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Journal of Composites and Compounds

Factors influencing the failure of dental implants: A systematic review

Leila Bazli [a], Hiva Nargesi Khoramabadi [b], Amir Modarresi Chahardehi [c], Hasni Arsad [d], Behzad Malekpouri [e], Mohammadreza Asgari Jazi [f], Negar Azizabadi [g]*

[a] *School of Metallurgy and Materials Engineering, Iran University of Science and Technology, Tehran, Iran*
[b] *Department of Medical Engineering, Payame Noor University (PNU),19395-3697 Alborz, Iran*
[c] *Integrative Medicine Cluster, Advanced Medical and Dental Institute, Universiti Sains Malaysia, Kepala Batas, 13200, Bertam, Pulau Pinang, Malaysia*
[d] *Advanced Medical and Dental Institute, Universiti Sains Malaysia, Bertam, Pulau Pinang 13200, Malaysia*
[e] *Department of Materials Science and Engineering, Sharif University of Technology, Tehran, Iran*
[f] *Department of Dentistry, Isfahan (khorasgan) Branch, Islamic Azad University (IAU) , Isfahan, Iran*
[g] *Department of Chemistry, Science and Research Branch, Islamic Azad University (IAU), Tehran, Iran*

ABSTRACT

Currently, dental implants are considered useful alternatives to missing teeth, although they may suffer from failure. In this study, the current scientific literature has been reviewed to highlight the risk factors affecting dental implant failure. Radiotherapy in the neck and head cancers, diabetes, smoking, osteoporosis, and HIV can increase the occurrence of risk factors for the failure of a dental implant. As a result of negative impacts on osseointegration, osteoporosis, smoking, and head, neck radiotherapy causes a higher risk of dental implant failure. The irradiation target volume during radiotherapy is the main cause of implant failure, especially due to the increment of marginal bone resorption. Additionally, the healing of bones around dental implants is negatively affected by heavy smoking due to the reduction of the healing speed. Moreover, diabetic patients have some complications (e.g., delayed wound healing of soft tissues, periodontitis, impaired response to infection, tooth loss, and microvascular disease) affecting therapyial preliminary considerations of dental implant treatment. However, in case of HIV-positive patients, the dental implant failure rate would not increase due to affective factors (e.g., prophylactic antibiotic treatment, the administration of active antiretroviral therapy, and control of the CD^{4+} T lymphocyte counts). Therefore, these patients have no clinical signs of mobility or infection in this treatment and much more attention should be paid to these patients and they should be treated with controlled oral surgical procedures.

Peer review under responsibility of JCC Research Group

ARTICLE INFORMATION

Article history:
Received 02 January 2020
Received in revised form 18 February 2020
Accepted 30 March 2020

Keywords:
Risk factor
Failure
Dental implants
Osseointegration
Diabetes

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1. Introduction

One of the restorative techniques practiced today for missing teeth replacement is using dental implants [1-5]. Enhancement of implant design, surgical protocols, and surface characteristics suggest implants as a procedure that is secure and highly predictable. The mean success rate and mean survival rate of implants are 89.7 % and 94.6 %, respectively, after more than 10 years [6].

For patients who suffer from tooth loss, dental implants are a widely utilized option that provides esthetic and functional resolution [7]. How-

* *Corresponding author: Hiva Nargesi Khoramabadi; E-mail: Hiva.nargesi@yahoo.com*
DOR: 20.1001.1.26765837.2020.2.2.3.1
https://doi.org/10.29252/jcc.2.1.3

ever, the associated factors leading to early implant failure have not been documented well. Moreover, it is required to determine the factors that affect the osseointegration establishment to minimize implant failures and maximize the predictability of the procedure [8].

The initial osseointegration and prolonged stability determine success in implant dentistry. Long-term implant stability depends on various factors, including periodontal pathogenic bacteria, implant macrodesign and microdesign, susceptibility to periodontal diseases, and patient systemic factors [9].

Successful osseointegration after placement is the initial factor influencing implant survival [10-15]. Treatment outcome may be affected adversely by any change in this biological process. by restoring and placing an implant into function, bone remodeling would be considered as a critical aspect of implant survival in terms of response to the functional demands placed on the supporting bone and implant restoration. Certain risk factors can be evaluated by the critical dependence on bone metabolism for implant survival [6].

In this study, the major problems and factors associated with dental implant failure as well as high-risk patients whose diseases affect dental implant survival are reviewed.

2. Dental implants

Since Brånemark introduced oral implants in the 1960s, they have been a reliable and optimal restoration option for missing teeth [16-20]. Regarding esthetics function, mastication, and speech function, dental implants are considered as effective oral rehabilitation [21].

There are substantial documented reports about chemical and physical characteristics of implant materials and factors influencing the prognosis of implant therapy and the clinical outcome [9, 22-29].

Implant dentistry includes a prosthetic procedure having a surgical protocol [30, 31]. It must be planned prior to the therapy so that an optimal prosthetic construct is obtained. The bone quality and quantity in different locations [32] and the size of prosthesis affect the position and number of implants required to support prosthesis [33].

Osseointegration provides a stable, long-lasting, and firm connection between the implant and surrounding bone tissue, which is necessary for implant survival. The absence of osseointegration would result in biological failure leading to consequent implant failure [34].

The long-term survival and highly desirable outcomes of dental implant therapy are reported widely in various studies; however, the duration of treatment could be decreased in patients with systemic conditions or a compromised medical status [35]. Additionally, there are a few documents regarding the influence of general health conditions on implant failure rates [34].

3. Failure of dental implants

Mechanical removal of the mobile implant, due to the absence of osseointegration, is the definition of implant failure outcome [36-39].

To obtain the best patient outcomes, dental clinicians should pay attention to the contraindications, precautions, and indications of treatment on a daily basis. Treatment indications generally are considered when patients initially face a complaint or problem. Subsequently, the contraindications and precautions must be considered as balancing elements of the informed consent process and decision-making. The seriousness of special treatment as well as the cases, cause a specific treatment to be inadvisable due to the harm, or serious negative outcome that makes precautions and contraindications be taken into account. Precautions indicate the ability to inhibit or mitigate the adverse impact [40].

Failure at the early stages is caused mostly by the initial phase disruption in which fibrous scar tissue is produced between the surrounding bone and the implant surface. However, failures at later stages are associated with multiple factors such as the prosthetic rehabilitation and microbial environment [34].

Although early failure is prevalent, the successful outcome of implantation after prosthetic loading has been mostly addressed, which limits our understanding of the mechanisms and causes of preloading failures. Sex, age, tobacco use, implant localization, and dimensions, bone volume and quality, systemic diseases, and immune factors, are attributed to early implant failure among other variables [41].

4. Influencing factors on dental implants failure

Although implant treatment is highly successful and predictable, some risk factors may reduce the success rates leading to a higher risk for implant failure for individuals [34]. The outcome for implant restoration is influenced by various conditions such as surgery-related factors (surgical design or surgeon's skill), risk factors related to the patients (systemic habits or diseases, like smoking), and design of implant (shape, surface, or length texture). Researchers have recently concentrated on risk factors related to the patients for the failure of the dental implant due to the considerable advancements in surgical techniques and materials science [35].

A person who has a distinctive mental or physical feature compared to individuals of the same age is considered as a medically compromised patient (MCP). These patients may face a higher medical risk due to the presence of more interactions between implant surgery and their disease [42-48]. Therefore, these patients are required to fill in a medical questionnaire and do some exhaustive medical examination before implant placement, which will be helpful for the estimation of the patient's risk and determination of the specific measures that should be adopted. To define the patient's risk, the system adopted by McCarthy and Malamed and the one proposed by the American Society of Anesthesiologists in 1941 to the dental patient were employed [49].

