ISSN: 2584-0355
DOI: doi.org/10.51219/MCCRJ/Rudrakshi-C/165

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Medical & Clinical Case Reports Journal

https://urfpublishers.com/journal/case-reports

Vol: 3 & Iss: 1

Research Article

Estimation of Titanium and Aluminium in Peri-Implant Gingival Tissue. A Preliminary Study

Dr. Jyoti T Naik, Dr. Rudrakshi C*, Dr. Prabhuji MLV

Krishnadevaraya Dental College Bengaluru, 562157, India

Citation: Naik JT, Rudrakshi C, Prabhuji MLV. Estimation of Titanium and Aluminium in Peri-Implant Gingival Tissue. A Preliminary Study. *Medi Clin Case Rep J* 2025;3(1):640-643. DOI: doi.org/10.51219/MCCRJ/Rudrakshi-C/165

Received: 31 December, 2024; **Accepted:** 02 January, 2025; **Published:** 04 January, 2025

***Corresponding author:** Dr Rudrakshi C, Krishnadevaraya Dental College Bengaluru, 562157, India

ABSTRACT

In the course of history, multiple implant surface options have been utilized to maximize contact between bone and dental implant. At present, in oral implantology, Grade V alloy i.e., pure titanium (cp-Ti) or Grade IV alloy, which is composed of 6% aluminum (Al) and 4% vanadium (V), are most commonly used. Leaching of metal ions in the gingival tissue from the implant have always been a concern. Corrosion products resulting from the degradation of the dental implant surface due to biological fluids and infection may accumulate in the body and lead to clinical consequences. The long-term presence of corrosion reaction products and ongoing corrosion lead to fractures of the alloy-abutment interface, abutment or implant body. The combination of stress, corrosion and bacteria contribute to implant failure. The present study aims to assess the gingival tissues around the dental implant for the levels of titanium and aluminium metal ions.

Keywords: Dental implants; Metal concentration; Corrosion; Implant failure; Peri-implantitis

Abbreviations: Ti- Titanium, Al- Aluminium, ICP-MS-Inductively coupled plasma Mass Spectrometry, ICP-OES Inductively coupled plasma Optical Emission Spectrometry

Introduction

Osseo-integrated dental implants are designed to be in direct contact with bone, ensuring a secure and stable fit. However, in spite of biocompatibility, various challenges like acidic environment, biofilm and saliva, implants are exposed to the risk of leaching of metal ions from the implant surfaces is heightened. Additionally, titanium particles are released from metallic instruments utilized during the implant drilling stage, from implant surfaces during placement and from the implant-abutment interface[1]. The presence of titanium (Ti) is the primary element found in peri-implant tissue, along with aluminum (Al) and vanadium (V). These metals are a result of the corrosion of titanium dental implant alloy[2]. The present study involves estimation of titanium and aluminium metal ion in the peri-implant gingival tissue following placement of Grade IV dental implants in stage II/stage III and Grade B periodontitis patients.

Materials and Methods

The patients were selected from Out-patient Department of Periodontology, Krishnadevaraya college of Dental science and Hospital. Inclusion criteria: Patients selected for the study were patients with systemically healthy gingiva with the age above 18 years having Stage II/ Stage III and Grade B periodontitis, patients willing for Grade IV bone level implants and with no history of dental implants, willing for 2 implants placement

and having good oral hygiene practices. Exclusion criteria, the study included: Patient having implanted metallic devices, diet /occupational/personal exposure to metallic particles, parafunctional habits and patient taking pharmacological agents influencing metallic exposure.

Pre-implant placement we had procured 8 samples for Ti and Al metal ion estimation. Following intervention 8 samples were again collected after 3 months, prior to healing cap placement. So 16 samples pertaining Ti metal ions and 16 samples pertaining Al ions were collected for analysis. On the same day of sample collection, procured samples were sent to "Raghavendra Spectro Metullurgical Lab"- 4th phase Peenya industrial area, Bangalore for assessment of titanium and aluminium metal ions. A total of 16 samples were collected and assessed for titanium and aluminium metal ion concentration. Each patient was assessed for 2 metal ion concentration, i.e., Titanium and Aluminium.

The sample size for the present study was estimated using GPower software (latest ver. 3.1.9.7; Heinrich-Heine-Universi-ta ̈t Du ̈sseldorf, Du ̈sseldorf, Germany). The sample size estimation was performed at 5% alpha error ($\alpha = 0.05$), with an effect size of 1.60 [Based on Cohen classification, considering a larger effect size (d=1.60) to observe between 2 groups in terms of Titanium and Aluminium elements in the gingival tissues]. The power of the study was set at 80%, revealed that a minimum of 16 samples were necessary for the present study. So, each study arm will comprise of 16 samples. P value was set at $P< 0.05$.

