

## Dental Implant Survival: A Literature Review

Janice Diaz-Rodriguez<sup>1</sup>, Robin Weltman<sup>1</sup>, Duong T Tran<sup>2</sup>, Lawrence Friedman<sup>1</sup> and Isabel C Gay<sup>3\*</sup>

<sup>1</sup>Department of Periodontics and Dental Hygiene, University of Texas, USA

<sup>2</sup>Department of Diagnostic and Biomedical Sciences, University of Texas, USA

<sup>3</sup>Division Director of Periodontics, East Carolina University, School of Dental Medicine, USA

**\*Corresponding Author:** Isabel C Gay, Division Director of Periodontics, East Carolina University, School of Dental Medicine, 1851, MacGregor Downs Rd, Greenville NC 27858, USA.

**Received:** June 24, 2015; **Published:** October 08, 2015

### Abstract

Tooth loss amongst adults can be a catastrophic event; the inability to properly masticate can lead to gastric disease and malnutrition. Facial collapse promoted by the missing bone structure contributes significantly to lack of self-esteem which may in turn; contribute to a decreased quality of life. Dentistry has been able to overcome this oral deterioration through the use of dental implants and proper prosthetic appliances. The objective of this literature search was to perform a narrative review of potential risk factors associated with implant loss such as: tobacco use, professional maintenance therapy, diabetes mellitus, implant surface characteristics, length and diameter of implants, bone density, bone graft procedure, age and osteoporosis. Relevant papers for this review were identified by a search of computerized databases and journals. Some factors associated with dental implant loss were consistently identified in the literature such as smoking and professional maintenance therapy; unfortunately some still remain controversial; further research is mandated to elucidate their role.

The total edentulism rate in the United States adult population is approximately 18 million people. In 45- to 54-year old patients, 31.3% have mandibular free-end edentulism, while 13.6% have free-end maxillary edentulism [1]. Among different alternatives for teeth replacement, dental implants have become a preferred treatment option. Augusti, *et al.* [2] evaluated the preference of a patient population, according to the willingness to pay for restoration of a single-tooth gap with either an implant-supported crown (ISC) or a 3-unit fixed partial denture prosthesis (FPDP) on natural teeth. Sixty-four percent of the patients expressed a preference for the implant-supported crown, while the remaining 36% of the population chose the fixed partial denture prostheses.

Published literature has reported favorable short term and long-term survival rates for implants. The term "survival rate" refers to whether the implant is still physically in the mouth or has been removed [3]. In a systematic review, based on 23 prospective studies including 1312 dental implants, the 5-year implant survival rate was estimated to be 97.7%; and based on four prospective studies including 124 implants; the 10-year implant survival rate was estimated to be 94.9% [4]. Other studies showed 10-year survival rates of more than 97% for implants replacing single missing teeth [5,6].

Because of the importance of implants in restorative dentistry, studies of new technology, techniques, and risk factors are being conducted to improve implant survival. This paper aimed at critically reviewing the current literature on risk factors associated with implant failures.

**Keywords:** Dental implants; Proper prosthetic appliances; Survival rate; Periodontitis; Peri-implantitis; Implant Survival

### Literature Search

Relevant papers for this review were identified by a search of computerized databases using the key words “dental implant”, “risk factors”, “survival rate”, and “failure”. A manual search was conducted in journals where articles on the risk factors of dental implants failure were found such as: *Clinical Oral Implants Research*, *Implant Dentistry*, *Journal of Clinical Periodontology*, *Journal of Periodontology*, *Journal of Dental Research*, *International Journal of Oral & Maxillofacial Implants*, *International Journal of Periodontics & Restorative Dentistry*, *Journal of Prosthodontics*, *Journal of Oral and Maxillofacial Surgery*, *Periodontology 2000*, *Annals of Periodontology*, *Clinical Implant Dentistry and Related Research*.

