

An overview of type-2 diabetes mellitus: dental implant survival rates

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ABSTRACT

Dental implants are an alternative treatment to replace missing teeth, as it is one of the oral health problems in the elderly. The success of dental implants is affected by a process known as osseointegration. Systemic condition such as T2DM can interfere with the osseointegration process which can lead to implant failure. As the patient's blood glucose level increases, it will increase the accumulation of AGEs. These AGEs will interfere with the stages of bone-implant contact and also bone growth around the implant. This review article is aimed to review dental implant survival rates in T2DM patients based on HbA1c, ISQ and CBCT examinations. It is concluded that dental implants in T2DM patients after being evaluated for 2 years showed a good result. This result is obtained with the condition that HbA1c control is below 8%. Another solution to support the success of dental implants placement in T2DM patients is the use of delayed insertion technique and modification of the implant surface with HA or SLA is also recommended. Evaluation of implant success can also be done with pre-operative planning, such as evaluation of the bone condition with ISQ and CBCT examinations.

Keywords: dental implant, uncontrolled T2DM, implant survival, CBCT, ISQ

INTRODUCTION

Dental implant treatment is one of the leading alternative treatments in dentistry aimed at edentulous patients with tooth loss. Tooth loss is one of the most common oral health problems experienced by the elderly. Based on data from the Center for Disease Control and Prevention (CDC) that almost 1 in 5 elderly people aged 65 years and over has lost their teeth.¹ According to the American Academy of Implant Dentistry (AAID), each year an additional 500,000 dental implants are placed.

The high procedure for dental implants placement is also inseparable from the factors that influence the success of the placing, namely bone-implant contact (BIC) by a process called osseointegration. After the implant is placed, inflammatory cells and bone cells will move to the surface of the bone-implant. The process of bone regeneration and mineralization or remodeling is continued until complete osseointegration occurs.²

Diabetes mellitus is a group of metabolic disorders with the main characteristic of chronic hyperglycemia.³ According to the International Diabetes Federation (IDF) in 2021, the global prevalence of diabetes mellitus in 2021 is 10.5%, with 90% of all diabetes cases being type-2DM (T2DM). The diagnostic criteria for DM can be indicated by an HbA1c level 6.5%.⁴ Optimal glycemic control in non-pregnant adults is defined as HbA1c <7% (53 mmol/mol) and uncontrolled diabetes HbA1c is 7% (53 mmol/mol).³

T2DM patients who get implants must pay at-

ention to their blood glucose control. Uncontrolled high blood glucose can change the quality of the dental-implant osseointegration process. As the patient's blood glucose level increases, it will increase the accumulation of AGEs through the formation of ROS. These AGEs will interfere with the stages of BIC and also bone growth around the implant.⁵

The clinical impact of implant integration can also be assessed by implant stability quotients (ISQ), or implant measurements.⁶ ISQ was used as a non-invasive indicator to determine the implant loading time frame and as a prognostic indicator for the likelihood of implant failure using the resonant frequency analysis (RFA) method as a quantitative ISQ parameter.⁷ The ISQ is based on the resonant frequency and ranges from 1 (lowest stability) to 100 (highest stability). A higher ISQ value indicates a higher primary.⁷ An ISQ value >70 is considered optimal for implant success.⁸ Meanwhile according to Sargolzaieet *al.*, the optimum ISQ value as the implant success is >60.⁹

To get a good implant adaptation to support the success of implant placement, the patient's condition before receiving a dental implant must be evaluated, namely those concerning the condition of the alveolar bone and systemic conditions of the patient such as diabetes, osteoporosis, obesity, and the use of drugs. In evaluating the condition of the alveolar bone, it is necessary to consider the distance between the crest of the alveolar bone and the opposing tooth, the mesiodistal distance

of the bone (in addition to considering the size of the implant diameter, which is 6-8mm on average), and the fasciolingual width of the bone (generally >6mm).¹⁰ Evaluation of the condition of the alveolar bone can be analyzed, one of which is by using a cone beam computed tomography (CBCT) examination. This CBCT examination can provide an accurate 3-D picture of the anatomy, quality and volume of alveolar bone. So that the use of CBCT can be used in planning the installation of pre-surgical implants.¹¹

There are six factors that can affect the osseointegration of dental implants: the biocompatibility of the implant material; macroscopic and microscopic properties of the implant surface; implant placement status; surgical technique; uninterrupted healing phase; and the prosthetic design continues and the long-term implant loading phase.¹² This article reviews the implant survival rate in T2DM patients based on HbA1c, ISQ examination, and CBCT examination.

LITERATURE STUDIES

A literature review of studies conducted on survival rates in T2DM patients based on HbA1c, ISQ examination, and CBCT examination using the *preferred reporting items for systematic reviews and meta-analyses* (PRISMA) method. A comprehensive literature search was conducted on the Pubmed database (US National Library of Medicine, USA) with studies published in the last 5 years (2017-2022) period. The keywords used were 'DM and dental implant survival', 'uncontrolled T2DM and dental implant survival', 'DM and immediately loaded implant'. Results are limited to studies published in English.

