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Evaluation of the maxillary and mandibular implant failure rate in patients with type 1 and type 2 diabetes: a systematic review and meta-analysis

Asal Moravej[1], Elnaz Mousavi[2], Amir Azizi[3], Ali Amiri[4*], Ayda Sameie[5]

[1] Department of Periodontics, School of Dentistry, Tehran University of Medical Sciences, Tehran, Iran.

[2] Endodontist, Private Office, Iran.

[3] Department of Prosthodontics, School of Dentistry, Alborz University of Medical Sciences, Karaj, Iran.

[4] Department of Orthodontics, College of Stomatology, The First Affiliated Stomatological Hospital, Xi'an Jiaotong University, Xi'an, PR China.

[5] Dental School, Mazandaran University of Medical Sciences, Sari, Iran.

Corresponding author:
Ali Amiri
Department of Orthodontics,
College of Stomatology,
The First Affiliated Stomatological Hospital, Xi'an Jiaotong University,
Xi'an, PR China
Tell: +86-2982655450
Email: draliamiri2020@gmail.com
aliamiri@stu.xjtu.edu.cn

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Aim: The present study evaluated maxillary and mandibular implant failure rates in patients with type 1 diabetes and type 2 diabetes. **Methods:** All articles published in international databases such as PubMed, Scopus, Science Direct, ISI Web of knowledge, and Embase between 2016 to July 2022 are included. 95% confidence interval on odds ratio and mean differences were done with a fixed effect model. Meta-analysis data collected from selected studies were performed using Stata/MP.V17 software. **Results:** In the initial review, duplicate studies were eliminated, abstracts of 1311 studies were reviewed, two authors reviewed the full text of 243 studies, and finally, 37 studies were selected. The odds ratio of implant failure rate between diabetic and non-diabetic patients was 5.31 (OR, 95% CI 5.06, 5.56; p=00). The mean difference in marginal bone loss between diabetic and non-diabetic patients was 1.63 (MD, 95% CI 0.89, 2.37; p=0.00). **Conclusion:** Based on the findings of the present study, the survival rate of implants in patients with diabetes was lower than in non-diabetic patients. Also, marginal bone loss was higher in patients with diabetes than in non-diabetic patients.

Keywords: Dental implants. Diabetes mellitus. Diabetes complications.

Introduction

Diabetes mellitus is a metabolic disease confirmed by high glucose levels in the blood (Hyperglycemia); In this disease, the body cannot use the produced insulin, and the pancreas cannot produce enough insulin, which indicates a defect in insulin secretion[1]. Type 2 diabetes is the most common type of diabetes mellitus, and about 90 to 95% of patients with diabetes are type 2 diabetes. According to global statistics, by 2030, 643 million adults will be diagnosed with type 2 diabetes[2]. These figures are very high and double the importance of investigating this disease. Long-term hyperglycemia caused by diabetes mellitus can affect the function of many tissues and organs, and we will see significant clinical complications after that[3,4].

Studies show that two factors, age, and blood sugar level, can affect people's clinical and functional status. Evidence shows that the duration of diabetes also affects the clinical and functional status[5]. Among the negative effects of diabetes on the patient, we can mention the following; microvascular complications[6,7], impaired metabolism and bone strength[8], delayed wound healing[9], and impaired response to infection[10,11]. Based on the results of studies, there is a direct relationship between glycemia and microvascular and macrovascular[12]. In patients with diabetes, controlling blood sugar levels can prevent or delay the progression of the disease and related complications[13].

The hemoglobin A1c (HbA1c) test measures the amount of blood sugar (glucose) bound to a person's hemoglobin. Hemoglobin is the part of red blood cells that carries oxygen from the lungs to the rest of the body. It is a very important blood test indicating how a person's diabetes is controlled[14,15]. Based on the results of the studies, if the HbA1c level is maintained up to 6.5%, the person is considered in the controlled diabetes group[16]. Based on the results of a previous study, diabetes, with its negative effect on bone metabolism, can endanger the long-term survival of dental implants[5].

Nevertheless, investigating the survival of dental implants in diabetic patients compared to non-diabetic patients is of great importance. Stronger evidence can be reached by updating information in this field and using newer studies; therefore, the present study was conducted to evaluate maxillary and mandibular implant failure rates in patients with type 1 diabetes and type 2 diabetes.

Materials and Methods

Search strategy

Based on PRISMA guidelines[17], the present study conducts a systematic review and meta-analysis of all articles published between January 2016 and 2022 in international databases, including PubMed, Scopus, Science Direct, Embase, and ISI Web of Knowledge. The reason for examining the studies in this period was to examine newer studies with newer evidence; It should be noted that if the number of studies and the sample size were small, the search would be conducted from 2010 to 2022. The Google Scholar search engine employed the PICO strategy to answer the research questions (Table 1).

Table1. PICO strategy.

PICO strategy	Description
P	Population: partially and fully edentulous patients with type 1 diabetes and type 2 diabetes.
I	Intervention: maxillary and mandibular implant
C	Comparison: non-diabetic patients
O	Outcome: marginal bone loss (MBL) and implant failure

The following keywords were used to search:

(((((“Jaw, Edentulous, Partially”[Mesh]) OR (“Mouth, Edentulous”[Mesh] OR “Jaw, Edentulous”[Mesh])) AND “Dental Implants”[Mesh]) OR “Dental Implants/statistics and numerical data”[Mesh]) OR “Dental Implants/adverse effects”[Mesh]) AND (“Diabetes Mellitus”[Mesh] OR “Diabetes Complications”[Mesh] OR “Diabetes Mellitus, Type 2”[Mesh] OR “Diabetes Mellitus, Type 1”[Mesh]).

Eligibility criteria

Inclusion criteria

1. Randomized controlled trials, controlled clinical trials, and cohort studies.
2. Availability of full text.
3. Only english-language articles were selected.
4. Diabetic patients with controlled glycemic
5. Human samples.

Exclusion criteria

1. Cross-sectional studies, in-vitro and in-vivo studies, review studies, case reports, and letters to the editor.
2. No comparison with the control group.

Selection process and Data collection process

Two reviewers blindly and independently extracted data from the included papers’ full texts and abstracts for data extraction. Kappa statistics were used to check the amount of agreement between the reviewers before the screening. The values of kappa were higher than 0.80. Studies data were reported by the first author’s name, years, study design, several patients, and outcome.

