Does Caffeine Affect Dental Implant Stability? A Prospective Cohort Study

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KEY WORDS
Dental implants; Caffeine; Maxilla; Osseointegration;

ABSTRACT
Statement of the Problem: Caffeine intake affects bone metabolism through inhibition of osteoblast proliferation.

Purpose: This study aims to assess the effect of caffeine consumption on implant stability in the healing period of patients.

Materials and Method: A prospective cohort study is designed to assess implant stability in the posterior of the maxilla. Subjects were divided into two groups based on daily caffeine intake: Group 1. Consumed 400 mg/daily Caffeine or more and group 2, consumed 100 mg/daily Caffeine or less. The implant stability was measured by resonance frequency analysis (RFA). The mean implant stability quotients (ISQs) were calculated. RFA measurements were made at 4, 6, and 8 weeks after implant placement.

Results: One hundred and two subjects were studied (51 subjects in each group). The mean of ISQ was measured to be 43.49±2.32 in group 1 and 42.78±2.34 in group 2 at four weeks after insertion. The mean of ISQ was 50.86±3.06 in group 1 and 51.37±2.44 in the group at six weeks after implant placement. At eight weeks after surgery, the mean of ISQ was 56.78 ±3.77 in group 1 and 57.84±1.82 in group 2. Analysis of the data did not demonstrate any difference for the mean of ISQ between the two groups at 4, 6 and 8 weeks after implant placement. (p= 0.13, p= 0.36 and p= 0.08 respectively) The repeated measure test indicated a similar increase in ISQ in various study times in the two studied groups (p=0.47, df=1, F=0.52).

Conclusion: Acquired data suggest that caffeine intake may not have a negative effect on implant stability in the healing period at the posterior of the maxilla.

Introduction
Caffeine is a well-known substance which is found in coffee, tea, energy drinks, chocolate, and etc. Up to 80% of people consume Caffeine around the world [1]. It is believed that Caffeine could inhibit osteoblast proliferation in vitro by the increase of cyclic adenine monophosphate (cAMP) and the inhibition of the intracellular phosphodiesterase [2]. In an animal study the use of caffeine results in lower volume of bone and reduced bone mineral density and delayed bone repair [3]. It was shown that the consumption of Caffeine increases orthodontic tooth movement [4].

Implant stability is defined as the absence of clinical mobility, which is crucial for osseointegration. Resonance frequency analysis (RFA) stability measurement applies a bending load, which is similar to the clinical load and indicates the stiffness of the implant-bone connection [15]. To best of our knowledge, no study has been done to assess the effect of caffeine intake on the stability and healing of dental implants.

The study's purpose is to address the following question: Do patients consuming Caffeine have lower implant stability during the healing period? We hypothesized that Caffeine affects the bone healing process and
decreases implant stability. Therefore, the aim of this study is to compare implant stability in subjects with and without caffeine consumption.

Materials and Method
The authors designed a prospective cohort study. The sample was derived from subjects who attended the oral and maxillofacial department of Shahid Beheshti University of medical sciences and a private clinic between September 1, 2018, and December 31, 2019. The committee has approved the study of the medical ethics group of Shahid Beheshti University of Medical Sciences. (IR.SBMU.DRC.REC.1397.60) Subjects eligible for study inclusion had a partially edentulous area at the posterior of the maxilla and received a dental implant for restoration there. The exclusion criteria were: a systemic disease affecting bone metabolism, smoking, need for augmentation and or sinus lift, and those who refused participation or failed to return for follow up.

Subjects were aligned into two groups: In group 1, subjects take Caffeine 400 mg/daily or more, and in group 2, 100 mg/ daily or less. The estimated amount of caffeine intake can be found in Table 1.

Implant Surgery
All implants were placed in healed bone at least 12 weeks after tooth removal. A crestal incision was made on the alveolar ridge with two short releasing with preserving gingival tissue in the proximal and distal aspects adjacent to neighbor teeth. Instrumentation was performed based on the company guidelines. A dental implant (SGS, Switzerland) with 4.5mm x 10mm size was placed at the first or second molar area in the posterior of the maxilla. A smart peg was connected to the fixture.

