

## Smoking & Implant Failure: An Evidence Based Review

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**Abstract:** The purpose of this review article is to collect the published data concerning factors affecting Osseointegration in smokers. Osseointegration refers to a direct structural and functional connection between bone & implant. Smoking is a significant factor in the failure of dental implants. Smoking leads to an increased incidence of non-union, lower bone density and increased time to union in fracture healing. An electronic search was undertaken in PubMed/Medline, Cochrane. Main search terms used as dental implants, smoking, tobacco. Eligibility criteria included clinical human studies, either randomized or not. Cigarette smoking has a detrimental effect on bone quality around implant. The present review suggests that smoking was identified a significant risk factor for dental implant therapy & the insertion of dental implants in smokers affects the implant success rate as well as the marginal bone loss.

**Keywords:** Implant , Osseointegration , Smoking.

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### I. Introduction:

Osseointegration or osteointegration refers to a direct bone-to-metal interface without interposition of non-bone tissue. This concept has been described by Branemark, as consisting of a highly differentiated tissue making a direct structural and functional connection between ordered, living bone and the surface of a load-carrying implant<sup>1,2</sup>. Through his initial observations on osseointegration, Branemark showed that titanium implants could become permanently incorporated within bone that is, the living bone could become so fused with the titanium oxide layer of the implant that the two could not be separated without fracture. It occurred to this investigator that such integration of titanium screws and bone might be useful for supporting dental prostheses on a long-term basis<sup>1</sup>.

Bone healing around implants involves a cascade of cellular and extracellular biological events that take place at the bone-implant interface until the implant surface appears finally covered with a newly formed bone. These biological events include the activation of osteogenic processes similar to those of the bone healing process, at least in terms of initial host response<sup>3,4</sup>. This cascade of biological events is regulated by growth and differentiation factors released by the activated blood cells at the bone-implant interface.

Initial interactions of blood cells with the implant influence clot formation. Platelets undergo morphological and biochemical changes as a response to the foreign surface including adhesion, spreading, aggregation, and intracellular biochemical changes such as induction of phosphotyrosine, intracellular calcium increase, and hydrolysis of phospholipids. The formed fibrin matrix acts as a scaffold (osteoconduction) for the migration of osteogenic cells and eventual differentiation (osteinduction) of these cells in the healing compartment. Osteogenic cells form osteoid tissue and new trabecular bone that eventually remodels into lamellar bone in direct contact with most of the implant surface (osseointegration)<sup>5,6</sup>.

Osteoblasts and mesenchymal cells seem to migrate and attach to the implant surface from day one after implantation, depositing bone-related proteins and creating a non-collagenous matrix layer on the implant surface that regulates cell adhesion and binding of minerals. This matrix is an early-formed calcified fibrillar layer on the implant surface, involving poorly mineralized osteoid similar to the bone cement lines and laminae limitans that forms a continuous, 0.5 mm thick layer that is rich in calcium, phosphorus, osteopontin and bone sialoprotein.

Various factors may enhance or inhibit osseointegration<sup>7</sup>. Factors enhancing osseointegration include implant-related factors such as implant design and chemical composition, topography of the implant surface, material, shape, length, diameter, implant surface treatment and coatings. Factors inhibiting osseointegration include excessive implant mobility and micromotion, inappropriate porosity of the porous coating of the implant, radiation therapy<sup>8,9</sup>.

## **II. Peri Implant Osseogenesis:**

osteogenesis refers to the newly formed peri-implant bone that develops from the implant to the healing bone. The newly formed network of bone trabeculae ensures the biological adaptation of the implant and neighbouring marrow spaces containing many mesenchymal cells and wide blood vessels. A thin layer of calcified and osteoid tissue is deposited by osteoblasts directly on the implant surface. Blood vessels and mesenchymal cells fill the spaces where no calcified tissue is present.