Risk of bias assessment

The quality of studies was assessed using the National Institutes of Health tools (NHLBI)[18]. This tool has 9 items; each item is given a score of 1 or 0; the range of grades is from 0 to 9, and grades 0 to 3 indicate the low quality of the study, 4 to 6 indicate average quality, and 7 to 9 indicate high quality.

Data analysis

Effect measures and synthesis methods

Stata/MP.V17 software was used to analyze the data. Odds ratio and mean differences (95% confidence interval) were done with the fixed effect model, Mantel-Haenszel, and inverse-variance method. The level of heterogeneity was assessed using the I^2 index test (I^2 50% = low levels, 50-I^2 75% = moderate, and I^2>75% = high levels).

Results

After the initial search for them in databases, 1311 articles were identified. Duplicate articles were deleted (n=149) after importing all articles into the EndNote.X9 software. In the second stage, one thousand one hundred sixty-two articles were entered and examined. At this stage, 919 unrelated articles were excluded from the study while reviewing the titles and abstract articles. The full texts of 243 articles were reviewed in the third step, and incomplete articles without data and inconsistency with the objectives of the study were excluded (206 articles). Thirty-seven articles that met the inclusion criteria were included (Figure 1).

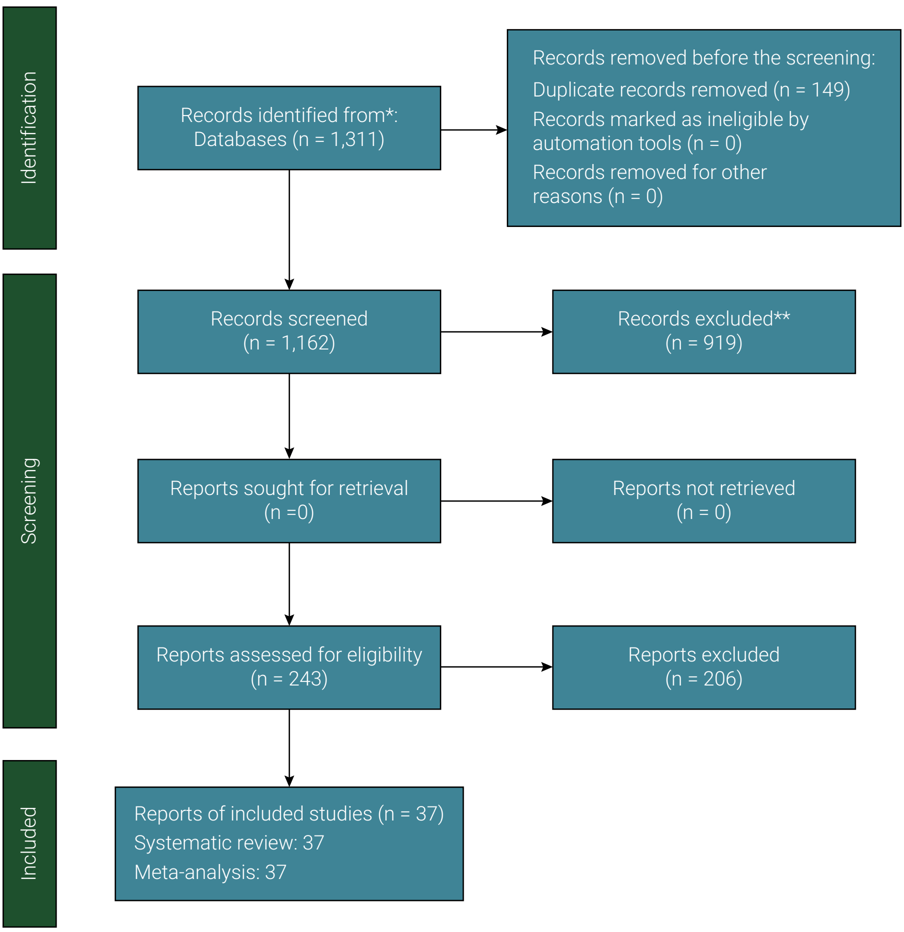

Figure 1. PRISMA 2020 checklist.

Characteristics

This study selected and included five prospective studies, 28 retrospective studies, one controlled clinical trial study, and four randomized controlled trial studies. A total of 4606 patients with type 1 or type 2 diabetes were examined; Table 2 shows the number of patients by gender. Also, demographic information is reported in table 2 (average age of patients, number of smoking patients, and location of implant placement).

Table 2. Demographic information was extracted from the full text of the selected studies.

No.	Study. Years	Study design	Number of patients		Mean of age	Implant location		Number of smokers	Quality of studies
			Male	Female		Maxilla	Mandible		
1	Coskunses and Tak[19], 2021	Prospective	17	11	52	√	√	6	9/9
2	Boboeva et al.[20], 2021	Retrospective	584	711	46.7	√	√	78	9/9
3	Troiano et al.[21], 2021	Retrospective	63	46	58	√	√	31	8/9
4	Schoenbaum et al.[22], 2021	Retrospective	181	197	60	√	√	56	8/9
5	Sicilia et al.[23], 2021	Retrospective	268		50	-	√	75	9/9
6	Tattan et al.[24], 2021	Retrospective	95	106	60	√	√	37	9/9
7	Stacchi et al.[25], 2021	Retrospective	61	95	60	√	-	29	9/9
8	Werbelow et al.[26], 2020	Retrospective	13	10	64	√	√	2	9/9
9	Wang et al.[27], 2020	Randomized controlled trial	15	34	46	√	√	1	8/9
10	Rondon Rmero et al.[28], 2020	Retrospective	26	22	68	-	√	22	7/9
11	Park et al.[29], 2020	Retrospective	87	91	53	√	-	NR	8/9
12	Lobato et al.[30], 2020	Randomized controlled trial	22	22	50	√	√	NR	7/9
13	Higuchi et al.[31], 2020	Prospective	50	60	61	-	√	23	9/9
14	Feher et al.[32], 2020	Retrospective	505	627	50	√	√	217	8/9
15	Chang[33], 2020	Retrospective	222	154	49	√	√	67	9/9
16	Atarchi et al.[34], 2020	Retrospective	516	827	61	√	-	58	8/9
17	Alqahtani et al.[35], 2020	Retrospective	101	0	NR	√	√	51	7/9
18	de Souza et al.[36], 2019	Retrospective	4	6	60	√	-	1	9/9
19	Alsahhaf et al.[37], 2019	Retrospective	76	43	43	√	√	0	9/9
20	Klotz et al.[38], 2019	Retrospective	28	56	60	√	√	NR	9/9
21	Lee et al.[39], 2019	Retrospective	70	86	59	√	√	NR	8/9
22	Romandini et al.[40], 2019	Retrospective	24	28	68	√	√	14	8/9