Implant stability measurements
Two examiners who were blinded to the groups evaluated the implant stability. The stability of the implants was measured by resonance frequency analysis (RFA). An Osstell device (Osstell, Gothenburg, Sweden) was used. The buccolingual and mesiodistal directions were measured. Next, the mean implant stability quotients (ISQs) were calculated. RFA measurements were made at 4.6 and 8 weeks after implant placement.

Statistical Analysis
The statistical analysis was performed using statistical package for the social sciences (SPSS) version 21 software (SPSS Inc., IBM, USA). The repeated measurement test was used to compare ISQ values between the two groups at each measurement time point. AN Independent T-test was used to compare the mean of age between the studied groups. A P-value of <0.05 was considered statistically significant. An inter-examiner reliability analysis (Kappa test) was applied to determine the agreement between the two examiners.

Results
One hundred two subjects who had an implant at the posterior of the maxilla were divided into two groups (51 subjects in each group). Group 1 consisted of 30 males and 21 females, and group 2 included 29 males and 22 females. The gender distribution between the two groups was not statistically different (p= 0.50). The mean age was 38.27±10.07 years in group 1 and 40.24±7.67 years in group 2. There was no difference in the mean of age between the two groups (p=0.27) (Table 2).

The mean of ISQ was 43.49±2.32 in group 1 and 42.78±2.34 in group 2 at four weeks after insertion. The mean of ISQ was 50.86±3.06 in group 1 and 51.37±2.44 in the group at six weeks after implant placement. Eight weeks after surgery, the mean of ISQ was measured to be 56.78±3.77 in group 1 and 57.84±1.82 in group 2. Analysis of the data did not demonstrate any difference for the mean of ISQ between the two groups at 4, 6 and 8 weeks after implant placement (p= 0.13, p= 0.36 and p= 0.08, respectively) (Table 3).

The repeated measure test indicated a similar increase in ISQ in various study times in the two studied groups (p= 0.47, df=1, F=0.52) (Figure 1). The inter-examiner reliability for the examiners was found to be

<table>
<thead>
<tr>
<th>Coffee drinks</th>
<th>Size in oz/ml</th>
<th>Caffeine (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brewed</td>
<td>8 (237)</td>
<td>96</td>
</tr>
<tr>
<td>Espresso</td>
<td>1 (30)</td>
<td>64</td>
</tr>
<tr>
<td>Instant</td>
<td>8 (237)</td>
<td>62</td>
</tr>
<tr>
<td>Brewed black tea</td>
<td>8 (237)</td>
<td>47</td>
</tr>
<tr>
<td>Cola</td>
<td>8 (237)</td>
<td>22</td>
</tr>
<tr>
<td>Energy drink</td>
<td>8 (237)</td>
<td>29</td>
</tr>
<tr>
<td>Energy Shot</td>
<td>1 (30)</td>
<td>215</td>
</tr>
<tr>
<td>Green tea</td>
<td>8 (237)</td>
<td>25</td>
</tr>
</tbody>
</table>
Caffeine (1,3,7-trimethyl xanthine) is the most commonly consumed psychoactive agent around the world. The possible effect of Caffeine on bone metabolism was evaluated in a series of animal and clinical studies [6-8]. It is believed that Caffeine has a negative effect on bone metabolism [9]. In this study, we studied the effect of Caffeine with a dose of 400 mg/daily on implant stability during the healing period.

The dose of Caffeine was estimated according to subjects’ self-reports. Various beverages with caffeine content were consumed which were documented. ISQ measurements at 4, 6, 8 weeks after implant placement indicated no significant difference in the mean of ISQ in subjects who consumed more than 400 mg/daily and less than 100 mg/daily. It was suggested that the dose of caffeine more than 400 mg is toxic for human kind and less than 100 mg does not have a clinical effect on bone [10]. It was suggested that mor than 300 mg daily caffeine (approximately 514 g, or 18 oz, brewed coffee) increases bone loss in human [11]. It could be interpreted that the use of Caffeine in the healing period of dental implants does not have a negative effect on implant stability. Generally, we expect a low stability in D4 bone at the posterior of the maxilla. Therefore, any detrimental effect of Caffeine could be easily observed. In our review, we did not find any similar study which evaluated the effect of Caffeine on implant stability during the healing period.