All studies obtained from database searches with the above search criteria were gathered and duplicates were removed. The remaining studies were then filtered by reading "title". Studies that did not match with the inclusion criteria were excluded at this stage. The remaining studies were screened at the final stage by reading the abstract and those that did not match with the inclusion criteria were excluded.

The inclusion criteria consisted of a) articles describing uncontrolled T2DM and dental implant placement, b) types of cohort studies and clinical studies, and c) research conducted in 2017-2022. Exclusion criteria included a) review articles, b) research published other than in English, c) research that did not address survival rates for uncontrolled T2DM and dental implant placement.

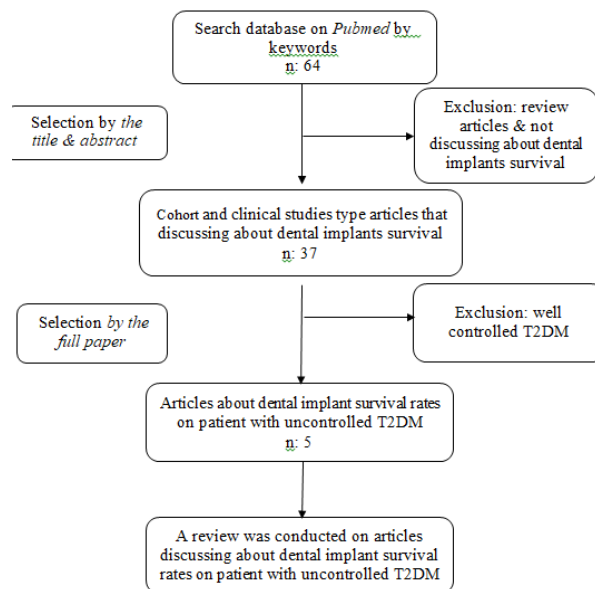


Figure 1 Schematic of the article exclusion process

DISCUSSION

Implants survival rates based on HbA1c

Diabetes mellitus is a systemic disease characterized by impaired insulin secretion which results in a high plasma glucose level in the blood, or commonly referred as hyperglycemia. Hyperglycemia is a result of an accumulation of advanced glycation end products (AGEs) through the formation of ROS, which will affect the quality of the collagen structure as an organic bone matrix. In addition, AGEs reduce the proliferation and function of osteoblasts and increase resorption by osteoclasts. Hyperglycemia can lead to decreased bone formation and poor new bone quality, also affects the reduced bone density around dental implants and reduced osteoconduction at the osseointegration stage.^{5,13}

Glycemic control is important for the maintenance and prevention of diabetes complications. The percentage of glycosylated hemoglobin that is HbA1c, is considered the best indicator for measuring glucose levels in the previous six to eight weeks than fasting plasma glucose. According to the criteria, optimal glycemic control in adults is defined as HbA1c <7% (53 mmol/mol) and uncontrolled diabetes HbA1c 7% (53 mmol/mol).³

Survival rates in dental implants are defined when the dental implants were able to stay in their sockets and when evaluated for 1 year, the implants did not experience infection, pain, mobility, peri-implant bone loss.^{14,15} In patients with uncontrolled T2DM, when evaluated for 2 years after insertion, good results were obtained, and there was

Table 1 Results of article characteristics

No	Author, year	Type of Study	No. of patients	No. of implants	Duration of Study	Survival rates (%)	Conclusion
1	Eskow <i>et al.</i> , 2017	Cohort study	24	72	2 years	96.7%	It was concluded that the 2-year evaluation of dental implants in patients with uncontrolled diabetes was good
2	Aguilar <i>et al.</i> , 2016	Cohort study	85	85	2 years	86.3%	In diabetic patients, implant treatment can be carried out provided that HbA1c control is carried out so that it must always be below 8% or diabetic patients with moderately-glycemic control
3	Juncar <i>et al.</i> , 2020		4	16	6 months	100%	Implant placement with an immediate filling technique got good results when the patient's HbA1c showed a level of 7.05% (range 6.8-7.3%)
4	Latimer <i>et al.</i> , 2021	Cohort study	21	21	1 year	100%	HbA1c >7.5% - <10% does not affect dental implant survival during 1 year of placement
5	Friedmann <i>et al.</i> , 2021	Pilot study	32	48	1 year	100%	Implants placement used in a minimally invasive approach and prevention of augmentation procedures will result in good implant integration.

was no significant difference with survival rates in patients with controlled T2DM.^{16,17} Aguilar *et al.*, also added that when an uncontrolled T2DM patient is to be treated with implants, there is a requirement for installation, namely HbA1c control so that blood glucose is always below 8%.¹⁷ Research conducted by Juncar, *et al.*¹⁸ showed a safe HbA1c level for implant placement was an average of 7.05%.¹⁸ Both studies are based on an immediate-loaded implant placement technique. The results of the research from Aguilar *et al.*, were supported by Latimer *et al.*,⁸ which was conducted for 1 year that dental implant survival reached 100% when the glycemic control was between >7.5%-10%. Other research reveals, when implant placement uses a minimally invasive approach and preventive augmentation procedures, it will result in good implant integration so that a high survival rate will be obtained.¹⁹