Continue

Continuation

23	Altay et al.[41], 2018	Retrospective	6	7	55	√	√	0	8/9
24	Nogueira et al.[42], 2018	Prospective	11	34	63	-	√	23	9/9
25	Saridakis et al.[43], 2018	Retrospective	49	49	61	√	√	0	8/9
26	Kim et al.[44], 2018	Retrospective	496	385	51	√	√	NR	9/9
27	Niedermaier et al.[45], 2017	Retrospective	188	192	61	√	√	141	7/9
28	Norton et al.[46], 2017	Prospective	10	12	63	√	√	1	7/9
129	Boardman et al.[47], 2016	Retrospective	21	77	51	√	-	7	7/9
30	Chrcanovic, et al.[48], 2016	Retrospective	2670		54	√	√	521	8/9
31	Daneshvar et al.[49], 2016	Retrospective	40	71	56	√	√	8	9/9
32	Gherlone et al.[50], 2016	Prospective	22	46	55	√	√	42	9/9
33	Ghiraldini et al.[51], 2016	Controlled clinical trial	28	23	56.4	√	√	0	8/9
34	Kappel et al.[52], 2016	Randomized controlled trial	34	12	69	√	√	8	7/9
35	Malchiodi et al.[53], 2016	Randomized controlled trial	24	16	52	√	√	10	7/9
36	Zumstein and Sennerby[54], 2016	Retrospective	22	28	58	√	√	4	7/9
37	Malo et al.[55], 2016	Retrospective	299	422	51	√	√	477	9/9

Implant failure rate

The odds ratio of implant failure rate between diabetic and non-diabetic patients was 5.31 (OR, 95% CI 5.06, 5.56; p=00) (I^2=99.50%; P=0.00; high heterogeneity). In terms of implant failure rate, a statistically significant difference was observed between the two groups. Based on these findings, the implant failure rate was higher in diabetic patients than in the non-diabetic group (Figure 2).

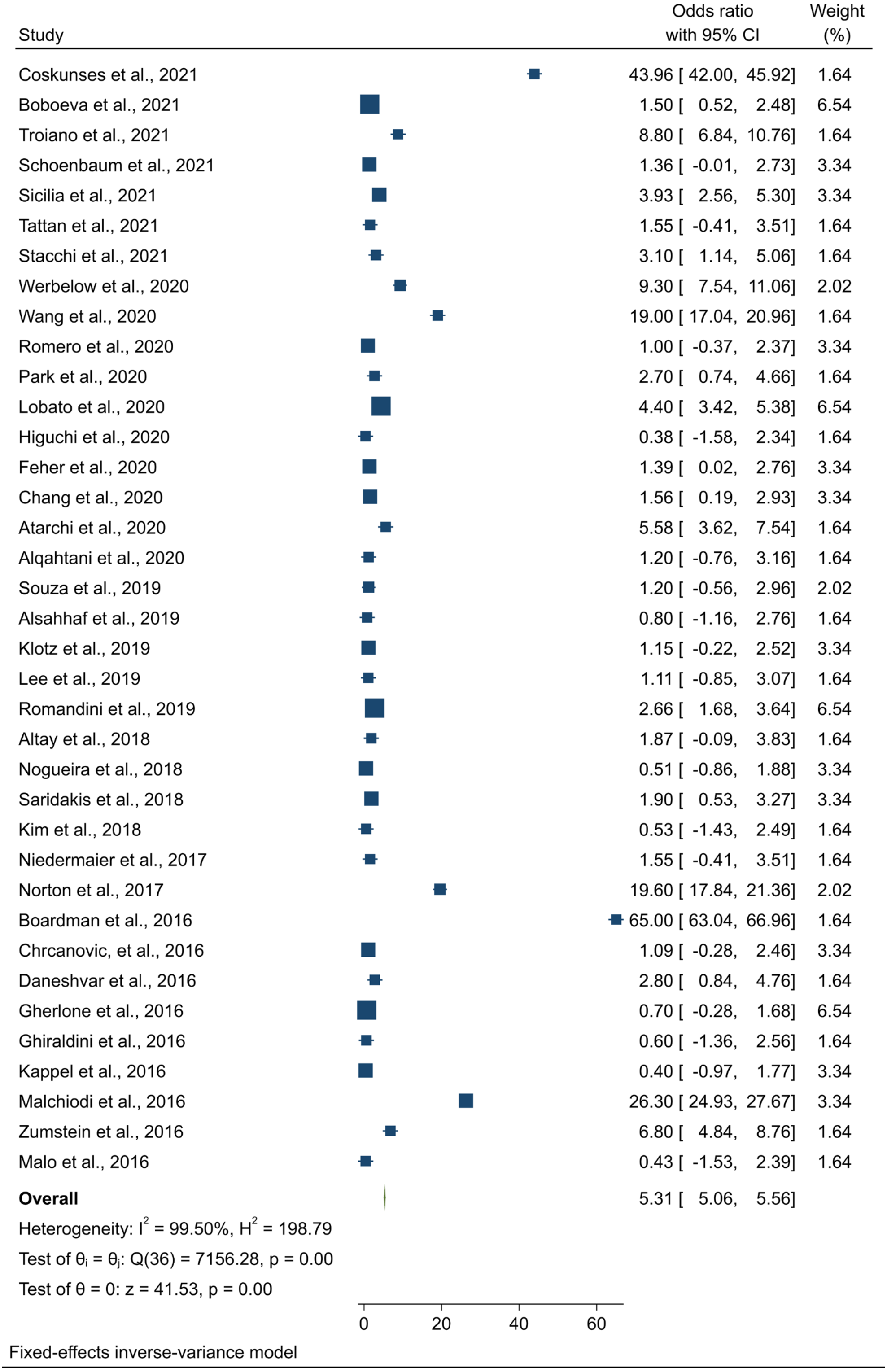

Figure 2. The forest plot showed the implant failure rate between diabetic and non-diabetic patients.