### Implant Survival: Smoking

Among the risk factors of implant failure, smoking was the one that is modifiable. According to the CDC, an estimated 42.1 million people, or 18.1% of all adults in the United States smoke cigarettes [7]. The detrimental systemic effects of smoking have been well documented. Smoking has been well established as a risk factor for periodontitis and as the second strongest of the modifiable risk factors, the first being bacterial plaque [8]. The negative effects of smoking on the periodontium have been attributed to decreased immunoglobulin G2 production, chronic reduction in blood flow and vascularity, increased prevalence of periodontal pathogens, shift in neutrophil function towards destructive activities, negative effects on cytokine and growth. Johnson, *et al.* [9] mentioned in her review article that implants placed in cigarette smoking individuals have shown approximately twice the failure rate based on a variety of implant designs and surfaces. In addition to the increased implant failure rates in smokers, Rodriguez-Argueta, *et al.* reported that smokers had an increased risk of complications such as infection (2 cases), peri-implantitis (70 cases), implant loss (32 cases) and mucositis (105 cases), compared to nonsmoking patients [10].

In 2008 a systematic review [11] that included implant placement in individuals with diabetes (4 articles), smokers (19 articles), and treated periodontitis (13 articles), showed that implant survival and success rates were statistically superior in non-smokers when compared to smokers. The survival rate differences were even greater when considering implant placement in trabecular bone. No significant difference was found for the other risk factors. Similar results have been found in other studies [12,13].

The amount of cigarettes smoked daily has been shown to influence implant survival. A case series study by Sanchez-Perez analyzed 66 patients that received a total of 165 implants over a period of 5 years and divided them into smokers and non-smokers [14]. The smokers were classified as light, moderate or heavy smokers. They found that the success rates were 84% for smokers and 98.6% for non-smokers. They also found that among smokers, heavy smokers had more than twice a risk for implant failure than light or moderate smokers. Non-smokers only had one failure.

Since it is not always realistic to expect individuals to abandon their smoking habits, a protocol for smokers undergoing implant surgery was proposed. Bain and Moy reported the outcome of 2,194 Brånemark implants placed in 540 patients over a 6 year period [15]. Smokers had a significantly greater percentage of failures (11.28%) compared with nonsmokers (4.76%). The authors proposed that individuals interested in implant retained restorations should cease smoking at least 1 week prior to surgery and 8 weeks after implant placement allowing time for bone healing and early osseointegration.

### Implant Survival: Maintenance

Maintenance of implant restorations is crucial because most causes of implant failure, after implant loading, can be identified, corrected or prevented by a regular maintenance program and monitoring of the implant restoration. Some causes of implant failure include inflammation due to bacterial plaque accumulation, occlusal discrepancies or iatrogenic factors such as residual excess cement. Wilson, *et al.* studied the relationship between excess dental cement and peri-implant disease using the dental endoscope [16]. Thirty-nine patients with peri-implantitis were studied. Twelve of these patients had similar implants without signs of inflammation; these implants served as controls. Twenty control implants, i.e. no peri-implantitis, and 42 test implants were evaluated over a 30-day follow-up period. The authors found excess cement in 81% of the test sites and in no cement within the sulci of the control implants. Thirty days after cement removal, 74% of the test sites from which the cement was removed had no clinical or endoscopic signs of peri-implant disease.

Oliveira, *et al.* followed 212 partially edentulous patients who received dental implants over a 5 year period [17]. Eighty individuals were diagnosed with mucositis (inflammation in the gingival tissues surrounding the implant restoration with no bone loss around the implant body) at the baseline examination. These individuals were divided into two groups: one group with preventive maintenance during the study period (n = 39), and another group without preventive maintenance (n = 41). Plaque index, bleeding on periodontal and peri-implant probing, periodontal and peri-implant probing depths, suppuration and peri-implant bone loss were monitored. Over the five year period, the incidence of peri-implantitis (inflammation in the surrounding gingival tissues along with bone loss around the implant body) when both groups were included was 31.2%. The incidence of peri-implantitis was 18% in the group with preventive maintenance, and 43.9% in the group without preventive maintenance. In this study, the absence of preventive maintenance in individuals with pre-existing peri-implant mucositis was associated with a high incidence of peri-implantitis. Clinical parameters, such as bleeding on peri-implant probing, periodontal probing depth and the presence of periodontitis were associated with a higher risk of developing peri-implantitis.