Sample Preparation: Gingival tissues were extracted through tissue punch **(Figure1)** from the designated implant site and were kept in ependroff tube with 10% formalin solution. Gingival tissue samples **(Figure 2)** were collected and assessed **(Figures 3-7)** for ion concentration before implant placement was considered as baseline (Control). Tissue samples collected at 3 months considered as test samples.

Figure 1: Sampling before implant placement.

Data Analysis: The method of analysis, using Inductively Coupled Plasma Optical Emission Spectrometry (ICP -OES). All samples were stored at room temperature in dark until the analysis day. Gingival samples were weighed, dissolved with the addition of 5 ml nitric acid (HNO_3) and 1 ml hydrogen peroxide (H2O2) in a 1000-watt microwave at 160 C for 1 hour. It was completed to 50 ml with ultrapure water. And then weight & volume data inputs is given to the Avio 560 Max ICP optical emission spectrometer of Syngistix software, so that automatically it will calculate & gives the results in mg/kg or ppb[2].

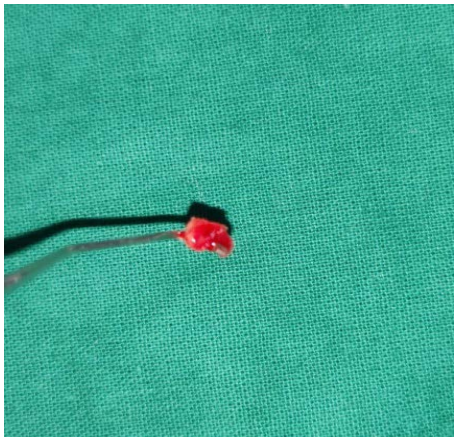

Figure 2: Tissue sample obtained.

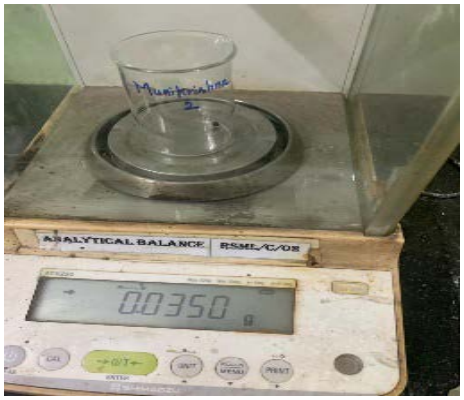

Figure 3: Weight of sample is estimated.

Figure 4: 5ml Nitric Acid is added.

Figure 5: Complete Dissolution of sample.

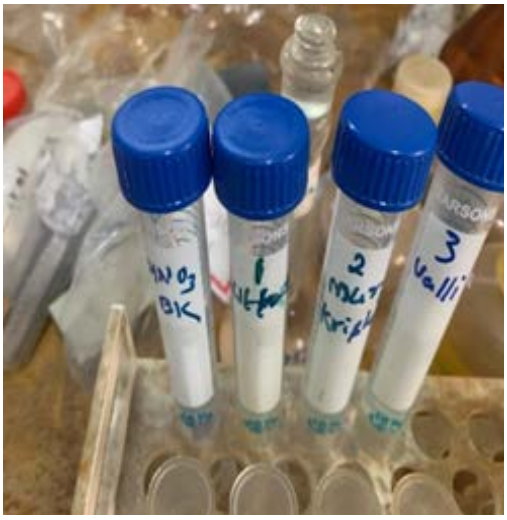

Figure 6: Pooling of samples.

Figure 7: Avio 560 Max ICP optical emission spectrometer.

Results

In the present study, the concentration of titanium and aluminium metal ions in gingival tissue was assessed using ICP-OES. There was highly significant difference for both the metal ions when comparison was done between before implant placement gingival tissue and post 3 months peri implant tissue. **(Tables 1 and 2)** shows significant presence of titanium and aluminium metal ions following placement of Grade IV dental implants.

Table1: Assessment of difference in Titanium ions pre implant tissue and post implant gingival tissue.

	pre implant placement	post implant placement	test statistic	p value
N	9	9	-2.668c	**0.008****
Mean	5.7333	21.6278		
Std. Deviation	3.38231	20.01429		
Median	6	18		

Table 2: Assessment of difference in Aluminium ions pre implant tissue and post implant gingival tissue.

	pre implant placement	post implant placement	test statistic	p value
N	9	9	-2.668c	**0.008****
Mean	30.7778	63.2222		
Std. Deviation	57.23368	78.0429		
Median	11	16		

Discussion

Dental implant corrosion products may accumulate in human body and that there may be relationship between metal ion levels, peri-implantitis and implant failure[2]. This study was undertaken to investigate release of metal ions, in gingival tissue in vicinity of Grade IV dental implant. We have considered surrounding implant gingival tissue prior to implant placement as control group and implant tissue retrieved before healing cap placement at 3 months as test group for evaluation of titanium (Ti) and aluminium (Al) metal ions released following placement of dental implants.