Subgroup meta-analysis showed an odds ratio of maxillary implant failure rate between diabetic and non-diabetic patients was 11.07 (OR, 95% CI 10.35, 11.80) (I^2=99.85%; P=0.00; high heterogeneity). The maxillary implant failure rate between diabetic and non-diabetic patients was 11.07 (OR, 95% CI 10.35, 11.80) (I^2=99.85%; P=0.00; high heterogeneity). The mandible implant failure rate between diabetic and non-diabetic patients was 1.26 (OR, 95% CI 0.64, 1.87) (I^2=99.71%; P=0.00; high heterogeneity) (Figure 3). Test of subgroup differences showed a statistically significant difference between groups (p=0.00).

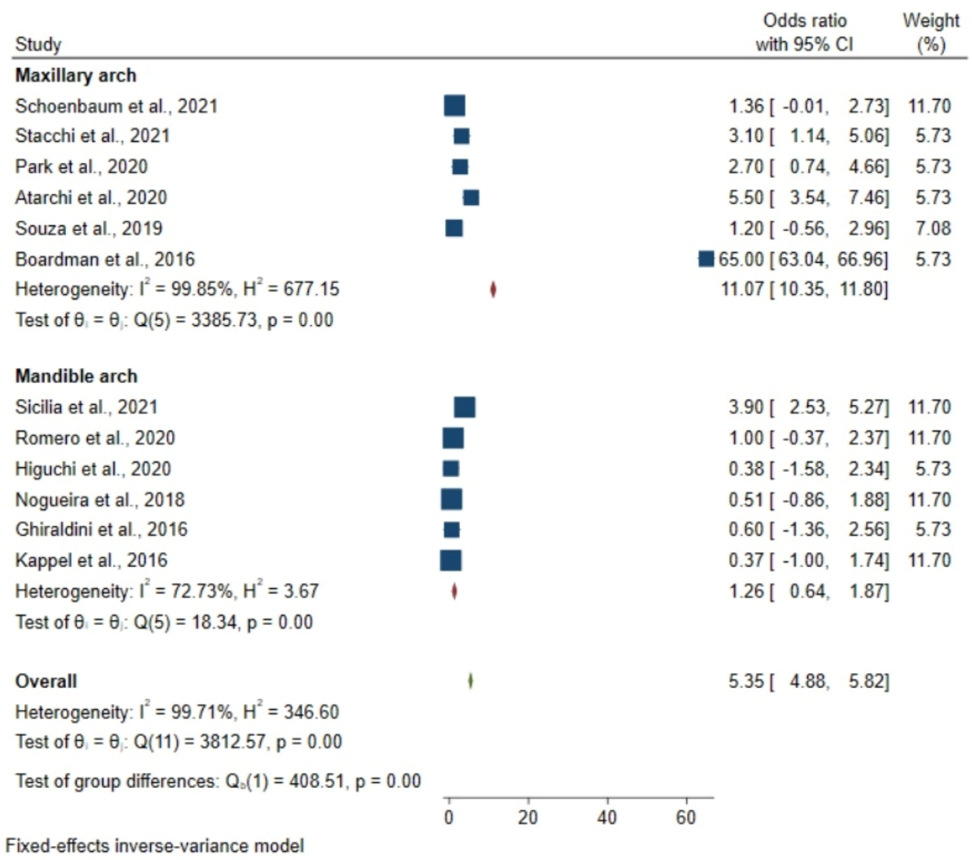

Figure 3. The forest plot showed a subgroup meta-analysis of implant failure rate based on implant location.

The odds ratio of implant failure rate between type 1 and type 2 diabetes was 1.56 (OR, 95% CI 0.69, 2.44; p=00) (I^2=88.66%; P=0.00; high heterogeneity) (Figure 4).

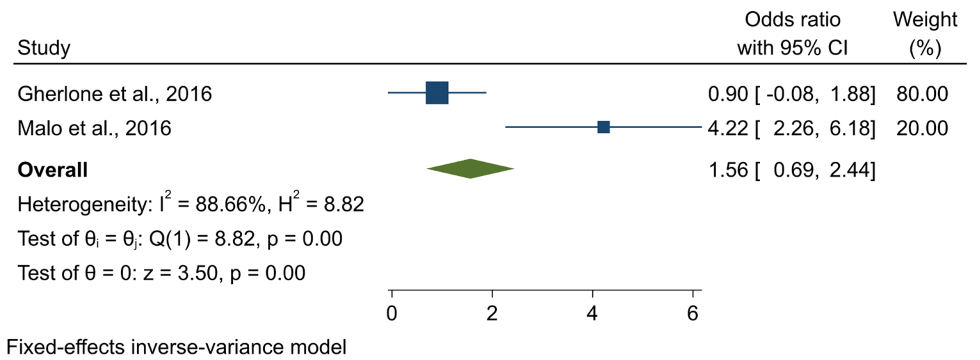

Figure 4. The forest plot showed implant failure rate between type 1 and type 2 diabetes.

Marginal bone loss

The mean difference in marginal bone loss between diabetic and nondiabetic patients was 1.63 (MD, 95% CI 0.89, 2.37; p=0.00) (I^2=78.69%; P=0.00; high heterogeneity) (Figure 5).

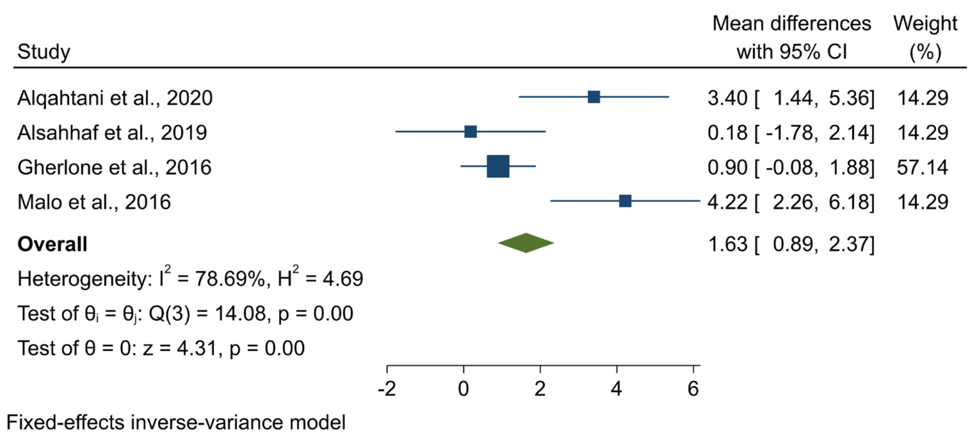

Figure 5. The forest plot showed mean differences in marginal bone loss.