Similar results were found in a 10-year retrospective study by Anner, *et al.* [18] Data were collected from 475 patient files with regards to smoking habits, periodontal condition, diabetes mellitus, implant survival, and time when implant failure occurred. Patients were divided into those who participated in a supportive periodontal program in the clinic and those who only attended the annual free-of-charge implant examination. Seventy-seven out of 1626 implants (4.7%) were lost in 58 patients after a mean period of 2 years. Fifty-seven percent of these patients participated in a structured supportive periodontal program in the clinic, and 48.3% only attended the annual free of charge implant examination. Smoking habits and attendance in a regular supportive periodontal program were statistically associated with implant survival. Twice as many implants failed in smokers compared to non-smoker, as well as in patients who did not participate in a regular maintenance program compared to individuals who participated in a structured supportive periodontal maintenance program. Patients with (treated) moderate-to-advanced chronic periodontal disease demonstrated higher implant failure rates but, this difference did not reach statistical significance. Diabetes mellitus was not related to implant survival in this patient cohort. Smoking and attendance to a regular supportive periodontal program were strongly related to implant survival. Special attention should be given to continuous periodontal supportive programs to implant patients.

As stated above, plaque accumulation around implant prostheses leads to an inflammatory reaction which results in a reversible peri-implant mucositis or a condition which results in loss of bone support around the implant, peri-implantitis. Inability or inaccessibility of oral hygiene practices, along with lack of regular professional periodontal maintenance supports plaque accumulation and may promote peri-implant inflammatory conditions which could ultimately cause implant failure.

Supporting the concept of accessibility to plaque control, a 2009 study evaluated 23 patients who were treated for peri-implantitis [19]. The patients were categorized into groups: Periodontitis/No periodontitis, Bone loss/No bone loss around teeth, Smoker/Non-smokers. The majority of patients (13) had minimal bone loss around their teeth and no current periodontitis. Six patients were smokers. Periodontal evaluation of the dentitions found that only 6% of the 281 teeth present had associated periodontal pockets measuring 6 mm or more, compared to 53% of the 109 implants. Seventy-four percent of the implants were stated to have no accessibility to proper oral hygiene. A high proportion of implants diagnosed with peri-implantitis (48%) were associated with no accessibility or capability for appropriate oral hygiene measures. Only 4% of the implants with adequate accessibility or capability for appropriate oral hygiene measures were diagnosed with peri-implantitis.

### Implant Survival: Diabetes Mellitus

Diabetes mellitus is one of the world's major chronic health problems. In the United States alone, this metabolic disorder affects an estimated 15.7 million individuals, 5.9% of the population [20]. Diabetes mellitus is a metabolic disorder resulting from defective secretion or lack of sensitivity to insulin leading to an increase of glucose circulating in the bloodstream, or hyperglycemia. According to the American Diabetes Association, there are three types of diabetes: Type 1, Type 2, and gestational diabetes [21].

Type 1 diabetes mellitus is caused by an autoimmune destruction of the beta- cells in the islets of Langerhans of the pancreas leading to an insulin deficiency. Only approximately 10% of the patients with DM have type 1 diabetes and the remaining 90% have type 2 diabetes mellitus [21]. The patient with type 1 diabetes must rely on insulin medication and close dietary control for survival. Type 2 diabetes is caused by a lack of sensitivity to insulin by the cells of the body, particularly fat and muscle cells. An increased insulin production occurs as a compensatory mechanism attempting for the cells to be able to recognize and use insulin. Gestational diabetes mellitus (GDM) is glucose intolerance that begins during pregnancy. Although dental implants may have enhanced functional and esthetic outcomes over other types of restorations, their use has some relative or absolute contraindications, such as certain systemic illnesses. The long term maintenance of osseointegration depends on physiological bone remodeling, which has been reported to be altered in diabetic patients. It has been demonstrated that diabetes decreases the rate of bone formation and alters bone remodeling due to advanced glycosylation end products [22].

A retrospective study of dental implants in diabetic patients was published by Fiorellini, *et al.* [23] Two hundred fifteen implants were placed in 40 patients with diabetes. The overall success rate was 85.6%. It was found that the survival rate of implants in controlled diabetic patients was lower than that documented for the general population. The increase in failure rate occurred during the first year following prosthetic loading.

Similar to the previous study, in a prospective study of 178 implants placed in 89 well-controlled type 2 diabetics, the survival rate was 92.7% within the first year of functional loading, while the 5-year survival rate was 90% [24]. The authors suggested that the diminished vascularization associated with diabetes could lead to a diminished bone remodeling, explaining implant failure in diabetic patients.