Buser et al. [35] reported that heavy smoking habits, severe diabetes, and being exposed to irradiation before implantation or after that have led to a significant rise in risks of failure in dental implants. Based on research reports, these conditions could affect the implant survival negatively by interfering with the process of tissue healing or by reducing the susceptibility of patients to other diseases. Fig. 1 the most important risk factors in dental implants.

4.1. Diabetes

Diabetes is a chronic metabolic malfunction that causes hypergly-

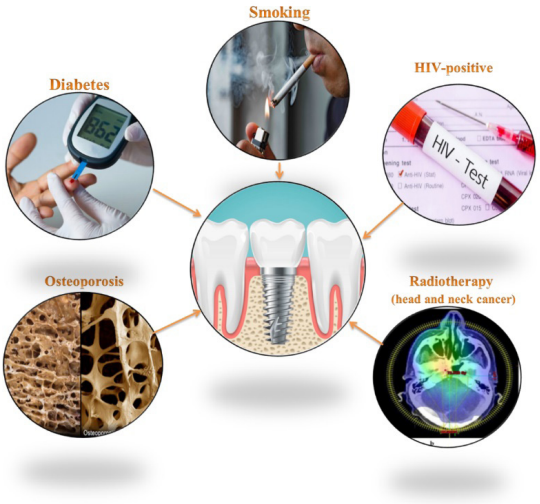

Fig. 1. Factors affecting dental implants.

cemia, leading to several complications resulting from macro- and microangiopathy [50-54]. Diabetes increases tooth loss and frequency of periodontitis, delays wound healing and disrupts the response to infection [46, 55-57]. According to statistics, more than 150 million people were affected by diabetes worldwide in 1980, and the number raised up to 350 million by 2008. Based on recent investigations, oral rehabilitation by dental implant treatment provides diabetic patients with indirect benefits. Patients avoid food that needs more effort to masticate patients after tooth loss, leading to malnutrition with poor metabolic control. The advantages of dental rehabilitation are the improvement of nutrition and metabolic control for patients [6].

In order to make appropriate decisions and refine the therapy procedure for optimizing the outcomes, surgeons should recognize situations that would create higher complication risk for the patient [6].

According to Halimi et al. [58], diabetic patients, particularly type 2 patients, are often elderly people whose dental status usually makes implant specialists ask their physician about the possible contraindications due to diabetes's status. As known, the risk of dental loss and periodontal disease in patients with diabetes (both types of 1 and 2) is high. According to a few studies, success rates of diabetic and non-diabetic subjects are almost equivalent to each other in this case. This result implies good glycemic control, strict oral hygiene, and the expertise of the odontologist at the time of implantation, which requires close collaboration among the different involving health actors.

Juncar et al. [59], performed mandible histological study in patients having type 2 diabetes mellitus for implant rehabilitation. Based on the results, diabetes mellitus is the main factor influencing the metabolic activity of various tissues. In the case of rehabilitation based on prosthetic restorations supported on dental implants, its effect on the jaw bones should be emphasized. The obtained results demonstrated a lower degree of mineralization in the bone, a higher cellular density in the diabetic bone, and the existence of diabetic angiopathy in the mandible taken from the patients.

Almehmadi et al. [60] analyzed population awareness in terms of the effects of diabetes on dental implant therapy in Jeddah, Saudi Arabia. According to the results, diabetes mellitus (DM) causes some problems. These complications that affect dental implant therapy adversely include impaired response to infections, microvascular disease, and delayed wound healing. The main goal of this study was the investigation of the population awareness about the DM impact on dental implant treatment. Based on the study, the awareness level about the relation between diabetes and oral hygiene in dental implant therapy was satisfying. On the other hand, the knowledge about diabetes effects on dental implants is less than adequate, and most of the respondents believed that the only factor that helps dental implant therapy is controlled diabetes.

4.2. HIV-positive

The acquired immunodeficiency syndrome (AIDS) results from infection with HIV leading to increased rates of morbidity and mortality. The infection impairs the immune system, particularly CD^{4+} T-cells, leading to host resistance reduction against various pathogens [61-63]. Moreover, several investigations have proposed a relation between HIV/AIDS and increased risk of complications in oral surgical procedures [42, 64-68]. Such complications may adversely affect implant survival and, consequently, contributing to failures [34].

Elective treatments and procedures are employed for HIV-infected individuals with adequate immune status. However, some factors have been introduced for distinguishing these patients from the general population including age (the majority of them are over 40 years old), chronic inflammation, the need for regular medication, a greater need for medical care, long-term complications of Highly Active Antiretroviral Therapy (HAART), and an increased prevalence of comorbidities [69].

Lemos et al. [34] investigated dental implants' survival in HIV-infected patients. Totally, 328 and 493 implants were placed in 135 normal and 169 HIV-positive patients. The follow-up was done in the mean duration of 47.9 months. Success rates and mean survival at the patient level were reported to be 93.81% and 94.76%, respectively. The average marginal bone loss was 0.99 mm at the implant level and 0.83 mm at the patient level; these rates were 90.37% and 94.53% at the implant level. Therefore, for patients with normal CD4+ cell counts and controlled risk factors, placing dental implants is a suitable way for rehabilitation.

Ata-Ali et al. [69] studied the impact of HIV infection on dental implant osseointegration. They reported that HIV infection does not accelerate the failure rate of the dental implant. The main contributing factors are controlling the CD^{4+} T lymphocyte counts, managing highly active antiretroviral therapy, and prophylactic antibiotic treatment. 38 and 135 implants were placed in 24 normal and 56 HIV-positive patients. Among HIV-positive patients, a single dental implant osseointegration loss was recorded. No clinical signs of infection or mobility were shown in implants, and periotest values revealed a progressive decrease.

Vidal et al. [70] investigated bone augmentation of dental implants in HIV-positive cases under HAART. Based on the results, as long as CD^{4+} T lymphocytes count and plasmatic HIV viral load of the patients are considered as the parameters indicating immune stability, HIV-infected patients who are under control and undergo HAART can be candidates for implant rehabilitation. Maintaining function and esthetics, a long-term stability of hard and soft tissues can be achieved. Nevertheless, more evidence and controlled clinical trials are required to prepare conclusive data for the medical and dental teams.

Escoda et al. [71] studied nine participants and 57 implants. The average age of the patients was 42 years (IQR of ~13 years), and the average follow-up period was 77.5 months. The implant survival and success rates were about 98 % and 68%, respectively. Satisfactory results were achieved in HIV-positive patients with regard to oral rehabilitation with dental implants. Strict maintenance programs have to be implemented to decrease the remarkably high incidence of peri-implant diseases.

4.3. Smoking

Another factor influencing peri-implant bone loss and dental implant survival is smoking [12, 42, 72-76]. According to various studies, smoking has a negative effect on osseointegration [77-83] and its dose-related impact [84].

Among more than 4000 potentially harmful constituents of tobacco products, nicotine is the most important substance [86-90]. Nicotine contributes to the pathogenesis of numerous diseases, mediates the smoking hemodynamic effects, and is the main chemical component causing tobacco addiction. Smokers have a higher number of missing teeth compared to non-smokers. Moreover, gingival recession, attachment loss, and moderate to severe periodontitis are more prevalent in smokers in comparison with non-smokers, revealing their poorer periodontal health [91].

The process of peri-implant bone healing is undermined by cigarette smoking [72, 80, 92-94]. The proliferation of precursor cells that is important for bone healing is inhibited by smoking, which delays the healing process of normal bones. Toxins, including nicotine, hydrogen cyanide, aldehydes, benzenes, nitrosamines, and carbon monoxide, have been reported to affect bone healing processes [95-99].