Murai et al. were the first person to report a 20-50 mm thin layer of flat osteoblast-like cells, calcified collagen fibrils and a slight mineralized area at a titanium implant-bone interface<sup>10</sup>. The newly formed bone was laid down on the reabsorbed surface of the old bone after osteoclastic activity. This suggested that the implant surface is positively recognizable from the osteogenic cells as a biomimetic scaffold which may favour early peri-implant osteogenesis. Cement lines of poorly mineralized osteoid demarcated the area where bonereabsorption was completed and bone formation initiated.

The early deposition of new calcified matrix on the implant surface is followed by the arrangement of the woven bone and bone trabeculae. This is very much needed for the peri-implant bone healing process as it shows a very active wide surface area, contiguous with marrow spaces rich in vascular and mesenchymal cells. Peri-implant bone contains regular osteons and host bone chips enveloped in mature bone. The implant surface is covered with flattened cells. The bone-implant interface shows inter-trabecular marrow spaces delimited by titanium surface from one side and by newly formed bone from the other one rich in cells and blood vessels<sup>11</sup>

Major factors for the failure of peri-implant osteogenesis include the decreased number and/or activity of osteogenic cells, the increased osteoclastic activity, the imbalance between anabolic and catabolic local factors acting on bone formation and remodeling, the abnormal bone cell proliferation rate and response to systemic and local stimuli and mechanical stress, and the impaired vascularization of the peri-implant tissue<sup>12</sup>. Vascularization is of critical importance for the process of osseointegration. Differentiation of osteogenic cells strictly depends on tissue vascularity. Ossification is also closely related to the revascularization of the differentiating tissue<sup>13</sup>.

Osseointegration mainly depends on the quality and quantity of the available bone. Various factors affect the process of osseointegration which include biocompatibility of the implant material, surface topography of the implant, various systemic medication, deleterious habits.

## **III. Factors Affecting Osseointegration In Smokers:**

Titanium is a biomaterial that is accepted and widely used in oral rehabilitation. The success of endosseous oral implants depends extensively on bone-healing mechanisms and the ability of the alveolar bone to rebuild and integrate the implant within the newly formed bone. The concept of osseointegration was first described by Branemark and colleagues in the 1960s and 70s. Osseointegration is defined as 'a direct structural and functional connection between living bone and the surface of a load-bearing implant'. The clinical application of osseointegration in implant dentistry first gained global acceptance following the Toronto Conference on Osseointegration in Clinical Dentistry in 1982<sup>14</sup>.

To obtain implant osseointegration, primary mechanical stability of the implant is essential, especially in one-stage surgical procedures. Primary mechanical stability consists of rigid fixation between the implant and the host bone cavity with no micro-motion of the implant or minimal distortional strains. Excessive implant motion or poor implant stability results in tensile and shear motions, stimulating a fibrous membrane formation around the implant and causing displacement at the bone-implant interface, thus inhibiting osseointegration and leading to aseptic loosening and failure of the implant<sup>15-16</sup>.

Smoking is a well-documented health risk. Smoking leads to an increased incidence of non-union, lower bone density and increased time to union in fracture healing. Skeletal effects were originally attributed to the vascular effects of cigarette smoking and increased carbon monoxide absorption. Other mechanisms including decreased bone mineral density, reduced blood supply and fewer bone-forming cells have been proposed<sup>21</sup>. Due to smoking nicotine has been shown to suppress osteoblast proliferation and the secretion of some key osteogenic and angiogenic mediators such as BMP-2 and VEGF. Nicotine together with LPS has been shown to stimulate the formation of osteoclast-like cells. High nicotine concentrations impaired osteogenic gene expression, nicotine in low concentrations enhanced osteogenic proliferation and differentiation<sup>17</sup>. Nicotine

reduces proliferation of red blood cells (RBCs), macrophages and fibroblast, which are the main elements of healing. It also increases platelet adhesiveness which can lead to poor perfusion due to microclots. It also acts as sympathomimetics by increasing the release of epinephrine and nor epinephrine and causes increased vasoconstriction which limits over all tissue perfusion.