A 1999 Fiorellini *et al.* study utilized a diabetic rat model to study the influence of insulin on osseointegration [25]. The authors found that when insulin was administered in the diabetic rat, bone formation was up regulated. However, the percentage of marrow bone to implant contact was lower in the insulin controlled group when compared to non-diabetic rats. Newly formed bone around implants that is immature and less organized has also been reported in other diabetic animal studies [26]. Reduced bone formation in individuals with diabetes has been also reported by other investigators such as Kotsovilis, *et al.* [27] and He, *et al.* [22].

A 2014 systematic review and meta-analysis conducted by Chrcanovic, *et al.* investigated the effects of diabetes mellitus on implant failure rates and marginal bone loss [28]. Fourteen studies were included. Statistically significant more marginal bone loss was found in individuals with diabetes compared to non-diabetic individuals, but no difference in failure rates.

Aside from the metabolic effects on bone homeostasis, the systemic effects of hyperglycemia influence collagen production, turnover, and tensile strength. Additionally, an increased production of collagenase occurs, which deteriorates collagen molecules. While collagen production and stability plays a role in establishing osseointegration, several studies have reported similar implant survival rates in diabetic individuals with well-controlled blood glucose levels as compared to non-diabetic individuals. In a 2009 systematic review of 18 articles published from 1982 to 2009, poorly controlled blood glucose negatively affected implant osseointegration [29]. However, under optimal glycemic control, osseointegration was found to be successful in diabetic patients. Similar results have been found in other studies [30,31]. A study by Balshi, *et al.* supported this concept following 227 Branemark implants placed in 34 well-controlled diabetic patients from 1987 to 1998 [20]. At the time of second-stage surgery, 214 of the implants had osseointegrated, yielding a survival rate of 94.3%. Only one failure was identified among the 177 implants followed through final restoration, a clinical survival rate of 99.9%. The authors concluded that success of dental implants in well and fairly controlled diabetic patients is comparable to that of non-diabetic patients. They also stated that the successful results were not only due to controlled diabetes but to prophylactic remedies and adequate postsurgical maintenance.

### Implant Survival: Implant Surface Characteristics

Dental implants have been a feasible treatment option since the 1960s. Transosseous implants were introduced in 1968. Today, many manufacturers produce root form, endosseous dental implants composed of titanium with varying dimensions and proprietary surface treatments. Implant surfaces vary in their structural and chemical compositions which aim to enhance the biologic response.

**Citation:** Isabel C Gay, *et al.* "Dental Implant Survival: A Literature Review". *EC Dental Science* 2.5 (2015): 385-393.

Surface treatments include sandblasted, acid etched, anodized, laser-modified, and calcium phosphate coatings. A systematic review by Esposito, *et al.* [32] stated that more than 1,300 different implants are available. Comparison of the failure rates of 38 different types of implants with different surface characteristics, shapes, and materials, did not find significant evidence from trials to demonstrate the superiority of any particular type of implant characteristic or implant system over another. There was no evidence showing that any particular type of dental implant had greater long-term success.

### Implant Survival: Short and Narrow Implants

A 2009 systematic review and meta-analysis evaluated the survival of short ( $\leq 8$  or  $<10$  mm) and conventional ( $\geq 10$  mm) rough-surface dental implants [33]. Three hundred articles were examined, and 37 articles reporting on 22 patient cohorts were selected for analysis. No statistically significant differences in survival rates were found between the short ( $\leq 8$  or  $<10$  mm) and conventional ( $\geq 10$  mm) rough-surface implants placed in totally or partially edentulous patients.

Similar findings were reported by Klein, *et al* relating to narrow diameter implants [34]. This systematic review evaluated implants placed from 1995 to 2012. Implant diameters were divided into 3 categories: 1 ( $< 3.0$  mm), 2 (3.00 to 3.25 mm), and 3 (3.30 to 3.50 mm). Dental implants  $< 3.0$  mm (mini-implants) had survival rates between 90.9% and 100%. For dental implants with a diameter between 3.0 and 3.25 mm, the survival rates ranged between 93.8% and 100%. The survival rates of implants of 3.3 to 3.5 were between 88.9% and 100%, and success rates ranged between 91.4% and 97.6%. They found no statistically significant difference in implant survival compared to conventional implants with an odds ratio of 1.16. A 2006 review which included 53 human studies from 1990-2005, corroborated these findings [35]. The authors stated that the survival rates for short and for wide-diameter implants have been found to be comparable with those obtained with longer implants and those of a standard diameter. They explained that the failures encountered were associated with operators' learning curves, the use of machined-surfaced implants, and the placement in sites with poor bone density.