Discussion

In the present study, implant failure and marginal bone loss in patients with diabetes were investigated, and the results were compared with non-diabetic patients. Compared to previous studies in this field, the present study has advantages, such as the fact that more clinical studies were used in the present study, the sample size was much higher, and a stronger meta-analysis was presented[56-58]. Also, in the current study, the survival rate of implants in both jaws has been investigated, and marginal bone loss has also been investigated. The present meta-analysis shows that implant survival in diabetic patients was lower than in non-diabetic patients, and higher marginal bone loss was observed in diabetic patients. Since diabetes has negative effects on bone metabolism and bone strength, so it can be one reason for decreasing implant survival in diabetic patients. Also, hyperglycemia can affect the bone mineral density and increase the risk of fracture[59,60]. A study found that total body bone density was significantly lower in patients with type 1 diabetes than in non-diabetic patients[61]. Another factor that can affect the survival of implants is the delay in wound healing, which is very common in diabetic patients. Also, disturbance in the metabolism of bone cells in diabetic patients can weaken proper bone repair[62]. Microvascular complications in diabetic patients can affect the failure of implants[63,64]. Hyperglycemia (high blood glucose) can cause vomiting, excessive hunger and thirst, fast heart rate, vision problems, and other symptoms. Untreated hyperglycemia can lead to serious health problems, disrupting the immune response (suppressing cytokine production) and making patients with diabetes more susceptible to infection[65]. It can affect the implant's failure; the immune system is needed to deal with the infection of the tissues around the implants[66]. All the things mentioned above, either directly or indirectly, can affect the survival rate of dental implants.

The present meta-analysis showed that MBL around implants was significantly higher in patients with diabetes than in patients without diabetes. Based on the findings of a study, bone loss around implants can be caused by hyperglycemia[67]. Also, a study showed that the increase in glycemic level is directly related to the prevalence of peri-implantitis[68]. Since the effects of various factors in diabetic patients lead to an increase in MBL; Therefore, it is necessary to control the tissues around the implant in patients with diabetes. A study showed that treating periodontal disease to control blood sugar does not improve blood sugar control in diabetic patients[69]; However, periodontitis was considered and not peri-implantitis. One of the interesting points is the importance of investigating the effect of different implant levels on MBL in patients with diabetes, which can affect the survival rate. Meta-analysis showed that the survival rate of dental implants in the upper jaw between diabetic and non-diabetic patients is statistically significant. It was also observed that implant failure in patients with type 1 diabetes was much more common than in type 2. The cause of these findings can depend on the difference in the pathophysiology of type 1 and type 2 diabetes, treatment regimen, and metabolic control. Symptoms may be more severe in patients with type 1 diabetes. As it is evident, type 1 diabetes begins at a younger age, and its micro and macrovascular complications are observed earlier[70]. Also, bone loss occurs earlier in patients with type 1 diabetes[71]. All the mentioned cases can cause patients with type 1 diabetes damage to the implant, and the bone site is more than in patients with type 2 diabetes. One of the limitations of the study was that few studies reported the mean MBL with standard deviation, which could affect the study results.

Conclusion

Based on the findings of the present study, the survival rate of implants in patients with diabetes was lower than in patients without diabetes. Also, marginal bone loss was higher in patients with diabetes than in the control group. Compared to the type of diabetes in affected people, it was observed that patients with type 1 diabetes are more at risk of dental implant failure.

Conflict of Interest

The authors declared that there is no conflict of interest.

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Authors contribution

Asal Moravej: Methodology, Data analysis, Writing - Original Draft and Writing - Review and Editing.

Elnaz Mousavi: Methodology, Review and Editing.

Amir Azizi: Methodology, Writing - Original Draft and Writing - Review and Editing.

Ali Amiri: Conceptualization, Methodology, Formal Analysis, Investigation, Writing - Original Draft, Writing - Review and Editing and Visualization.

Ayda Sameie: Validation and Writing - Review and Editing.

Data availability

Datasets related to this article will be available upon request to the corresponding author.

References

1. Foster NB. Diabetes mellitus. Lippincott; 1915. 243p.
2. Shaw JE, Sicree RA, Zimmet PZ. Global estimates of the prevalence of diabetes for 2010 and 2030. Diabetes Res Clin Pract. 2010 Jan;87(1):4-14. doi: 10.1016/j.diabres.2009.10.007.
3. Preshaw PM, Bissett SM. Periodontitis and diabetes. Br Dent J. 2019 Oct;227(7):577-584. doi: 10.1038/s41415-019-0794-5.
4. American Diabetes Association. Diagnosis and classification of diabetes mellitus. Diabetes care. 2014;37(Suppl 1):S81-90. doi: 10.2337/dc14-S081.
5. Munshi M, Slyne C, Adam A, Davis DQ, Michals A, Atakov-Castillo A, et al. Impact of diabetes duration on functional and clinical status in older adults with type 1 Diabetes. Diabetes Care. 2022 Mar;45(3):754-57. doi: 10.2337/dc21-2000.
6. Dal Canto E, Ceriello A, Rydén L, Ferrini M, Hansen TB, Schnell O, et al. Diabetes as a cardiovascular risk factor: an overview of global trends of macro and micro vascular complications. Eur J Prev Cardiol. 2019 Dec;26(2_suppl):25-32. doi: 10.1177/2047487319878371.
7. Onyema Oshim I, Regina Agbakoba N, Celestine Oguejiofor O, Anukam KC. Selective microbial biomarkers in type-2 diabetes with principal component analysis and receiver-operating characteristic curves. Int J Sci Res Dent Med Sci. 2021;3(1):23-34. doi: 10.30485/ijsrdms.2021.272435.1110.
8. Guha G, Das A. A study of visual evoked potential for functional assessment of visual pathway in ophthalmologically Normal diabetes mellitus patients. Int J Sci Res Dent Med Sci. 2021;3(3):133-40. doi: 10.30485/ijsrdms.2021.295355.1173.