Pereira and colleagues evaluated the effect of nicotine of different doses and tobacco compounds on the proliferation and functional activity of human bone marrow osteoblastic cells cultured on the surfaces of plasma-sprayed titanium implants. They used different doses of nicotine, low doses corresponding to levels of nicotine in the plasma of smokers and high doses corresponding to the levels in saliva in smokers. They found a dose-dependent effect, suggesting a direct modulation of the osteoblast activity in human bone marrow cells as an overall effect of nicotine. They also evaluated the role of nicotine in the matrix mineralization of human bone marrow, as well as Saos-2 cells on the plasma-sprayed surfaces of titanium implants, revealing a dose-dependent deleterious effect of nicotine mostly on human bone marrow cells<sup>18</sup>.

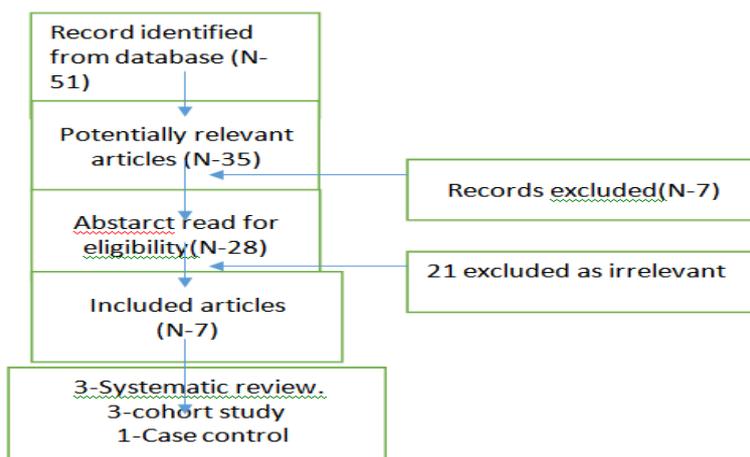
With respect to bone and bone healing, the majority of animal studies demonstrate negative effects on bone by tobacco/nicotine exposure. Nicotine has also been reported to affect angiogenesis and to delay and decrease vascularization. experimental animal studies have demonstrated that nicotine attenuates the expression of a wide range of factors involved in osteogenic differentiation and the formation of extracellular matrix and blood vessels, such as VEGF, bone morphogenic protein BMP-2, 4, 6 and FGF<sup>19</sup>.

This review is an attempt to understand the evidences identifying smoking as an important risk factor for failure of osseointegration & implant failure as whole.

#### IV. Search Methodology:

A systematic literature search in electronic databases was conducted, using the following search term combinations: “dental implants AND smoking”, “dental implants AND tobacco”, “oral implants AND smoking” and “oral implants AND tobacco”. Publications were included for this evidence based systematic review, if they were published between January 2005 and December 2017 in English language and listed in electronic databases Med- line/Pubmed or Embase, Cochrane.

Figure:1-search methodology



#### V. Results:

##### 1.1 Literature search:

The initial search generated 51 titles from Medline/PubMed, Cochrane. After the initial evaluation, 35 full articles were selected. 7 were excluded for the title duplication & 21 excluded as they were irrelevant. Therefore, 7 studies published between 2005 and 2017 were included in this evidence based review<sup>20-26</sup>. The selection process for exclusion of studies are presented in fig.1

##### 1.2 Description of the Studies:

Detailed data of the 7 included studies are listed in Table 1. 3-Systematic review & meta-analysis, 3-cohort study & 1-Case control were included in this review.

Most of the literatures suggest that smoking is one of the prominent risk factors affecting the success rate of dental implants. With only few studies failing to establish a significant result on the smoking effects on implants. Studies suggest smoking as the factor associated with complications like marginal bone loss. Peri-implantitis, bone quality, and quantity, which in turn affect the implant success rate.