### Implant Survival: Bone density

Survival rates based on bone density have been previously reported by Jaffin and colleagues [36]. In a five year analysis of 1,054 implants, the authors found a 3% failure rate when implants were placed in types 1, 2 and 3 bone, compared to a 35% failure rate when placed in type 4 bone. They concluded that implants placed in the posterior maxilla are less well supported compared to implants placed in the anterior mandible.

Misch [37] described four bone densities found in the anterior and posterior edentulous regions of the maxilla and mandible. D1 bone is primarily dense cortical bone and is mostly seen in the anterior mandible. D2 bone has dense to thick porous cortical bone on the crest and coarse trabecular bone underneath and can be found in the anterior and posterior mandible and anterior maxilla. D3 bone has a thinner porous cortical crest and fine trabecular-bone-within and can be found in the anterior and posterior maxilla and posterior mandible. D4 bone has almost no crystal cortical bone with fine trabecular bone composing almost all of the total volume of bone and is found most frequently in the posterior maxilla.

### Implant Survival: Grafted Bone versus Native Bone

There have been few studies published which have made direct comparisons of survival rates of implants placed in grafted versus native bone. The results have been contradictory and often affected by various limitations. A systematic review [38] and three retrospective studies [39-41] found no difference between the survival of implants placed in native or augmented bone. However, these four studies limited the comparison to the posterior maxilla. A 2003 systematic review by Hammerle, *et al.* [42] compared the survival rates of implants placed at sites augmented by GBR versus native bone. No significant differences were found between implants in regenerated compared to implants in non-regenerated bone.

Other studies found differences in the survival rates of implants placed in grafted sites as compared to native bone [43-45]. Sesma, *et al.* [43] published a study evaluating survival of 988 dual acid-etched implants placed in native bone, after sinus augmentation, or after autogenous block bone grafting procedures. After following implant survival up to six years post-placement, the authors found a

significant association between dental implant failure and the presence of bone graft in the implant area. However, due to the specificity of the implant design and augmentation procedures outlined by Sesma, *et al.* [43] the results could not be applied to other types of implants and bone augmentation therapies.

Contrary to all of the above, two studies found higher implant success rates for implants placed in the grafted maxillary sinuses compared to implants placed at non-grafted posterior maxilla sites [44,45]. Olson, *et al.* explained that their results could be attributed to the use of longer implants in the grafted sites.<sup>44</sup> Shortcomings of these studies include insufficient follow up time, sample size to allow necessary statistical analyses, [45] and lack of control for confounders.

### Implant Survival: Age

Aside from bone quality and bone grafting, implant survival rates have also been associated with other factors, including patient's age. Elderly people have a slower healing response. The inflammatory response is decreased or delayed [46]. These factors added to the co morbidities that many elderly people have, could have an impact in the dental implants outcome. In a 7 year longitudinal study of 1,022 ITI implants placed in 440 patients, the lowest success rates were observed for implants placed in older patients (older than 60 years), periodontally treated patients, and completely edentulous arches [47].

However, the effect of age on implant survival was not clear in other studies [48-50]. In a 1993 study by Jemt [48], marginal bone response around the neck of the implant showed a modeling and remodeling pattern similar to that found in younger patients. Most patients had minimal post-placement problems, similar to what has been observed in younger patients. Meijer, *et al.* [49] found that after 3 years, performance of implant-supported over dentures in the mandible was equally successful in younger and older patients, both clinically and radiographically.

### Implant Survival: Osteoporosis

Implant survival and surgical risks have been questioned in post-menopausal women mostly due to the risk of osteoporosis. In the United States, according to the World Health Organization (WHO) criteria, from 13 to 18% of women aged 50 years or older have osteoporosis, and another 37 to 50% have osteopenia [51]. According to the National Osteoporosis Foundation, osteoporosis, or porous bone, is a disease characterized by low bone mass and structural deterioration of bone tissue, leading to bone fragility and an increased risk of fractures of the hip, spine, and wrist. It develops when bone resorption occurs too quickly or when replacement occurs too slowly. According to the Lekholm and Zarb classification [52], osteoporotic bone is characterized as type IV bone. Some studies have found a decreased implant survival in type IV bone due to decreased initial implant stability.