9. Vijayakumar V, Samal SK, Mohanty S, Nayak SK. Recent advancements in biopolymer and metal nanoparticle-based materials in diabetic wound healing management. Int J Biol Macromol. 2019 Feb;122:137-48. doi: 10.1016/j.ijbiomac.2018.10.120.

10. Elgouhari HM, Zein CO, Hanouneh I, Feldstein AE, Zein NN. Diabetes mellitus is associated with impaired response to antiviral therapy in chronic hepatitis C infection. Dig Dis Sci. 2009;54(12):2699-705. doi: 10.1007/s10620-008-0683-2.

11. Zhou Y, Chi J, Lv W, Wang Y. Obesity and diabetes as high-risk factors for severe coronavirus disease 2019 (Covid-19). Diabetes Metab Res Rev. 2021;37(2):e3377. doi: 10.1002/dmrr.3377.

12. Tabák AG, Brunner EJ, Lindbohm JV, Singh-Manoux A, Shipley MJ, Sattar N, et al. Risk of macrovascular and microvascular disease in diabetes diagnosed using oral glucose tolerance test with and without confirmation by hemoglobin A1c: the whitehall ii cohort study. Circulation. 2022;146(13):995-1005. doi: 10.1161/CIRCULATIONAHA.122.059430.

13. Moelands SV, Lucassen PL, Akkermans RP, De Grauw WJ, Van de Laar FA. Alpha-glucosidase inhibitors for prevention or delay of type 2 diabetes mellitus and its associated complications in people at increased risk of developing type 2 diabetes mellitus. Cochrane Database Syst Rev. 2018 Dec 28;12(12):CD005061. doi: 10.1002/14651858.CD005061.pub3.

14. Vashist SK, Schleicher E, Luppa PB, Luong JHT. Glycated haemoglobin (HbA1c) monitoring for diabetes diagnosis, management and therapy. In: Vashist SK, Luong JHT. Point-of-care glucose detection for diabetic monitoring and management. Boca Raton: CRC Press; 2017. Chapter 5.

15. Jansen H. Determinants of HbA1c in non-diabetic children and adults. University Groningen; 2011.

16. Evans M, Welsh Z, Ells S, Seibold A. The impact of flash glucose monitoring on glycaemic control as measured by HbA1c: a meta-analysis of clinical trials and real-world observational studies. Diabetes Ther. 2020 Jan;11(1):83-95. doi: 10.1007/s13300-019-00720-0.

17. Ghasemnia B, Kordi S, Mehraban SH, Azizi A, Moravej A, Salehi M. Evaluation of the success rate of endoscopic sinus surgery after dental implantation: a systematic review and meta-analysis. Int J Sci Res Dent Med Sci. 2022;4(3):134-9. doi: 10.30485/ijsrdms.2022.359443.1362.

18. National Institutes of Health. National Heart, Lung, and Blood Institute. Study Quality Assessment Tools. 2021 Jul [cited 2022 Apr 15]. Available from: https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools.

19. Coskunses FM, Tak Ö. Clinical performance of narrow-diameter titanium–zirconium implants in immediately loaded fixed full-arch prostheses: a 2-year clinical study. Int J Implant Dent. 2021 Apr;7(1):30. doi: 10.1186/s40729-021-00312-3.

20. Boboeva O, Kwon TG, Kim JW, Lee ST, Choi SY. Comparing factors affecting dental-implant loss between age groups: a retrospective cohort study. Clin Implant Dent Relat Res. 2021 Apr;23(2):208-15. doi: 10.1111/cid.12967.

21. Troiano G, Luongo R, Romano DC, Galli M, Ravidà A, Wang HL, et al. Comparison of immediate versus delayed implant placement in a failed implant site: A retrospective analysis of early implant survival. Int J Oral Implantol (Berl). 2021 Mar;14(1):67-76.

22. Schoenbaum TR, Moy PK, Aghaloo T, Elashoff D. Risk Factors for dental implant failure in private practice: a multicenter survival analysis. Int J Oral Maxillofac Implants. 2021 Mar-Apr;36(2):388-94. doi: 10.11607/jomi.8983.

23. Sicilia A, Gallego L, Sicilia P, Mallo C, Cuesta S, Sanz M. Crestal bone loss associated with different implant surfaces in the posterior mandible in patients with a history of periodontitis. a retrospective study. Clin Oral Implants Res. 2021 Jan;32(1):88-99. doi: 10.1111/clr.13682.

24. Tattan M, Puranam M, Comnick C, McBrearty C, Xie XJ, Caplan DJ, et al. Surgery start time and early implant failure: A case–control study. Clin Oral Implants Res. 2021 Jul;32(7):871-80. doi: 10.1111/clr.13763.

25. Stacchi C, Troiano G, Rapani A, Lombardi T, Sentineri R, Speroni S, et al. Factors influencing the prevalence of peri-implantitis in implants inserted in augmented maxillary sinuses: a multicenter cross-sectional study. J Periodontol. 2021 Aug;92(8):1117-25. doi: 10.1002/JPER.20-0483.

26. Werbelow L, Weiss M, Schramm A. Long-term follow-up of full-arch immediate implant-supported restorations in edentulous jaws: a clinical study. Int J Implant Dent. 2020 Jul;6(1):34. doi: 10.1186/s40729-020-00232-8.

27. Wang J, Lerman G, Bittner N, Fan W, Lalla E, Papapanou PN. Immediate versus delayed temporization at posterior single implant sites: a randomized controlled trial. J Clin Periodontol. 2020 Oct;47(10):1281-91. doi: 10.1111/jcpe.13354.

28. Rondon Romero JL, Ortiz Garcia I, Jiménez Guerra A, Matos Garrido N, España López A, Monsalve Guil L, et al. [Treatment with implants in patients with diabetes. A 7-year comparative study]. Av Odontoestomatol. 2020;36(2):81-8. Spanish. doi: 10.4321/s0213-12852020000200004.

29. Park SH, Song YW, Sanz-Martín I, Cha JK, Lee JS, Jung UW. Clinical benefits of ridge preservation for implant placement compared to natural healing in maxillary teeth: a retrospective study. J Clin Periodontol. 2020 Mar;47(3):382-91. doi: 10.1111/jcpe.13231.