**Table:1** evidence based studies on smoking & dental implant:

Authors	Type of Study	Study design & characteristic	result	Level of evidence
Nitzan d et al (2005) <sup>20</sup>	Cohort study	Total 161 patients with 646 implants were inserted. OPG were obtained before implant exposure & yearly thereafter.	Smokers had more MBL than non-smokers ( $0.153 \pm 0.092$ mm and $0.047 \pm 0.048$ mm, respectively; $P < .001$ ). When comparing both jaws MBL in the maxilla than in the mandible ( $0.158 \pm 0.171$ mm versus $0.146 \pm 0.158$ mm, respectively; $P < .001$ ).	<u>2a</u>
Strietzel f b et al (2007) <sup>21</sup>	Systematic review & meta-analysis	64 studies included after electrical & hand searched in b/w 1989 & 2005. Risk of bias is low. SPSS software (version12.0) is used for analysis.	The systematic review indicated significantly enhanced risks for implant failure among smokers compared to non-smokers with the odds ratio (OR) 2.25, confidence interval (CI <sub>95%</sub> ).	<u>1a</u>
Twito d et al(2014) <sup>22</sup>	Cohort study	Study refers 7680 implants. 7359 survived & 321 failed. Total smokers were 2406 & non-smokers were 5259. Total 135 smokers & 185 non-smokers implants were failed.	Implant failure rate was higher in smokers 5.6% & in non-smokers its less with 3.5%. (P value <0.001)	<u>2a</u>
Moraschini v et al (2015) <sup>23</sup>	Systematic review	electronic search was performed & identify relevant articles published up to feb 2015. 15 articles were included. The meta-analysis was expressed in terms of the odds ratio (OR) or standardized mean difference (SMD) with a confidence interval (CI) of 95%.	Statistically significant difference in MBL was found in smoking group especially in maxilla compared to mandible (95% CI 0.24–0.55; $P < 0.00001$ )	<u>1a</u>
Bezerra Ferreira et al (2015) <sup>24</sup>	Case control	22 patients were divided into two groups. i) smoker ii) non-smokers. Each received 1 micro implant. After 8 weeks micro implant & surrounding tissue were removed for histomorphometric analysis.	MBL, gap & fibrous tissue were present around implants received from smokers. Cigarette smoking has a detrimental effect on early bone tissue response around sandblasted acid-etched implant surface topographies.	<u>3b</u>
Ramos Chrcanovic et al (2015) <sup>25</sup>	Systematic review & meta-analysis	Electrical search was undertaken. 107 articles were selected. 19,836 implants were placed in smokers. 1259 failed (6.35%) & 60,464 implants placed in non-smokers with 1923 failures (3.18%)	Smoking is a factor that has the potential to negatively affect healing and the outcome of implant treatment.	<u>1a</u>
Arora et al(2017) <sup>26</sup>	Cohort study	Participants were selected for the implant procedure undertaken from 2005-2015. Total patients were 3721 & among that 3600 were successful and 121 failures.	Higher risk of implant failure was associated with long term and increased frequency of smoking due to bone resorption.	<u>2a</u>

## VI. Conclusion:

The present review suggest that smoking was identified a significant risk factor for dental implant therapy & the insertion of dental implants in smokers affects the implant success rates as well as the marginal bone loss. Cigarette smoke inhalation had a negative influence on the bone-implant contact and quality of bone. Higher the frequency of smoking there are greater chances of implant failure.