The effect of cigarette smoking on the early stages of osseointegration in dental implants was studied by Bezerra Ferreira et al. [95]. No osseointegration was observed in two micro-implants placed in smokers, while the newly formed bone (mainly in the non-smokers) indicated early stages of maturation. In addition, around few implants retrieved from smokers marginal bone loss, fibrous tissue and gap were presented. Based on the histometric evaluation, the mean bone to-implant contact

(BIC) % increased from 25.9 ± 9.1 for smokers to 39.8 ± 14.2 for non-smokers. Initial bone tissue response around implant surface topographies that are sandblasted and acid-etched is adversely influenced by cigarette smoking.

D'haese et al. [84] studied smoking habits effect on implant placement outcome using mucosally supported stereolithographic surgical instructions. The dental implant placement accuracy was significantly different among smokers and nonsmokers. In comparison with non-smokers, supporting mucosal tissues was thicker in smokers, which could explain inaccuracy resulting from reduced stability of the surgical guide or the scanning prosthesis.

Shenava et al. [85] investigated the relation between bone healing process around dental implants and smoking. They reported that smoking had a remarkable influence on implant survival, and smokers should be aware of the negative effects of tobacco. While the amount of tobacco does not exhibit a major impact, the habit duration plays a significant role in implant failure.

Sun et al. [100] reported the effect of heavy smoking on dental implants placed in posterior mandibles of male patients. They placed the dental implants into the partially edentulous posterior mandibles of 16 nonsmokers and 16 heavy smokers. For both smokers and non-smokers, an initial decrease in the implant stability quotient (ISQ) was observed from the ISQ obtained immediately after surgery and after 2 weeks started to increase. By reducing the healing rate, bone healing around dental implants is negatively affected by heavy smoking. The results demonstrated the importance of selecting the right time for applying the implant loading in heavy smokers. Additionally, heavy smoking accelerated the marginal bone loss and the consequent development of dental pockets.

Omran et al. [101] studied the survival short endosseous dental implants rate. It was concluded that the survival time was in the range of 6 to 141 months, with an average time of 47.3 months. The short implants' survival rate was achieved to be 95.77% revealing that it was not statistically remarkable compared to regular implants. Short implants with a high survival rate can be predictably placed for rehabilitation, and the survival rate of these implants is adversely affected by smoking.

4.4. Radiotherapy

More than 550,000 cases of head and neck cancer are recorded annually worldwide. Its survival rate is 50% over 5 years and it is the sixth common cancer site. The survival rate of this cancer has not changed in the past few decades. However, some evidence shows a decrease in mortality rates over the last 20 years. A combination of radiotherapy and surgery are treatment modalities. Radiotherapy may cause a reduction of bone-healing capacity, soft tissues, and fibrosis of blood vessels, xerostomia, irradiation caries, and oral mucositis, and surgery may result in anatomical alterations [102].

Patients having oral cancer are treated by a combination of ablative surgery and radiotherapy. Following radical surgery, the oral rehabilitation of a patient is required. Surgical resection and radiotherapy lead to hard and soft tissue defects in most patients, which results in esthetic deformity and functional disabilities [21].

Because dental implants are placed in the bone that is usually in the irradiation field, implant therapy in oral cancer patients is a challenging issue and leads to an increase in implant failure in irradiated bone [103]. The reason is partly due to progressive fibrosis of soft tissue and vessels caused by radiotherapy, which results in healing capacity decline. Furthermore, the osseointegration of implants is hindered by radiations (osteoradionecrosis) by decreasing bone vascularity [21].

Based on the results obtained by Granstrom et al. [104], irradiated points are prone to tissue necrosis and, consequently, implants loss. Complications such as fungal infections, periodontal disease, and dental caries can be caused by a decreased salivary flow rate in irradiated patients. Cao and Weischer [105], studied the efficiency of dental implants in 27 patients who suffered from oral carcinoma and undergone radiotherapy. Compared to non-irradiated patients, a considerably lower implant survival rate was observed in irradiated patients after approximately two years of follow-up [106].

Claudy et al. [107] studied the effect of time-interval after radiotherapy on the failure of dental implants. They proposed that a minimum waiting period of 6 months after radiotherapy before placing dental implants is not suitable, while the duration over 12 months may be advantageous to healing periods. To install dental implants, clinicians should wait longer than a year after radiotherapy. Higher pooled relative risk (RR) of failure was obtained in patients who installed dental implants in 6 to 12 months post-radiotherapy.

Ettl et al. [108] investigated the effect of neck and head cancer radiotherapy on implant rehabilitation. Results proved that rehabilitation of implant prosthetic in patients suffering from the neck, and head cancer is feasible at a calculable risk. Implant success rates obtained from Albrektsson criteria are greatly lower compared to non-tumor patients. The main causes for failure of the implant, especially for accelerated marginal bone resorption are implant placement in the target area of the irradiation and xerostomia. Placing dental implants outside the target area showed a promising prognosis comparable to those implanted in non-irradiated patients. Implant prosthetic rehabilitation enhances patients' functional quality of life, social integration, and self-confidence in terms of irritation by dry mouth, eating, swallowing, and/or speaking.

Chen et al. [35] investigated different risk factors such as osteoporosis, diabetes, radiotherapy, and smoking for the failure of a dental implant. The analysis supported the insight that radiotherapy and smoking are considered as higher risks of failure in dental implants. They suggested that smoking or radiotherapy before or after implant placement might result in about 35% or 70% higher risk of failure of a dental implant, respectively.

Korfage et al. [109] studied overdentures in patients with oral cancer during 14 years of follow-up. Implant-retained mandibular overdentures showed that oral functioning and prosthetic rehabilitation did not relate to type or number of implants, stage or primary site of the tumor, or the type of reconstruction. Inflammation was not observed in the peri-implant mucosa over time. The number of lost implants was higher in radiotherapy-treated patients (8.5%) compared to the untreated ones (0.5%). Compared to non-treated patients, problems in oral functioning was more in patients who had been radiotherapy-treated, and less satisfaction was reported. Fewer problems were reported in oral functioning by patients having an implant-retained mandibular overdenture in comparison with patients without an overdenture. Since peri-implant health was reasonable in patients with mandibular overdentures and oral functioning enhanced significantly, the initial placement of an implant should be considered as a routine procedure in the surgical planning implemented for patients suffering from oral cancer.

Patients with oral cancer who had been treated by radiotherapy and surgery were studied by Pompa et al. [21] in terms of survival of dental implants. Results showed that the location and position of the implants had an effect on implant loss. Furthermore, radiotherapy considerably influenced implant survival. When the implant was loaded at least 6 months after placement, considerably better outcomes were observed. According to the study, the best chance of implant stability, osseointegration, and, consequently, effective dental rehabilitation can be achieved by a delayed loading protocol.

4.5. Osteoporosis

A very common skeletal disease in human is osteoporosis, which is determined by the low density of bone tissues [110-115]. A constant

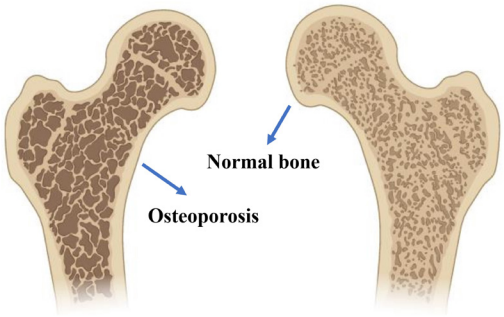

Fig. 2. Comparison of normal bone and osteoporosis.

reduction in bone quantity and volume results from imbalances in bone remodeling [116]. Fig. 2 depicts the normal bone and osteoporosis.