30. Lobato RP, Kinalski MD, Martins TM, Agostini BA, Bergoli CD, Dos Santos MB. Influence of low-level laser therapy on implant stability in implants placed in fresh extraction sockets: a randomized clinical trial. Clin Implant Dent Relat Res. 2020 Jun;22(3):261-9. doi: 10.1111/cid.12904.

31. Higuchi K, Rosenberg R, Davó R, Albanese M, Liddelow G. A prospective single-cohort multicenter study of an innovative prefabricated three-implant-supported full-arch prosthesis for treatment of edentulous mandible: 1-year report. Int J Oral Maxillofac Implants. 2020 Jan/Feb;35(1):150-9. doi: 10.11607/jomi.7650.

32. Feher B, Lettner S, Heinze G, Karg F, Ulm C, Gruber R, et al. An advanced prediction model for postoperative complications and early implant failure. Clin Oral Implants Res. 2020 Oct;31(10):928-35. doi: 10.1111/clr.13636.

33. Chang LC. Risk factors associated with early failure of maxillary versus mandibular implants: a retrospective study. Int J Oral Implantol (Berl). 2020;13(1):55-63.

34. Atarchi AR, Miley DD, Omran MT, Abdulkareem AA. Early failure rate and associated risk factors for dental implants placed with and without maxillary sinus augmentation: a retrospective study. Int J Oral Maxillofac Implants. 2020 Nov/Dec;35(6):1187-94. doi: 10.11607/jomi.8447.

35. Alqahtani F, Alqhtani N, Alkhtani F, Devang Divakar D, Al-Kheraif AA, Javed F. Clinicoradiographic markers of peri-implantitis in cigarette-smokers and never-smokers with type 2 diabetes mellitus at 7-years follow-up. J Periodontol. 2020 Sep;91(9):1132-8. doi: 10.1002/JPER.19-0501.

36. de Souza CS, Ortega-Lopes R, Barreno AC, De Moraes M, Albergaria-Barbosa JR, Nóia CF. Analysis of the survival of dental implants installed in reconstructed maxilla with autogenous iliac crest graft: 7-to 9-year follow-up. J Oral Implantol. 2019 Dec;45(6):427-36. doi: 10.1563/aaid-joi-D-18-00321.

37. Alsahhaf A, Alshiddi IF, Alshagroud RS, Al-Aali KA, Vohra F, Abduljabbar T. Clinical and radiographic indices around narrow diameter implants placed in different glycemic-level patients. Clin Implant Dent Relat Res. 2019 Aug;21(4):621-6. doi: 10.1111/cid.12778.

38. Klotz AL, Ott L, Krisam J, Schmitz S, Seyidaliyeva A, Rammelsberg P, et al. Short-term performance of implant-supported restorations fitted in general dental practice: a retrospective study. Int J Oral Maxillofac Implants. 2019;34(5):1169–16. doi: 10.11607/jomi.7400.

39. Lee KJ, Cha JK, Sanz-Martin I, Sanz M, Jung UW. A retrospective case series evaluating the outcome of implants with low primary stability. Clin Oral Implants Res. 2019 Sep;30(9):861-71. doi: 10.1111/clr.13491.

40. Romandini M, Cordaro M, Donno S, Cordaro L. Discrepancy between patient satisfaction and biologic complication rate in patients rehabilitated with overdentures and not participating in a structured maintenance program after 7 to 12 years of loading. Int J Oral Maxillofac Implants. 2019;34(5):1143-51. doi: 10.11607/jomi.7465.

41. Altay MA, Tozoğlu S, Yıldırımyan N, Ozarslan MM. Is History of periodontitis a risk factor for peri-implant disease? a pilot study. Int J Oral Maxillofac Implants. 2018;33(1):152-60. doi: 10.11607/jomi.5781.

42. Nogueira TE, Aguiar FM, de Barcelos BA, Leles CR. A 2-year prospective study of single-implant mandibular overdentures: Patient-reported outcomes and prosthodontic events. Clin Oral Implants Res. 2018 Jun;29(6):541-50. doi: 10.1111/clr.13151.

43. Saridakis SK, Wagner W, Noelken R. Retrospective cohort study of a tapered implant with high primary stability in patients with local and systemic risk factors—7-year data. Int J Implant Dent. 2018 Dec;4(1):41. doi: 10.1186/s40729-018-0151-5.

44. Kim S, Jung UW, Cho KS, Lee JS. Retrospective radiographic observational study of 1692 Straumann tissue-level dental implants over 10 years: I. Implant survival and loss pattern. Clin Implant Dent Relat Res. 2018 Oct;20(5):860-6. doi: 10.1111/cid.12659.

45. Niedermaier R, Stelzle F, Riemann M, Bolz W, Schuh P, Wachtel H. Implant-supported immediately loaded fixed full-arch dentures: evaluation of implant survival rates in a case cohort of up to 7 years. Clin Implant Dent Relat Res. 2017 Feb;19(1):4-19. doi: 10.1111/cid.12421.

46. Norton MR. The influence of low insertion torque on primary stability, implant survival, and maintenance of marginal bone levels: a closed-cohort prospective study. Int J Oral Maxillofac Implants. 2017 Jul/Aug;32(4):849-57. doi: 10.11607/jomi.5889.

47. Boardman N, Darby I, Chen S. A retrospective evaluation of aesthetic outcomes for single-tooth implants in the anterior maxilla. Clin Oral Implants Res. 2016 Apr;27(4):443-51. doi: 10.1111/clr.12593.

48. Chrcanovic BR, Kisch J, Albrektsson T, Wennerberg A. Factors influencing early dental implant failures. J Dent Res. 2016 Aug;95(9):995-1002. doi: 10.1177/0022034516646098.

49. Daneshvar SS, Matthews DC, Michuad PL, Ghiabi E. Success and survival rates of dental implants restored at an undergraduate dental clinic: a 13-year retrospective study with a mean follow-up of 5.8 years. Int J Oral Maxillofac Implants. 2016 Jul-Aug;31(4):870-5. doi: 10.11607/jomi.4507.

50. Gherlone EF, Capparé P, Tecco S, Polizzi E, Pantaleo G, Gastaldi G, et al. Implant prosthetic rehabilitation in controlled HIV-positive patients: a prospective longitudinal study with 1-year follow-up. Clin Implant Dent Relat Res. 2016 Aug;18(4):725-34. doi: 10.1111/cid.12353.