A review by Tsolaki, *et al.* of 39 studies, including animal and human studies, found that there were lower osseointegration rates in osteoporotic/osteopenia bone than in normal bone [53]. The authors suggested that even though implants are not contraindicated in osteoporotic patients, the surgical technique should be adjusted and a longer healing period provided so that successful osseointegration can be achieved. They suggested placing the implant with the osteotome technique to improve bone density around the implant, using smaller drills or larger diameter implants and a longer healing period.

However, other studies found no effect of osteoporosis on implant survival. A retrospective study by Holahan, *et al.* [54] showed that women with osteoporosis or osteopenia had an implant survival comparable to women without osteoporosis. Arch location and bone mineral density score did not have a statistically significant effect on implant survival rates. In a meta-analysis by Chen, *et al.* [55], fifty-one studies were included with more than 40,000 dental implants placed. The influence of osteoporosis on the risk of dental implant failure was direct but not significant. In a retrospective study of a 12-year cumulative survival rate of 164 dental implants placed in 37 individuals diagnosed with osteoporosis or osteopenia. [56], high survival rates were found, 95.45% (osteopenia) and 98.59% (osteoporosis). A high cumulative survival rate of the dental implants in osteoporosis patients, similar to that found in non-osteoporosis patients, indicated the possibility that placing dental implants in individuals with osteoporosis can be considered with high treatment predictability.

Bisphosphonates are used to prevent and reduce the bone resorption associated with osteoporosis. For individuals treated for osteoporosis or osteopenia, the American Association of Oral and Maxillofacial Surgeons recommends a discussion related to compromised bone healing after implant therapy, especially if the implant is placed within 3 years of bisphosphonate therapy [57]. A 2009 systematic review by Madrid, *et al.* found that no bisphosphonate related osteonecrosis of the jaw (BRONJ) occurred in patients taking oral bisphosphonates for less than 5 years, and concluded that implant placement in individuals taking bisphosphonates was safe [58]. The intake of oral bisphosphonates did not influence short term implant survival rates up to 4 years, ranging from 95 to 100%.

## Conclusion

In conclusion, some factors associated with dental implant loss were consistently identified in the literature such as smoking and professional maintenance therapy; unfortunately some still remain controversial and need more evidence from studies in the future.

## Bibliography

1. Byrne G. "Fundamentals of Implant Dentistry". First ed.; John Wiley & Sons, Inc. Publication; (2014): 4.
2. Augusti D., *et al.* "Prosthetic restoration in the single-tooth gap: patient preferences and analysis of the WTP index". *Clinical Oral Implants Research* 25.11 (2014): 1257-1264.
3. Branemark P. "Introduction to osseointegration. Tissue-Integrated Prostheses. Osseointegration in Clinical Dentistry. Quintessence Publishing Co., Chicago, (1985): 11-76.
4. Bruggenkate C., *et al.* "Success criteria in oral implantology: A review of the literature". *International Journal of Oral Implantology* 7.1 (1990): 45-51.
5. Priest G. "Single-Tooth Implants and Their Role in Preserving Remaining Teeth: A 10-Year Survival Study". *The International Journal of Oral & Maxillofacial Implants* 14.2 (1999): 81-88.
6. Misch C., *et al.* "Posterior implant single-tooth replacement and status of adjacent teeth during a 10-year period: a retrospective report". *Journal of Periodontology* 79.12 (2008): 2378-2382.
7. Jamal A., *et al.* "Current Cigarette Smoking Among Adults-United States, 2005-2013". *Morbidity and Mortality Weekly Report* 63.47 (2014): 1108-1112.
8. Van Dyke T and Dave S. "Risk Factors for Periodontitis". *Journal of the International Academy of Periodontology* 7.1 (2005): 3-7.
9. Johnson G Guthmiller J. "The impact of cigarette smoking on periodontal disease and treatment". *Periodontology* 2000 44 (2007): 178-194.
10. Rodriguez-Argueta O., *et al.* "Postoperative complications in smoking patients treated with implants: a retrospective study". *Journal of Oral and Maxillofacial Surgery* 69.8 (2011): 2152-2157.
11. Klokkevold P and Han T. "How do smoking, diabetes, and periodontitis affect outcomes of implant treatment". *The International Journal of Oral & Maxillofacial Implants* 22 (2008): 173-202.
12. Strietzel F., *et al.* "Smoking interferes with the prognosis of dental implant treatment: a systematic review and meta-analysis". *Journal of Clinical Periodontology* 34.6 (2007): 523-544.
13. Hinode D., *et al.* "Influence of smoking on osseointegrated implant failure: a meta-analysis". *Clinical Oral Implants Research* 17.4 (2006): 473-478.
14. Sanchez-Perez A., *et al.* "Tobacco as a risk factor for survival of dental implants". *Journal of Periodontology* 78.2 (2007): 351-359.
15. Bain C and Moy P. "The association between the failure of dental implants and cigarette smoking". *The International Journal of Oral & Maxillofacial Implants* 8.6 (1993): 609-615.
16. Wilson T Jr. "The positive relationship between excess cement and peri-implant disease: a prospective clinical endoscopic study". *Journal of Periodontology* 80.9 (2009): 1388-1392.
17. Oliveira F., *et al.* "Peri-implant disease in subjects with and without preventive maintenance: a 5-year follow-up". *Journal of Clinical Periodontology* 39.2 (2012): 173-181.