Osteoporosis that is highly prevalent in the aged population has detrimental impacts on dental implant therapy; the low bone mineral density and alveolar ridge atrophy, resulting from osteoporosis can deteriorate bone quality and quantity in implant location [35].

According to the latest estimations, osteoporosis is expected to influence 200 million women around the world, among which two-thirds aged 90 years, two-fifths aged 80, one-fifth aged 70, and one-tenth aged 60 [117]. Primary osteoporosis is senile and postmenopausal. Senile osteoporosis appears at older ages and is caused by a reduction in bone mass, while postmenopausal osteoporosis occurrs due to bone loss acceleration caused by low levels of oestrogen [116].

Apart from the surgical procedure and properties of the implant, osseointegration can be affected by patient dependent variables altering the bone quantity and quality. Hence, osteoporosis that causes the reduction of the bone mass and strength, decreases in the regenerative capacity of bone, and changes in the microstructure that is regarded as a risk factor for dental implants. Nevertheless, there is no strong evidence that shows differences in the survival of patients with osteoporosis and healthy individuals. Thus, the disease could not be considered as a contraindication for placing implants. Unfortunately, the use of bisphosphonates (BP), especially parenteral BPs, which is the most commonly utilized pharmacologic agents for osteoporosis treatment, leads to the acceleration of problems related to implant osseointegration [117].

Niedermaier et al. [118] also evaluated survival rates of implant-supported dentures in osteoporosis patients for up to 7 years. Although the results showed a higher level of implant failure in osteoporosis patients during 7 years of followed up, the researchers investigated only seven patients with such conditions. They mentioned that two of the failures were related to a patient who was being treated with oral bisphosphonates. However, the relation between the use of bisphosphonates and implant failure is still controversial.

Alsaadi et al. [119], studied the influence of systemic and local factors on the failures in oral implant, up to abutment connection. A positive relation between osteoporosis and osseointegrated implant failure was reported, and also higher implant failure rates were observed in patients who smoke, patients with lower bone quality, patients with implants placed in the posterior region, and individual suffering from Crohn's disease, and the ones with short and wide implants.

Liu et al. [120] reported that the combined use of silicon and gallium improve osseointegration of the dental implant in osteoporosis patients. Based on the study, gallium could directly augment bone mass, inhibit bone calcium release, and prevent bone osteolysis. Bone anabolic effects are seen in silicon that acts as a necessary modulator in bone formation. They proposed that their hypothesis could be beneficial to osteoporotic patients by improving the success rate of dental implants.

5. Conclusions and future insights

In the present study, the impact of different risk factors including osteoporosis, diabetes, smoking, radiotherapy in head and neck on dental implant failure has been reviewed. Due to the adverse influence on osseointegration, osteoporosis, radiotherapy, and smoking are considered as higher risk factors for dental implant failure. Additionally, taking some drugs such as bisphosphonates that are used for osteoporosis treatment can cause some complications in osseointegration. Heavy smoking has an adverse impact on the healing of bone surrounding dental implants through the reduction of healing speed. In addition, the target area of radiotherapy is susceptible to marginal bone resorption leading to implant failure. However, diabetes has lower risk factors (i.e., complications compromise the healing of soft tissues, periodontitis, tooth loss, delayed wound healing, and impaired response to infection, etc.). Overall, additional insight for implementing dental implants through controlled and predictable treatment procedures should be provided for clinical dentists.

Coatings are of great importance in medical applications and offer various advantages in extensive fields. Hence, a special coating can be developed to reduce the possibility, and risk factors contributing to dental implant failure such as osteoporosis, radiotherapy, smoking, etc. that are influenced by some external factors including chemical materials, radio waves, and effective drugs. Considering the lack of individual risk-isolated research with high quality in terms of osteoporosis and diabetes, there is a need for further well-designed investigations, with precise control of confounding parameters in future studies.

Acknowledgments

The authors received no financial support for the research, authorship and/or publication of this article.

Conflict of Interest

All authors declare no conflicts of interest in this paper.

REFERENCES

[1] H. Mously, B. Badeeb, N. Bahbishi, W. Mzain, G. Naguib, M. Hamed, Knowledge and attitude toward replacing missing teeth with dental implants among the Saudi population, journal of orthodontic science 9(1) (2020) 5-5.

[2] A. Solderer, A. Al-Jazrawi, P. Sahrmann, R. Jung, T. Attin, P.R. Schmidlin, Removal of failed dental implants revisited: Questions and answers, Clinical and Experimental Dental Research 5(6) (2019) 712-724.

[3] M. Roy, L. Loutan, G. Garavaglia, D. Hashim, Removal of osseointegrated dental implants: a systematic review of explantation techniques, Clinical Oral In-vestigations 24(1) (2020) 47-60.

[4] C. Machuca, M.V. Vettore, P.G. Robinson, How peoples' ratings of dental implant treatment change over time?, Quality of Life Research 29(5) (2020) 1323-1334.

[5] P. Vasamsetty, T. Pss, D. Kukkala, M. Singamshetty, S. Gajula, 3D printing in dentistry – Exploring the new horizons, Materials Today: Proceedings 26 (2020) 838-841.

[6] H. Naujokat, B. Kunzendorf, J. Wiltfang, Dental implants and diabetes melli-tus—a systematic review, International journal of implant dentistry 2(1) (2016) 5.

[7] N. Pranno, G. La Monaca, A. Polimeni, M.S. Sarto, D. Uccelletti, E. Bruni, M.P. Cristalli, D. Cavallini, I. Vozza, Antibacterial Activity against Staphylococ-cus Aureus of Titanium Surfaces Coated with Graphene Nanoplatelets to Prevent Peri-Implant Diseases. An In-Vitro Pilot Study, International Journal of Environ-mental Research and Public Health 17(5) (2020) 1568.

[8] M.V. Olmedo-Gaya, F.J. Manzano-Moreno, E. Cañaveral-Cavero, J. de Dios Luna-del Castillo, M. Vallecillo-Capilla, Risk factors associated with early implant failure: A 5-year retrospective clinical study, The Journal of prosthetic dentistry 115(2) (2016) 150-155.