**Reference:**

- [1]. Brånemark PI. Vital microscopy of bone marrow in rabbit. *Scand J Clin Lab Invest* 1959;11(Suppl.38):1-82.
- [2]. Brånemark PI. Osseointegration and its experimental studies. *J Prosthet Dent* 1983;50:399-410.
- [3]. Soballe K, Hansen ES, Brockstedt-Rasmussen H, Bünger C. Hydroxyapatite coating converts fibrous tissue to bone around loaded implants. *J Bone Joint Surg Br* 1993;75:270-8.
- [4]. Soballe K. Hydroxyapatite ceramic coating for bone implant fixation. Mechanical and histological studies in dogs. *Acta Orthop Scand Suppl* 1993;255:1-58.
- [5]. Berglundh T, Abrahamsson I, Lang NP, Lindhe J. De novo alveolar bone formation adjacent to endosseous implants. *Clin Oral Implants Res* 2003;14:251-62.
- [6]. Meyer U, Joos U, Mythili J, Stamm T, Hohoff A, Fillies T, Stratmann U, Wiesmann HP. Ultrastructural characterization of the implant/bone interface of immediately loaded dental implants. *Biomaterials* 2004;25:1959-67.
- [7]. Giori NJ, Ryd L, Carter DR. Mechanical influences on tissue differentiation at bone-cement interfaces. *J Arthroplasty* 1995;10:514-22.
- [8]. Pilliar RM, Lee JM, Maniopoulos C. Observations on the effect of movement on bone ingrowth into porous-surfaced implants. *Clin Orthop Relat Res* 1986; 208:108.
- [9]. Kudo M, Matsui Y, Ohno K, Michi K. A histomorphometric study of the tissue reaction around hydroxyapatite implants irradiated after placement. *J Oral Maxillofac Surg* 2001;59:293-300.
- [10]. Murai K, Takeshita F, Ayukawa Y, Kiyoshima T, Suetsugu T, Tanaka T. Light and electron microscopic studies of bone-titanium interface in the tibiae of young and mature rats. *J Biomed Mater Res* 1996;30:523-33.
- [11]. Franchi M, Fini M, Martini D, Orsini E, Leonardi L, Ruggeri A, Giavaresi G, Ottani V. Biological fixation of endosseous implants. *Micron* 2005;36:665-71.
- [12]. Marco F, Milena F, Gianluca G, Vittoria O. Peri-implant osteogenesis in health and osteoporosis. *Micron* 2005;36:630-44.
- [13]. Mavrogenis A. Biology of implant osseointegration. *J Musculoskelet Neuronal Interact* 2009; 9(2):61-71.
- [14]. Brånemark PI. Osseointegration and its experimental background. *J Prosthet Dent* 1983;50:399-410.
- [15]. Mosely LH, Finseth F. Cigarette smoking: impairment of digital blood flow and wound healing in the hand. *Hand* 1977;9:97-101.
- [16]. Yoon V, Maalouf NM, Sakhaee K. The effects of smoking on bone metabolism. *Osteoporos Int* 2012;23:2081-2092.
- [17]. Pereira ML, Carvalho JC, Peres F, Gutierrez M, Fernandes MH. Behaviour of human osteoblastic cells cultured on plasma-sprayed titanium implants in the presence of nicotine. *Clinical oral implants research* 2008;19:582-589.
- [18]. Ma L, Zwahlen RA, Zheng LW, Sham MH. Influence of nicotine on the biological activity of rabbit osteoblasts. *Clinical oral implants research* 2011;22:338-342.
- [19]. Kallala R, Barrow J, Graham SM, Kanakaris N, Giannoudis PV. The in vitro and in vivo effects of nicotine on bone, bone cells and fracture repair. *Expert Opin Drug Saf* 2013;12:209-233.
- [20]. Nitzan D, Mamlider A. impact of smoking on marginal bone loss. *The International Journal of Oral & Maxillofacial Implants*. 2005;20.
- [21]. Strietzel FP, Reichart PA, Kale A. Smoking interferes with the prognosis of dental implant treatment: a systematic review and meta-analysis. *J Clin Periodontol* 2007; 34: 523-544.
- [22]. Twito D, Sade P. The effect of cigarette smoking habits on the outcome of dental implant treatment. *PeerJ*. 2014; 2: e546.
- [23]. Moraschini E. dS. Porto Barboza: Success of dental implants in smokers and non-smokers: a systematic review and meta-analysis. *Int. J. Oral Maxillofac. Surg*.
- [24]. Bezerra Ferreira. Effect of smoking on early osseointegration. *Clin. Oral Impl. Res.* 0, 2016:1-6.
- [25]. Ramos Chrcanovic, Tomas Albrektsson. Smoking and dental implants: A systematic review and meta-analysis. *JJOD* 2015:1-12.
- [26]. Arpana Arora, Madhan Mohan Reddy. Comparative Evaluation of Effect of Smoking on Survival of Dental Implant. *Journal of International Oral Health*. 2017:9.

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