18. Anner R., *et al.* "Smoking, diabetes mellitus, periodontitis, and supportive periodontal treatment as factors associated with dental implant survival: a long-term retrospective evaluation of patients followed for up to 10 years". *Implant Dentistry* 19.1 (2010): 57-64.
19. Serino G and Strom C. "Peri-implantitis in partially edentulous patients: association with inadequate plaque control". *Clinical Oral Implants Research* 20.2 (2009): 169-174.
20. Balshi T and Wolfinger G. "Dental Implants in the Diabetic Patient- A Retrospective Study". *Implant Dentistry* 8.4 (1999): 355.
21. Centers for Disease Control and Prevention. National Diabetes Statistics Report: Estimates of Diabetes and Its Burden in the United States, (2014). Atlanta, GA: U.S. Department of Health and Human Services.
22. He H., *et al.* "Diabetes causes decreased osteoclastogenesis, reduced bone formation, enhanced apoptosis of osteoblastic cells in bacteria stimulated bone loss". *Endocrinology* 145.1 (2004): 447-452.
23. Fiorellini J., *et al.* "A retrospective study of dental implants in diabetic patients". *The International Journal of Periodontics Restorative Dentistry* 20.4 (2000): 366-373.
24. Olson JW., *et al.* "Dental endosseous implant assessments in a type 2 diabetic population: a prospective study". *International Journal of Oral Maxillofacial Implants* 15.6 (2000): 811-818.
25. Fiorellini JP, *et al.* "The effect of insulin therapy on osseointegration in a diabetic rat model". *Clinical Oral Implants Research* 10.5 (1999): 362-368.
26. Wilmowsky V., *et al.* "Diabetes mellitus negatively affects peri-implant bone formation in the diabetic domestic pig". *Journal of Clinical Periodontology* 38.8 (2011): 771-779.
27. Kotsovilis S., *et al.* "A comprehensive and critical review of dental implant placement in diabetic animals and patients". *Clinical Oral Implants Research* 17.5 (2006): 587-599.
28. Chrcanovic BR., *et al.* "Diabetes and Oral Implant Failure: A Systematic Review". *Journal of Dental Research* 93.9 (2014): 859-867.
29. Javed F and Romanos G. "Impact of diabetes mellitus and glycemic control on the osseointegration of dental implants: a systematic literature review". *Journal of Periodontology* 80.11 (2009): 1719-1730.
30. Farzad P., *et al.* "Dental implant treatment in diabetic patients". *Implant Dentistry* 11.3 (2002): 262-267.
31. Peled M., *et al.* "Dental implants in patients with type 2 diabetes mellitus: a clinical study". *Implant Dentistry* 12.2 (2003): 116-122.
32. Esposito M., *et al.* "Interventions for replacing missing teeth: different types of dental implants". *Cochrane Database of Systematic Reviews* 7 (2014): CD003815.
33. Kotsovilis S., *et al.* "Systematic review and meta-analysis on the effect of implant length on the survival of rough-surface dental implants". *Journal of Periodontology* 80.11 (2009): 1700-1718.
34. Kotsovilis S., *et al.* "A systematic review and meta-analysis on the effect of implant length on the survival of rough-surface dental implants". *International Journal of Oral Maxillofacial Implants* 80.11 (2004): 1700-1718.
35. Renouard F and Nisand D. "Impact of implant length and diameter on survival rates". *Clinical Oral Implants Research Suppl 2* (2007): 35-51.
36. Jaffin R and Berman C. "The excessive loss of Branemark fixtures in type IV bone: a 5-year analysis". *Journal Periodontology* 62.1 (1991): 2-4.
37. Misch CE. "Contemporary Implant Dentistry". 2<sup>nd</sup> ed. USA: Mosby publication; (1999): 239-250.
38. Wallace SS and Froum SJ. "Effect of maxillary sinus augmentation on the survival of endosseous dental implants. A systematic review". *Annals Periodontology* 8.1 (2003): 328-343.
39. Sbordone L., *et al.* "Implant survival in maxillary and mandibular osseous onlay grafts and native bone: a 3-year clinical and computerized tomographic follow-up". *International Journal of Oral Maxillofacial Implants* 24.4 (2009): 695-703.
40. Pabst AM., *et al.* "Analysis of implant-failure predictors in the posterior maxilla: A retrospective study of 1395 implants". *Journal of Craniomaxillofacial Surgery* 43.3 (2015): 414-420.
41. Huynh-Ba G., *et al.* "Implant failure predictors in the posterior maxilla: a retrospective study of 273 consecutive implants". *Journal of Periodontology* 79.12 (2008): 2256-2261.