[9] J. Yazdani, E. Ahmadian, S. Sharifi, S. Shahi, S.M. Dizaj, A short view on nano-hydroxyapatite as coating of dental implants, Biomedicine & Pharmacother-apy 105 (2018) 553-557.
[10] X.-y. Qi, L. Sui, W.-q. Liu, Dental Implant and Oral Diseases, in: Q. Yuan (Ed.), Dental Implant Treatment in Medically Compromised Patients, Springer In-ternational Publishing, Cham, 2020, pp. 185-209.
[11] G.C. Boven, H.J.A. Meijer, A. Vissink, G.M. Raghoebar, Maxillary implant overdentures retained by use of bars or locator attachments: 1-year findings from a randomized controlled trial, Journal of Prosthodontic Research 64(1) (2020) 26-33.
[12] A. Bezdjian, Z. Verzani, H.G.X.M. Thomeer, B. Willie, S.J. Daniel, Smoking as a risk factor for spontaneous bone anchored hearing implant extrusion: A case report and review of literature, Otolaryngology Case Reports 14 (2020) 100140.
[13] J.-J. Kim, J.-H. Lee, J.C. Kim, J.-B. Lee, I.-S.L. Yeo, Biological Responses to the Transitional Area of Dental Implants: Material- and Structure-Dependent Responses of Peri-Implant Tissue to Abutments, Materials 13(1) (2019) 72.
[14] A. Alghamdi, K. Al-Motari, C. Sundar, J.A. Jansen, H. Alghamdi, Chapter 2 - Dental implants treatment: Clinical indications, in: H. Alghamdi, J. Jansen (Eds.), Dental Implants and Bone Grafts, Woodhead Publishing, London, 2020, pp. 23-42.
[15] M. Hou, R.S.B. Lee, Z. Du, S.M. Hamlet, C. Vaquette, S. Ivanovski, The influence of high-dose systemic zoledronate administration on osseointegration of implants with different surface topography, Journal of Periodontal Research 54(6) (2019) 633-643.
[16] S. Mohammadpour, S. Khorramymehr, Comparing one-and two-piece dental abutments under dynamic loading: A 3-D finite element analysis.
[17] A. TV, SIGN IN/REGISTER, Compendium (2020).
[18] M. Assery, A 22-Year Follow Up of Immediate Implant Placement without Bone Augmentation: A Case Series Study, Journal of Prosthodontics 29(2) (2020) 101-106.
[19] Z.M. Al-Sadah, M.S. AlShakhas, Osseous Integration After Exenteration, in: T.E. Johnson (Ed.), Anophthalmia : The Expert's Guide to Medical and Surgical Management, Springer International Publishing, Cham, 2020, pp. 107-126.
[20] B.R. Chrcanovic, J. Kisch, T. Albrektsson, A. Wennerberg, A retrospective study on clinical and radiological outcomes of oral implants in patients followed up for a minimum of 20 years, Clinical Implant Dentistry and Related Research 20(2) (2018) 199-207.
[21] G. Pompa, M. Saccucci, G. Di Carlo, E. Brauner, V. Valentini, S. Di Carlo, T. Gentile, G. Guarino, A. Polimeni, Survival of dental implants in patients with oral cancer treated by surgery and radiotherapy: a retrospective study, BMC Oral Health 15(1) (2015) 5.
[22] X. Wen, R. Liu, G. Li, M. Deng, L. Liu, X.-T. Zeng, X. Nie, History of peri-odontitis as a risk factor for long-term survival of dental implants: a me-ta-analysis, Int J Oral Maxillofac Implants 29(6) (2014) 1271-80.
[23] Z. Goudarzi, N. Parvin, F. Sharifianjazi, Formation of hydroxyapatite on sur-face of SiO_2– P_2O_5–CaO–SrO–ZnO bioactive glass synthesized through sol-gel route, Ceramics International 45(15) (2019) 19323-19330.
[24] M.S.N. Shahrbabak, F. Sharifianjazi, D. Rahban, A. Salimi, A Comparative Investigation on Bioactivity and Antibacterial Properties of Sol-Gel Derived 58S Bioactive Glass Substituted by Ag and Zn, Silicon 11(6) (2019) 2741-2751.
[25] S. Rahimi, F. SharifianJazi, A. Esmaeilkhanian, M. Moradi, A.H. Safi Samgh-abadi, Effect of SiO_2 content on Y-TZP/Al_2O_3 ceramic-nanocomposite proper-ties as potential dental applications, Ceramics International 46(8, Part A) (2020) 10910-10916.
[26] A.R. Rouhani, A.H. Esmaeil-Khanian, F. Davar, S. Hasani, The effect of agarose content on the morphology, phase evolution, and magnetic properties of $CoFe_2O_4$ nanoparticles prepared by sol-gel autocombustion method, International Journal of Applied Ceramic Technology 15(3) (2018) 758-765.
[27] M. Alizadeh, M.H. Paydar, F. Sharifian Jazi, Structural evaluation and me-chanical properties of nanostructured Al/B4C composite fabricated by ARB pro-cess, Composites Part B: Engineering 44(1) (2013) 339-343.
[28] K. Shirvanimoghaddam, S.U. Hamim, M. Karbalaei Akbari, S.M. Fakhrho-sei-ni, H. Khayyam, A.H. Pakseresht, E. Ghasali, M. Zabet, K.S. Munir, S. Jia, J.P. Davim, M. Naebe, Carbon fiber reinforced metal matrix composites: Fabrication processes and properties, Composites Part A: Applied Science and Manufacturing 92 (2017) 70-96.
[29] M. Shahedi Asl, I. Farahbakhsh, B. Nayebi, Characteristics of multi-walled carbon nanotube toughened ZrB_2–SiC ceramic composite prepared by hot press-ing, Ceramics International 42(1, Part B) (2016) 1950-1958.
[30] A. Klinge, D. Khalil, B. Klinge, B. Lund, A. Naimi-Akbar, S. Tranaeus, M. Hultin, Prophylactic antibiotics for staged bone augmentation in implant dentistry, Acta Odontologica Scandinavica 78(1) (2020) 64-73.
[31] R. Lieber, N. Pandis, C.M. Faggion Jr, Reporting and handling of incomplete outcome data in implant dentistry: A survey of randomized clinical trials, Journal of Clinical Periodontology 47(2) (2020) 257-266.
[32] A. Esmaeilkhanian, F. Sharifianjazi, A. Abouchenari, A. Rouhani, N. Parvin, M. Irani, Synthesis and Characterization of Natural Nano-hydroxyapatite Derived from Turkey Femur-Bone Waste, Applied Biochemistry and Biotechnology 189(3) (2019) 919-932.
[33] J. Carpentieri, G. Greenstein, J. Cavallaro, Hierarchy of restorative space re-quired for different types of dental implant prostheses, The Journal of the American Dental Association 150(8) (2019) 695-706.
[34] C.A.A. Lemos, F.R. Verri, R.S. Cruz, J.F. Santiago Júnior, L.P. Faverani, E.P. Pellizzer, Survival of dental implants placed in HIV-positive patients: a system-at-ic review, International Journal of Oral and Maxillofacial Surgery 47(10) (2018) 1336-1342.
[35] H. Chen, N. Liu, X. Xu, X. Qu, E. Lu, Smoking, Radiotherapy, Diabetes and Osteoporosis as Risk Factors for Dental Implant Failure: A Meta-Analysis, PLOS ONE 8(8) (2013) e71955.
[36] E. Madeley, The use of MRFA as an adjunct to conventional clinical exam-ina-tion following peri-implantitis treatment. A 12 month follow-up, Trinity Col-lege Dublin, (2020).
[37] F. Rodríguez Sánchez, C. Rodríguez Andrés, I. Arteagoitia, Which antibiot-ic regimen prevents implant failure or infection after dental implant surgery? A sys-tematic review and meta-analysis, Journal of Cranio-Maxillofacial Surgery 46(4) (2018) 722-736.
[38] A. Puisys, M. Schlee, T. Linkevicius, P. Petrakakis, A. Tjaden, Photo-activated implants: a triple-blinded, split-mouth, randomized controlled clinical trial on the resistance to removal torque at various healing intervals, Clinical Oral Investiga-tions 24(5) (2020) 1789-1799.
[39] S. Sprio, L. Preti, M. Montesi, S. Panseri, A. Adamiano, A. Vandini, N.M. Pugno, A. Tampieri, Surface Phenomena Enhancing the Antibacterial and Os-teo-genic Ability of Nanocrystalline Hydroxyapatite, Activated by Multiple-Ion Dop-ing, ACS Biomaterials Science & Engineering 5(11) (2019) 5947-5959.
[40] A.S. Kullar, C.S. Miller, Are There Contraindications for Placing Dental Im-plants?, Dental Clinics 63(3) (2019) 345-362.
[41] A. Monje, G. Alcoforado, M. Padial-Molina, F. Suarez, G.H. Lin, H.L. Wang, Generalized aggressive periodontitis as a risk factor for dental implant failure: A systematic review and meta-analysis, Journal of periodontology 85(10) (2014) 1398-1407.
[42] Y. Huang, P. Gong, The Role of Substance Abuse in Dental Implant Treat-ment, in: Q. Yuan (Ed.), Dental Implant Treatment in Medically Compromised Patients, Springer International Publishing, Cham, 2020, pp. 21-35.
[43] T.V. Sparrow, D.W. Dodington, J.L. Yumol, P.C. Fritz, W.E. Ward, Higher intakes of flavonoids are associated with lower salivary IL-1β and maintenance of periodontal health 3–4 years after scaling and root planing, Journal of Clinical Periodontology 47(4) (2020) 461-469.
[44] X.-b. Duan, K. Doi, Q. Yuan, S.-w. Zhang, Other Conditions Affecting Den-tal Implant Treatment, in: Q. Yuan (Ed.), Dental Implant Treatment in Medically Compromised Patients, Springer International Publishing, Cham, 2020, pp. 211-253.
[45] C. Hsiao, H. Qing, Drug-Induced Disorders and Dental Implant Treatment, in: Q. Yuan (Ed.), Dental Implant Treatment in Medically Compromised Patients, Springer International Publishing, Cham, 2020, pp. 149-183.
[46] Y.-s. Wu, Y. Wang, Q. Yuan, Dental Implant Treatment for Diabetic Patients, in: Q. Yuan (Ed.), Dental Implant Treatment in Medically Compromised Patients, Springer International Publishing, Cham, 2020, pp. 103-127.
[47] J. Collen, C. Lettieri, E. Wickwire, A. Holley, Obstructive sleep apnea and cardiovascular disease, a story of confounders!, Sleep and Breathing 24(4) (2020) 1299-1313.
[48] C.R. Ellis, G.G. Jackson, When to Refer Patients for Left Atrial Appendage Closure, Cardiac Electrophysiology Clinics 12(1) (2020) 29-37.
[49] R. Gómez-de Diego, Indications and contraindications of dental implants in medically compromised patients: update, Medicina oral, patologia oral y cirugia bucal 19(5) (2014) e483.
[50] E. van Duinkerken, A.M.A. Brands, Neurocognitive Functioning in Type 1 and Type 2 Diabetes Mellitus, in: A.M. Delamater, D.G. Marrero (Eds.), Be-hav-ioral Diabetes: Social Ecological Perspectives for Pediatric and Adult Popula-tions, Springer International Publishing, Cham, 2020, pp. 365-380.
[51] J. Dissemond, Peripheral Occlusive Arterial Disease, in: G. Plewig, L. French, T. Ruzicka, R. Kaufmann, M. Hertl (Eds.), Braun-Falco´s Dermatology, Springer Berlin Heidelberg, Berlin, Heidelberg, 2020, pp. 1-10.
[52] M. Karvani, P. Simos, S. Stavrakaki, D. Kapoukranidou, Neurocognitive im-pairment in type 2 diabetes mellitus, Hormones 18(4) (2019) 523-534.
[53] G. Sharma, M.U. Ashhar, V. Aeri, D.P. Katare, Development and charac-

