literature that compared the efficacy of MC with or without adjunct aPDT in the treatment of peri-implant diseases among exclusively smokers. For this reason, the patient population included in the present investigation comprised solely of smokers that underwent MC with and without adjunct aPDT. Another interesting finding in the present study was that scores of BOP remained unchanged throughout the study period on both groups. One explanation in this regard could be associated with the fact that nicotine exerts a vasoconstrictive effect on gingival blood vessels thereby demonstrating lower scores of BOP in smokers compared with non-smokers [33]. In this regard, smokers may remain unaware of their periodontal and peri-implant inflammatory status for prolonged durations.

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5. Conclusion

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Conflict of interest statement

None declared.

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