42. Hammerle C and Jung R. "Bone augmentation by means of barrier membranes". *Periodontology* 2000 33 (2003): 36-53.
43. Sesma N., et al. "Retrospective clinical study of 988 dual acid-etched implants placed in grafted and native bone for single-tooth replacement". *International Journal of Oral Maxillofacial Implants* 27.5 (2012): 1243-1248.
44. Olson JW., et al. "Long-term assessment (5 to 71 months) of endosseous dental implants placed in the augmented maxillary sinus". *Annals Periodontology* 5.1 (2000): 152-156.
45. Lozada JL., et al. "Root-form implants placed in subantral grafted sites". *Journal of the California Dental Association* 21.1 (1993): 31-35.
46. Gerstein AD., et al. "Wound healing and aging". *Dermatology Clinics* 11.4 (1993): 749-757.
47. Brocard D., et al. "A multicenter report on 1,022 consecutively placed ITI implants: a 7-year longitudinal study". *The International Journal of Oral & Maxillofacial Implants* 15.5 (2000): 691-700.
48. Jemt T. "Implant treatment in elderly patients". *The International Journal of Prosthodontics* 6.5 (1993): 456-461.
49. Meijer HJ., et al. "Influence of patient age on the success rate of dental implants supporting an overdenture in an edentulous mandible: a 3-year prospective study". *The International Journal of Oral & Maxillofacial Implants* 16.4 (2001): 522-526.
50. H. Shin H., et al. "A retrospective clinical study of survival rate for dental implants in elderly patients". *Clinical oral implantation research* 25.10 (2014): 400.
51. Office of the Surgeon General (US). Bone Health and Osteoporosis: A Report of the Surgeon General. Rockville (MD):4, The Frequency of Bone Disease (2004).
52. Lekholm U., et al. "Patient selection and preparation". *Tissue integrated prostheses* (1985): 199-209.
53. Tsolaki I., et al. "Outcomes of dental implants in osteoporotic patients. A literature review". *Journal of Prosthodontics* 2009 18.4 (2009): 309-323.
54. Holahan C., et al. "Effect of osteoporotic status on the survival of titanium dental implants". *The International Journal of Oral & Maxillofacial Implants* 23.5 (2008):905-910.
55. Chen H., et al. "Smoking, Radiotherapy, Diabetes and Osteoporosis as Risk Factors for Dental Implant Failure: A Meta-Analysis". *PLoS One* 8.8 (2013): e71955.
56. Lee G., et al. "A retrospective study of survival rate of dental implants placed in osteoporosis patients". *Journal of Korean Academy of Periodontology* 39.4 (2009): 413-423.
57. Grant B., et al. "Implants and Oral Biphosphonates: 115 Cases". *Journal of Oral and Maxillofacial Surgery* 66.2 (2008): 223-230.
58. Madrid C and Sanz M. "What impact do systemically administrated bisphosphonates have on oral implant therapy? A systematic review". *Clinical Oral Implants Research* 20 Suppl 4 (2009): 87-95.

**Volume 2 Issue 5 October 2015**

**© All rights are reserved by Isabel C Gay., et al.**