teri-zation of late-stage diabetes mellitus and -associated vascular complications, Life Sciences 216 (2019) 295-304.
[54] S. Kolahian, V. Leiss, B. Nürnberg, Diabetic lung disease: fact or fiction?, Reviews in Endocrine and Metabolic Disorders 20(3) (2019) 303-319.
[55] D. Cabanillas-Balsera, J. Martín-González, P. Montero-Miralles, B. Sán-chez-Domínguez, M.C. Jiménez-Sánchez, J.J. Segura-Egea, Association between diabetes and nonretention of root filled teeth: a systematic review and meta-analy-sis, International Endodontic Journal 52(3) (2019) 297-306.
[56] V. Nagendrababu, J.J. Segura-Egea, A.F. Fouad, S.J. Pulikkotil, P.M.H. Dummer, Association between diabetes and the outcome of root canal treatment in adults: an umbrella review, International Endodontic Journal 53(4) (2020) 455-466.
[57] A. Ghadiri-Anari, N. Hazar, M. Jalili Sadrabad, S. Kharazmi, K. Kheirollahi, A. Mohiti, N. Namiranian, Comparing the frequency of some oral lesions in pre-diabetic and healthy individuals: Is there any difference?, International Journal of Preventive Medicine 10(1) (2019) 177-177.
[58] S. Halimi, J.P. Brun, Peut-on poser des implants dentaires chez les patients diabétiques ?, Médecine des Maladies Métaboliques 12(4) (2018) 333-339.
[59] D. Popa, R.I. Juncar, M. Juncar, Histological Analysis of the Mandible in Patients with Type 2 Diabetes Mellitus for Implant-Prosthetic Rehabilitation. A Pilot Case-Control Study, American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS) 61(1) (2019) 54-60.
[60] A.H. Almehmadi, Awareness of population regarding the effects of diabetes on dental implant treatment in Jeddah, Saudi Arabia, Heliyon 5(9) (2019) e02407.
[61] P. Barrionuevo, G.H. Giambartolomei, Inhibition of antigen presentation by Brucella: many more than many ways, Microbes and Infection 21(3) (2019) 136-142.
[62] Y. Suzuki, The immune system utilizes two distinct effector mechanisms of T cells depending on two different life cycle stages of a single pathogen, Toxo-plas-ma gondii, to control its cerebral infection, Parasitology International 76 (2020) 102030.
[63] K.B. Arnold, G.L. Szeto, G. Alter, D.J. Irvine, D.A. Lauffenburger, CD4<-sup>+</sup> T cell–dependent and CD4⁺ T cell–independent cytokine-chemokine network changes in the immune responses of HIV-infected individuals, Science Signaling 8(399) (2015) ra104.
[64] M.T. Goupil, C. Niekrash, Surgical complications in dentistry, Clinical Dentistry Reviewed 4(1) (2020) 3.
[65] D. Lauritano, G. Moreo, L. Oberti, A. Lucchese, D. Di Stasio, M. Conese, F. Carinci, Oral Manifestations in HIV-Positive Children: A Systematic Review, Pathogens 9(2) (2020) 88.
[66] L.T. Odono, C.M. Brady, M. Urata, 1.14 - Mandible Fractures, in: A.H. Doraf-shar, E.D. Rodriguez, P.N. Manson (Eds.), Facial Trauma Surgery, Content Repo-si-tory Only!, London, 2020, pp. 168-185.
[67] A. Bonito, L. Palton, D. Shugars, K. Lohr, J. Nelson, J. Bader, A. Jackman, Management of dental patients who are HIV-positive: complications, (2019).
[68] M.C. Sloniak, S.R.B. Todero, L.A. Lyra, E.B. Fontana, P.S. Batista, A.A.S. de Lima, Dental extraction in patients with HIV/AIDS: report of two cases, RSBO 16(1) (2019) 51-56.
[69] J. Ata-Ali, F. Ata-Ali, N. Di-Benedetto, L. Bagán, J.-V. Bagán, Does HIV in-fection have an impact upon dental implant osseointegration? A systematic review, Medicina oral, patologia oral y cirugia bucal 20(3) (2015) e347.
[70] F. Vidal, R. Vidal, J. Bochnia, R.C. de Souza, L.S. Gonçalves, Dental implants and bone augmentation in HIV-infected patients under HAART: Case report and review of the literature, Special Care in Dentistry 37(3) (2017) 150-155.
[71] C. Gay-Escoda, D. Pérez-Álvarez, O. Camps-Font, R. Figueiredo, Long-term outcomes of oral rehabilitation with dental implants in HIV-positive patients: A retrospective case series, Medicina oral, patologia oral y cirugia bucal 21(3) (2016) e385.
[72] R. Naseri, J. Yaghini, A. Feizi, Levels of smoking and dental implants failure: A systematic review and meta-analysis, Journal of Clinical Periodontology 47(4) (2020) 518-528.
[73] S.Ş. Güven, F. Cabbar, N. Güler, Local and systemic factors associated with marginal bone loss around dental implants: a retrospective clinical study, Quintes-sence Int 51(2) (2020) 128-41.
[74] F. Zuffetti, L. Testarelli, P. Bertani, S. Vassilopoulos, T. Testori, R. Guarnieri, A Retrospective Multicenter Study on Short Implants With a Laser-Microgrooved Collar (≤7.5 mm) in Posterior Edentulous Areas: Radiographic and Clinical Results up to 3 to 5 Years, Journal of Oral and Maxillofacial Surgery 78(2) (2020) 217-227.
[75] S. Attia, C. Narberhaus, H. Schaaf, P. Streckbein, J. Pons-Kühnemann, C. Schmitt, F.W. Neukam, H.-P. Howaldt, S. Böttger, Long-Term Influence of Platelet-Rich Plasma (PRP) on Dental Implants after Maxillary Augmentation: Implant Survival and Success Rates, Journal of Clinical Medicine 9(2) (2020) 391.