51. Ghiraldini B, Conte A, Casarin RC, Casati MZ, Pimentel SP, Cirano FR, et al. Influence of glycemic control on peri-implant bone healing: 12-month outcomes of local release of bone-related factors and implant stabilization in type 2 diabetics. Clin Implant Dent Relat Res. 2016 Aug;18(4):801-9. doi: 10.1111/cid.12339.

52. Kappel S, Giannakopoulos NN, Eberhard L, Rammelsberg P, Eiffler C. Immediate loading of dental implants in edentulous mandibles by use of l ocator® attachments or d older® bars: two-year results from a prospective randomized clinical study. Clin Implant Dent Relat Res. 2016 Aug;18(4):752-61. doi: 10.1111/cid.12349.

53. Malchiodi L, Balzani L, Cucchi A, Ghensi P, Nocini PF. Primary and secondary stability of implants in postextraction and healed sites: a randomized controlled clinical trial. Int J Oral Maxillofac Implants. 2016 Nov/Dec;31(6):1435-43. doi: 10.11607/jomi.4710.

54. Zumstein T, Sennerby L. A 1-year clinical and radiographic study on hydrophilic dental implants placed with and without bone augmentation procedures. Clin Implant Dent Relat Res. 2016 Jun;18(3):498-506. doi: 10.1111/cid.12329.

55. Maló P, de Araújo Nobre M, Gonçalves Y, Lopes A. Long-term outcome of implant rehabilitations in patients with systemic disorders and smoking habits: A retrospective clinical study. Clin Implant Dent Relat Res. 2016 Aug;18(4):649-65. doi: 10.1111/cid.12346.

56. Chrcanovic BR, Albrektsson T, Wennerberg A. Diabetes and oral implant failure: a systematic review. J Dent Res. 2014 Sep;93(9):859-67. doi: 10.1177/0022034514538820.

57. Shang R, Gao L. Impact of hyperglycemia on the rate of implant failure and peri-implant parameters in patients with type 2 diabetes mellitus: systematic review and meta-analysis. J Am Dent Assoc. 2021 Mar;152(3):189-201.e1. doi: 10.1016/j.adaj.2020.11.015.

58. Wagner J, Spille JH, Wiltfang J, Naujokat H. Systematic review on diabetes mellitus and dental implants: An update. Int J Implant Dent. 2022 Jan;8(1):1. doi: 10.1186/s40729-021-00399-8.

59. Iki M, Fujita Y, Kouda K, Yura A, Tachiki T, Tamaki J, et al. Hyperglycemia is associated with increased bone mineral density and decreased trabecular bone score in elderly Japanese men: the Fujiwara-kyo osteoporosis risk in men (FORMEN) study. Bone. 2017 Dec:105:18-25. doi: 10.1016/j.bone.2017.08.007.

60. Romero-Díaz C, Duarte-Montero D, Gutiérrez-Romero SA, Mendivil CO. Diabetes and bone fragility. Diabetes Ther. 2021 Jan;12(1):71-86. doi: 10.1007/s13300-020-00964-1.

61. Joshi A, Varthakavi P, Chadha M, Bhagwat N. A study of bone mineral density and its determinants in type 1 diabetes mellitus. J Osteoporos. 2013:2013:397814. doi: 10.1155/2013/397814.

62. Lu X, Yu S, Chen G, Zheng W, Peng J, Huang X, et al. Insight into the roles of melatonin in bone tissue and bone-related diseases. Int J Mol Med. 2021 May;47(5):82. doi: 10.3892/ijmm.2021.4915.

63. Nibali L, Gkranias N, Mainas G, Di Pino A. Periodontitis and implant complications in diabetes. Periodontol 2000. 2022 Oct;90(1):88-105. doi: 10.1111/prd.12451.

64. Hu XF, Wang L, Xiang G, Lei W, Feng YF. Angiogenesis impairment by the NADPH oxidase-triggered oxidative stress at the bone-implant interface: critical mechanisms and therapeutic targets for implant failure under hyperglycemic conditions in diabetes. Acta Biomater. 2018 Jun:73:470-87. doi: 10.1016/j.actbio.2018.04.008.

65. Ekwebene OC, Nnamani CP, Edeh CG, Obidile CV, Tyotswame YS. Prevalence of falciparum malaria in conjunction with age, gravidity, abo blood group/rhesus factor, and genotype Among gravid women in south-eastern Nigeria. Int J Sci Res Dent Med Sci. 2021;3(1):12-7. doi: 10.30485/ijsrdms.2021.272680.1112.

66. Belibasakis GN. Microbiological and immuno-pathological aspects of peri-implant diseases. Arch Oral Biol. 2014 Jan;59(1):66-72. doi: 10.1016/j.archoralbio.2013.09.013.

67. Yamazaki S, Masaki C, Nodai T, Tsuka S, Tamura A, Mukaibo T, et al. The effects of hyperglycaemia on peri-implant tissues after osseointegration. J Prosthodont Res. 2020 Apr;64(2):217-23. doi: 10.1016/j.jpor.2019.07.007.

68. Monje A, Catena A, Borgnakke WS. Association between diabetes mellitus/hyperglycaemia and peri-implant diseases: systematic review and meta-analysis. J Clin Periodontol. 2017 Jun;44(6):636-48. doi: 10.1111/jcpe.12724.

69. Simpson TC, Weldon JC, Worthington HV, Needleman I, Wild SH, Moles DR, et al. Treatment of periodontal disease for glycaemic control in people with diabetes mellitus. Cochrane Database Syst Rev. 2015 Nov;2015(11):CD004714. doi: 10.1002/14651858.CD004714.pub3.

70. Tachkov K, Mitov K, Koleva Y, Mitkova Z, Kamusheva M, Dimitrova M, et al. Life expectancy and survival analysis of patients with diabetes compared to the non diabetic population in Bulgaria. PloS one. 2020 May;15(5):e0232815. doi: 10.1371/journal.pone.0232815.

71. Henderson S, Ibe I, Cahill S, Chung YH, Lee FY. Bone quality and fracture-healing in type-1 and type-2 diabetes mellitus. J Bone Joint Surg Am. 2019 Aug;101(15):1399-410. doi: 10.2106/JBJS.18.01297.