Duarte et al. studied the effect of Caffeine on the early stage of bone healing and also bone density in rats. They concluded that a high daily caffeine intake may have a negative effect on the early stages of bone healing, but does not change bone density 56 days after administration [12]. A hypothesis for the possible role of Caffeine in bone metabolism is its effect on calcium metabolism and the proliferation of osteoblast-like cells [12]. Caffeine raises urinary calcium excretion by a decrease renal reabsorption and calcium absorption which leads to a negative calcium balance [3, 13-14]. There was several studies that described the effect of caffeine on osteoblast function in-vivo:

Tasuang et al. studied the effect of caffeine on osteoblasts derived in newborn Wistar-rat calvaria. They reported that caffeine had possible deleterious effect on the osteoblasts viability, which may increase the rate of osteoblasts apoptosis [13]. Rapuri et al., caffeine could stimulate 1,25(OH)2D3 stimulated vitamin D receptor protein expression which reduces human osteoblast cells through 1,25(OH)2D3 mediated actions [11]. Bezerra et al. studied the effects of Caffeine on ligature-induced bone loss, trabecular bone area and post-extraction bone healing in rats. They found that caffeine consumption resulted in bone loss in ligated teeth and delayed bone healing in post-extraction sockets [17]. Sakamoto et al. indicated that Caffeine did not increase bone loss in rats [14]. Ferreira et al., studied Caffeine and/or estrogen deficiency in bone healing. They concluded that Caffeine affects bone healing, but estrogen deficiency mainly disturbs trabecular bone area [18].

In dentistry, Caffeine was studied in orthodontic tooth movement. It was showed that drinking coffee may accelerate tooth movement in orthodontic treatment [4] Shirazi et al., studied caffeine intake in rats and orthodontic tooth movement. They demonstrated that caffeine intake resulted in decrease root resorption

| Table 3: Comparison of ISQ in study times between two groups |
|------------------|------------------|------------------|------------------|
| Outcomes         | Group 1          | Group 2          | Independent T-test |
| The mean of ISQ at four weeks after the implant placement | 43.49±2.32       | 42.78±2.34       | p = 0.13         |
| The mean of ISQ at six weeks after the implant placement | 50.86±3.06       | 51.37±2.44       | p = 0.36         |
| The mean of ISQ at eight weeks after the implant placement | 56.78±3.77       | 57.84±1.82       | p = 0.08         |

Figure 1: The mean of ISQ at 4, 6, 8 weeks after implant placement in two groups

Kappa 0.90 (p< .001), 95% CI, which shows almost a perfect agreement between the examiners.

Discussion

Caffeine (1,3,7-trimethyl xanthine) is the most commonly consumed psychoactive agent around the world. The possible effect of Caffeine on bone metabolism was evaluated in a series of animal and clinical studies [6-8]. It is believed that Caffeine has a negative effect on bone metabolism [9]. In this study, we studied the effect of Caffeine with a dose of 400 mg/daily on implant stability during the healing period.

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and also concentrations of 2 g/L and 3 g/L inhibited orthodontic tooth movement due to its influence on osteoclast numbers [19]. In socket healing following tooth extraction in rats, Caffeine caused a delay in bone healing [20].

The estimation of the amount of caffeine intake by subjects was performed based on their self-reports. So, it may not be exact. Therefore, the measurement of proper caffeine intake is not possible, and it should be considered as a limitation of the study.

**Conclusion**

Our findings indicate that caffeine intake may not have a negative effect on implant stability in the healing period at the posterior of the maxilla.

**Conflict of Interest**

The authors declare that there is no conflict of interest.

**References**


29: 221-231.