[76] S. Uppala, A.S. Parihar, V. Modipalle, L. Manual, V.M. Oommen, P. Kar-adiguddi, P. Gupta, Crestal bone loss around dental implants after implantation of Tricalcium phosphate and Platelet-Rich Plasma: A comparative study, Journal of Family Medicine and Primary Care 9(1) (2020) 229.
[77] J.V.d.S. Canellas, R.C. da Costa, R.C. Breves, G.P. de Oliveira, C.M.d.S. Figueredo, R.G. Fischer, A.A. Thole, P.J.D.A. Medeiros, F.G. Ritto, Tomographic and histomorphometric evaluation of socket healing after tooth extraction using leukocyte- and platelet-rich fibrin: A randomized, single-blind, controlled clinical trial, Journal of Cranio-Maxillofacial Surgery 48(1) (2020) 24-32.
[78] L. Van Doorne, L. De Kock, A. De Moor, R. Shtino, E. Bronkhorst, G. Meijer, H. De Bruyn, Flaplessly placed 2.4-mm mini-implants for maxillary overdentures: a prospective multicentre clinical cohort study, International Journal of Oral and Maxillofacial Surgery 49(3) (2020) 384-391.
[79] A. Truschnegg, P. Rugani, B. Kirnbauer, L. Kqiku, N. Jakse, R. Kirmeier, Long-term Follow-up for Apical Microsurgery of Teeth with Core and Post Resto-rations, Journal of Endodontics 46(2) (2020) 178-183.
[80] X.-f. Zheng, A.-c. Mo, Immune System-Related Diseases and Dental Implant Treatment, in: Q. Yuan (Ed.), Dental Implant Treatment in Medically Compro-mised Patients, Springer International Publishing, Cham, 2020, pp. 129-147.
[81] D. Zhao, Q.-c. Xiong, S. Ono, Y. Ninomiya, M. Takechi, Organ Diseases and Dental Implant Treatment, in: Q. Yuan (Ed.), Dental Implant Treatment in Medi-cally Compromised Patients, Springer International Publishing, Cham, 2020, pp. 37-72.
[82] A. Parihar, S. Madhuri, R. Devanna, G. Sharma, R. Singh, K. Shetty, Assess-ment of failure rate of dental implants in medically compromised patients, Journal of Family Medicine and Primary Care 9(2) (2020) 883-885.
[83] J. Nazeer, R. Singh, P. Suri, C. Mouneshkumar, S. Bhardwaj, M. Iqubal, D. , Evaluation of marginal bone loss around dental implants in cigarette smokers and nonsmokers. A comparative study, Journal of Family Medicine and Primary Care 9(2) (2020) 729-734.
[84] J. D'Haese, H. De Bruyn, Effect of Smoking Habits on Accuracy of Implant Placement Using Mucosally Supported Stereolithographic Surgical Guides, Clini-cal Implant Dentistry and Related Research 15(3) (2013) 402-411.
[85] S. Shenava, P. Singh, C.S. Babu, V. Kumar, B. Jyoti, S. Sharma, Co-relation between smoking and bone healing around dental impants: A clinical study, Journal of International Oral Health 8(2) (2016) 199.
[86] J.D. Chetwood, P. Garg, P. Finch, M. Gordon, Systematic review: the etiology of esophageal squamous cell carcinoma in low-income settings, Expert Review of Gastroenterology & Hepatology 13(1) (2019) 71-88.
[87] I.E. Williams, D.R. Betterton, P.T. Davis, T.P. Ronaldson, Transporter-Medi-ated Delivery of Small Molecule Drugs to the Brain: A Critical Mechanism That Can Advance Therapeutic Development for Ischemic Stroke, Pharmaceutics 12(2) (2020) 154.
[88] E.G. Xu, W.H. Richardot, S. Li, L. Buruaem, H.-H. Wei, N.G. Dodder, S.F. Schick, T. Novotny, D. Schlenk, R.M. Gersberg, E. Hoh, Assessing Toxicity and in Vitro Bioactivity of Smoked Cigarette Leachate Using Cell-Based Assays and Chemical Analysis, Chemical Research in Toxicology 32(8) (2019) 1670-1679.
[89] H.A. Alhazmi, A. Khalid, S. Sultana, S.I. Abdelwahab, W. Ahsan, M.E. Ora-iby, M.A. Bratty, Determination of Phytocomponents of Twenty-one Varieties of Smokeless Tobacco using Gas Chromatography-Mass Spectroscopy (GC-MS), South African Journal of Chemistry 72 (2019) 47-54.
[90] D.H. Nguyen, Y.-C. Liao, Y.-S. Ho, L.-C. Chen, H.-W. Chang, T.-C. Cheng, D. Liu, W.-R. Lee, S.-C. Shen, C.-H. Wu, S.-H. Tu, The α9 Nicotinic Acetylcholine Receptor Mediates Nicotine-Induced PD-L1 Expression and Regulates Melanoma Cell Proliferation and Migration, Cancers 11(12) (2019) 1991.
[91] B.R. Chrcanovic, T. Albrektsson, A. Wennerberg, Smoking and dental implants: A systematic review and meta-analysis, Journal of Dentistry 43(5) (2015) 487-498.
[92] J. Meyle, P. Casado, I. Fourmousis, P. Kumar, M. Quirynen, G.E. Salvi, General genetic and acquired risk factors, and prevalence of peri-implant diseases – Consensus report of working group 1, International Dental Journal 69(S2) (2019) 3-6.
[93] F.V. Ribeiro, S.P. Pimentel, M.G. Corrêa, J.P. Bortoli, M.R. Messora, M.Z. Casati, Resveratrol reverses the negative effect of smoking on peri-implant repair in the tibia of rats, Clinical Oral Implants Research 30(1) (2019) 1-10.
[94] L. Xiang, Y.-q. Chen, Q. Yuan, Medically Compromised Patients: A Biologi-cal and Social Challenge, in: Q. Yuan (Ed.), Dental Implant Treatment in Medically Compromised Patients, Springer International Publishing, Cham, 2020, pp. 11-20.
[95] J.D. Bezerra Ferreira, J.A. Rodrigues, A. Piattelli, G. Iezzi, S.A. Gehrke, J.A. Shibli, The effect of cigarette smoking on early osseointegration of dental