Although the survival rates of dental implants in patients with uncontrolled T2DM are notably good, several post-installation complications were found. Such as bone destruction, low BIC value, increased plaque index, probing depth, bleeding on probing (BOP) are also causes of peri-implantitis. The risk of peri-implantitis is due to the increased inflammatory and immune response of the host. Hyperglycemia causes an increase in AGEs, AGEs together with RAGEs will reduce the synthesis of matrix proteins such as collagen and osteocalcin. In addition, the binding of AGEs and RAGEs will increase the production of pro-inflammatory cytokines such as IL-6, IL-1b, and TNF-a so that it will increase inflammation around the installation of dental implants.^{20,21}

ISQ examination as a support for the successful of dental implants placement

ISQ values are influenced by many clinical and

biological factors, with a possible association of ISQ with bone quality at the implant site.⁷ In a study in rats with alloxan-induced diabetes, severe diabetes can cause ultrastructural changes in bone formation. In this study, non-insulin-treated and implanted diabetic rats exhibited a loose bone matrix with loose aspect, irregular arrangement, thin trabeculae, empty spaces and large amounts of proteoglycans.²² In a recent observational study, Alshahrani *et al.* showed that cortical bone loss (CBL) levels in patients with uncontrolled T2DM were significantly higher than in pre-diabetic, controlled diabetic, and non-diabetic patients. In a clinical study also reported that cortical bone thickness showed a positive correlation with local ISQ values, and cortical bone loss caused a decrease in implant stability resulting in a decrease in ISQ values.²³ Based on the above study, patients with uncontrolled T2DM may be able to show a decrease in ISQ values resulting in lower implant stability.

CBCT examination as a support for the successful of dental implants placement

In support of a successful implant, CBCT examination has the advantage in which when used during diagnostic planning as well as pre- and post-operatively, CBCT produces detailed 3D volumetric images, with low exposure doses of around 10-1000 Sv, fast exposure time, lighter equipment, and small, and ease of use may be the main contributors to its growing success.¹¹

Failure and complications of implant placement can be caused by poor bone quality, inadequate bone volume, errors in pre-operative planning, and errors in viewing the anatomical structure of the bone. In pre-operative planning, it is necessary to assess bone quality which consists of bone density and thickness. In addition, bone density measurements were also carried out to see how much

free space was available for dental implants. Meanwhile, post-operative CBCT is also used to evaluate bone formation including the height and width of the bone around the implant.²⁴

Research by Pramanik and Firman²⁴ determined that the minimum mesiodistal, buccolingual distance is 8 mm while the minimum distance from the alveolar crest to the superior border of the mandibular canal or the inferior floor of the sinus is 10 mm. The value of bone density that is safe for dental implants is in the range of 400-800 HU.

Implant surface modification and implant placement techniques as a solution to increase survival rates in T2DM patients

In a study of rats with streptozotocin-induced diabetes, modification on the implant surface with hydroxyapatite (HA) and sandblasted and acid-etched (SLA) may provide the potential to enhance implant osseointegration. Histomorphometric results showed the highest BIC value were in implant surface modified with HA group, the highest new bone formation value in implant surface modified with SLA group, and increased osseointegration in both groups HA and SLA.^{8,25} Therefore, implant surface modification with HA and SLA can be suggested in T2DM patients to enhance new bone formation and osseointegration.

There are 3 methods of implant placement, namely 1) implant that is inserted directly after tooth extraction (immediate insertion), 2) implants that are inserted 6-8 weeks after tooth extraction, and 3) implants that are inserted 4-6 months after tooth extraction (delayed insertion). A study found that patients with moderately T2DM who had implants implanted immediately after tooth extraction experience failure. Although immediate implant place-

ment has the advantage of shortening treatment time and minimizing invasive procedures in patients, when applied to T2DM patients, there were higher failure survival rates than those with delayed implant placement. This is due to the bone graft given when the implant is inserted immediately after tooth extraction prevents BIC from occurring so that the osseointegration was not optimal.²⁶ Thus patients with T2DM can be advised to use the delayed insertion technique. Research conducted by Aguilar et al, showed that when an uncontrolled T2DM patient is to be treated with implants, there is a requirement for installation, namely HbA1c control so that blood glucose is always below 8%.¹⁷ Juncar, et al¹⁸ also added a safe HbA1c level for implant placement was an average of 7.05%.

It is concluded that the placement of dental implants in T2DM patients after being evaluated for a short period of 2 years showed a good result. High survival rates were obtained with the condition that HbA1c control is carried out so that it is always below 8%. In the evaluation of implant placement, control HbA1c > 10% caused complications such as decreased rate of new bone formation, bone density, and high risk of peri-implantitis. In addition, HbA1c control must be below 8%. Our solution to support the successful installation of dental implants in T2DM patients are the use of a delayed insertion technique compared to immediate insertion, and modification of the implant surface using HA or SLA is also recommended. Evaluation of implant success can also be done with pre-operative planning, such as evaluation of the bone condition with ISQ and CBCT examinations. So, further research is needed on the survival rates of T2DM patients in terms of various aspects such as insertion technique, CBCT examination, ISQ stability level.

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