Many studies have been done to evaluate the metal ion concentration with dental implants in blood[2], hair[2], serum[3] and saliva[4]. Because gingival tissue will surround around immediate vicinity of dental implants, highest metal ion accumulation is possible. Therefore, in our study we have considered gingival tissue obtained from tissue punch before implant placement and post 3 months during exposure of implant for healing cap placement.

Inductively Coupled Plasma Optical Emission Spectrometry (ICP -OES) measurement was used to detect titanium (Ti) and aluminium (Al) metal ions. Similar to our study, Martin camean 2015, also have determined the content of Aluminium, Cobalt, Chromium, Nickel, Titanium and Vanadium in oro-mucosal cells of orthodontic patients with and without mini-implants using Inductively Coupled Plasma Mass Spectrometry (ICP-MS)[5]. Contrarily, to their study our study showed there is significant release of titanium (Ti) and aluminium (Al) levels in tissues, following 3 months after placement of Grade IV implants when compared to the baseline values using Inductively Coupled Plasma Optical Emission Spectrometry (ICP–OES).

Our study had after implant placement in Patients with Stage II/III and grade B periodontitis, Inflammatory condition have shown to influence implant corrosion rate in presence of elevated inflammatory stress and hyperglycemia[6]. Galvanic corrosion and fretting corrosion may release metal ions that may contribute to peri-implantitis and implant failure[7]. Understanding the metal ion release may provide us the information that may contribute to the future consequences of implant placement. A low pH creates favorable environment for aerobic bacteria for corrosion, contributing to microbial corrosion[7].

GCF and serum of patients with periodontitis and healthy individuals were evaluated for levels of trace elements like copper, zinc, selenium and chromium by Meenakshi B 2017 using Inductively Coupled Plasma Optical Emission Spectrometry (ICP–OES)[3]. Similarly in our study, we have evaluated titanium (Ti) and aluminium (Al) metal ions using Inductively Coupled Plasma Optical Emission Spectrometry. Their study has concluded chromium levels were more in patients with periodontitis than healthy. In our study we have compared prior to implant placement and 3 months prior to prosthetic placement and concluded increased levels of titanium (Ti) and aluminium (Al) metal ions above the threshold level.

Altay B 2024, in their study to measure the accumulation of titanium (Ti), aluminium (Al) and vanadium(V) in hair and blood and secondarily aim to estimate their association between corrosion products and fatigue outcome. They concluded that healthy dental implants, do not have a significant

impact on accumulation of titanium (Ti) ,aluminium (Al) and vanadium(V)in body and have shown elevated Al levels in their group II (patients with peri-implantitis) showing possibly due to infection influencing the corrosion process[2]. Contrary to their study, our study shows elevation of titanium (Ti) and aluminium (Al) levels at 3 months following placement of dental implants in healthy gingival tissue. We conclude that these factors may play a critical role in the existing oral environment to tip towards peri-implantitis.

Lacey DC 2009, in their study on effect of low dose metal particles, on monocyte/macrophages survival concluded that their influence possibly can promote monocyte/macrophages survival in vitro possibly via an endogenous mediator. They directed, if this phenomenon occurs in vivo, increased number of macrophages could contribute to local inflammatory reaction and osteolysis critically showing implant failure[8]. Our preliminary study shows the release of titanium (Ti) and aluminium (Al) metal ions in gingival tissues. The clinical scenario could detect the future consequences depending upon the maintenance of oral health. Dissolution of titanium from dental implants has an association to peri-implantitis[9]. There is also correlation of effect of titanium (Ti) showing increased inflammatory cytokines from surrounding host tissue cells[10-12]. These studies show the levels of metal ions having immunological effects to titanium corrosion.

Our study clearly demonstrates the level of titanium (Ti) and aluminium (Al) metal ion concentration in healthy gingival tissue immediately before implant placement and post 3 months after implant placement in patients with Stage II/ III and grade B periodontitis. In our study many confounding variables needed to be monitored which can have an influencing factor for metal ions to tip towards peri-implantitis. Cumulative interceptive supportive therapy (CIST) protocol needed to be followed for effective implant therapy. Limitation of our study include, here we have included discarded tissue sample before implant placement and after 3 months of post implant placement. We have considered less (16) samples for evaluation and the tissue which is in vicinity of implant for the duration of 3 months only. Metal ion concentration was evaluated in punched out gingival tissue at post three months following dental implant placement. Long term assessment with larger sample size may be conclusive for the observed outcome.

Several conclusions can be drawn from the present study. Firstly, our study demonstrates that there is a definite release of titanium (Ti) and aluminium (Al) metal ion in the gingival tissue following Grade IV dental implant placement compared to tissue prior to implant placement. Long term assessment may necessitate a tissue biopsy for evaluation. Importance of CIST protocol for implant patients' needs to be stressed for better clinical outcome.

Funding

Nil

Conflict of Interest

Nil

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