implants: a prospective controlled study, Clinical Oral Implants Research 27(9) (2016) 1123-1128.
[96] J.M.d. Campos, A.J. Prati, F.R. Cirano, S.P. Pimentel, G.P. Pastore, V.G. Pec-orari, F.V. Ribeiro, M.Z. Casati, R.C.V. Casarin, Smoking Modulates Gene Expres-sion of Type I Collagen, Bone Sialoprotein, and Osteocalcin in Human Alveolar Bone, Journal of Oral and Maxillofacial Surgery 73(11) (2015) 2123-2131.
[97] K. Hemani, D. Ganapathy, V. Ramanathan, Factors contributing to peri-im-plantitis-A practitioner's perspective, Drug Invention Today 12(5) (2019).
[98] G. Iezzi, A. Piattelli, A. Scarano, M. Degidi, J.A. Shibli, C. Mangano, V. Per-rotti, Histological Evaluation of Early and Immediately Loaded Implants Retrieved from Human Jaws, in: M. Peñarrocha-Diago, U. Covani, L. Cuadrado (Eds.), Atlas of Immediate Dental Implant Loading, Springer International Publishing, Cham, 2019, pp. 29-47.
[99] L. Romito, Perioperative Management of the Tobacco User, in: E.M. Ferneini, J.D. Bennett (Eds.), Perioperative Assessment of the Maxillofacial Surgery Patient: Problem-based Patient Management, Springer International Publishing, Cham, 2018, pp. 345-358.
[100] C. Sun, J. Zhao, C. Jianghao, T. Hong, Effect of heavy smoking on dental implants placed in male patients posterior mandibles: A prospective clinical study, Journal of Oral Implantology 42(6) (2016) 477-483.
[101] M.T.A. Omran, D.D. Miley, D.E. McLeod, M.N. Garcia, Retrospective As-sessment of Survival Rate for Short Endosseous Dental Implants, Implant Dentist-ry 24(2) (2015) 185-191.
[102] B. Shugaa-Addin, H.-M. Al-Shamiri, S. Al-Maweri, B. Tarakji, The effect of radiotherapy on survival of dental implants in head and neck cancer patients, Journal of clinical and experimental dentistry 8(2) (2016) e194.
[103] M. Mancha de la Plata, L.N. Gías, P.M. Díez, M. Muñoz-Guerra, R. González-García, G.-Y.C. Lee, S. Castrejón-Castrejón, F.J. Rodríguez-Campo, Osseointegrated Implant Rehabilitation of Irradiated Oral Cancer Patients, Journal of Oral and Maxillofacial Surgery 70(5) (2012) 1052-1063.
[104] G. Granström, M. Jacobsson, A. Tjellström, Titanium implants in irradiated tissue: benefits from hyperbaric oxygen, International Journal of Oral & Maxillo-facial Implants 7(1) (1992).
[105] C. Yingguang, T. Weischer, Comparison of maxillary implant-supported prosthesis in irradiated and non-irradiated patients, Journal of Huazhong Universi-ty of Science and Technology [Medical Sciences] 23(2) (2003) 209-212.
[106] F. Javed, K. Al-Hezaimi, A. Al-Rasheed, K. Almas, G.E. Romanos, Implant survival rate after oral cancer therapy: A review, Oral Oncology 46(12) (2010) 854-859.
[107] M.P. Claudy, S.A.Q. Miguens Jr, R.K. Celeste, R. Camara Parente, P.A.G. Hernandez, A.N. da Silva Jr, Time Interval after Radiotherapy and Dental Implant Failure: Systematic Review of Observational Studies and Meta-Analysis, Clinical Implant Dentistry and Related Research 17(2) (2015) 402-411.
[108] T. Ettl, J. Weindler, M. Gosau, S. Müller, M. Hautmann, F. Zeman, M. Koller, D. Papavasileiou, R. Bürgers, O. Driemel, I. Schneider, C. Klingelhöffer, J. Meier, U. Wahlmann, T.E. Reichert, Impact of radiotherapy on implant-based prosthetic rehabilitation in patients with head and neck cancer: A prospective observational study on implant survival and quality of life—Preliminary results, Journal of Cra-nio-Maxillofacial Surgery 44(9) (2016) 1453-1462.
[109] A. Korfage, G.M. Raghoebar, J.J.R.H. Slater, J.L.N. Roodenburg, M.J.H. Witjes, A. Vissink, H. Reintsema, Overdentures on primary mandibular implants in patients with oral cancer: a follow-up study over 14 years, British Journal of Oral and Maxillofacial Surgery 52(9) (2014) 798-805.
[110] I. Macías, N. Alcorta-Sevillano, I.C. Rodríguez, A. Infante, Osteoporosis and the Potential of Cell-Based Therapeutic Strategies, International Journal of Molecular Sciences 21(5) (2020) 1653.
[111] Y.-c. Guo, Q. Yuan, Bone Diseases and Dental Implant Treatment, in: Q. Yuan (Ed.), Dental Implant Treatment in Medically Compromised Patients, Springer International Publishing, Cham, 2020, pp. 73-101.
[112] Y. Zhou, C. Xu, W. Zhu, H. He, L. Zhang, B. Tang, Y. Zeng, Q. Tian, H.-W. Deng, Long Noncoding RNA Analyses for Osteoporosis Risk in Caucasian Women, Calcified Tissue International 105(2) (2019) 183-192.
[113] T. Gupta, N. Das, S. Imran, The Prevention and Therapy of Osteoporosis: A Review on Emerging Trends from Hormonal Therapy to Synthetic Drugs to Plant-Based Bioactives, Journal of Dietary Supplements 16(6) (2019) 699-713.
[114] N.N. Younes, Genome-Wide Association Study (Gwas) To Uncover Genetic Risk Factors Associated With Low Bone Mineral Density And Osteoporosis In Qatar Population, (2019).
[115] P. Locantore, V. Del Gatto, S. Gelli, R.M. Paragliola, A. Pontecorvi, The Interplay between Immune System and Microbiota in Osteoporosis, Mediators of Inflammation 2020 (2020) 3686749.
[116] F.C.F.L. de Medeiros, G.A.H. Kudo, B.G. Leme, P.P. Saraiva, F.R. Verri, H.M. Honório, E.P. Pellizzer, J.F. Santiago Junior, Dental implants in patients with osteoporosis: a systematic review with meta-analysis, International Journal of Oral and Maxillofacial Surgery 47(4) (2018) 480-491.
[117] A.Y. Alqutaibi, I.A.-E. Radi, No Clear Evidence Regarding the Effect of Os-teoporosis on Dental Implant Failure, Journal of Evidence Based Dental Practice 16(2) (2016) 124-126.
[118] R. Niedermaier, F. Stelzle, M. Riemann, W. Bolz, P. Schuh, H. Wachtel, Implant-Supported Immediately Loaded Fixed Full-Arch Dentures: Evaluation of Implant Survival Rates in a Case Cohort of up to 7 Years, Clinical Implant Dentist-ry and Related Research 19(1) (2017) 4-19.
[119] G. Alsaadi, M. Quirynen, A. Komárek, D. Van Steenberghe, Impact of local and systemic factors on the incidence of oral implant failures, up to abutment con-nection, Journal of Clinical Periodontology 34(7) (2007) 610-617.
[120] J. Liu, Z. Wu, H. He, K. Cai, H. Zhang, L. Xu, Gallium and silicon syner-gistically promote osseointegration of dental implant in patients with osteoporosis, Medical Hypotheses 103 (2017) 35-38.