




The Comparison of Survival Rates between Narrow Diameter Implants and Standard Diameter Implants: An Updated Meta-analysis

Kimia Ganji¹, Masomeh Rostamzadeh¹, Ideh Talimkhani², Yousef Moradi^{3,4*} 

Received: 13 Sep 2022

Published: 9 Feb 2023

Abstract

Background: One of the key objectives is to update knowledge in order to develop treatment and care recommendations based on research findings. The purpose of the present meta-analysis was to compare the survival rate of narrow dental implants (NDI) with standard dental implants (SDI).

Methods: The international databases targeted for conducting a broad search included PubMed (Medline), Scopus, Web of Sciences, and Embase (Elsevier), which were searched to retrieve articles from January 1, 2000, to the end of July 2022. After the search, studies were screened based on the title, abstract, and full text, and finally, information extraction and quality assessment of the articles were performed based on the Newcastle-Ottawa Quality Assessment Scale checklist. All analyzes were conducted in STATA software Version 17.

Results: After the screening, 8 retrospective and prospective cohort studies remained in the research for analysis. The outcomes demonstrated that the probability of healthy teeth in the 2 groups of NDI and SDI was not substantially different at least a year after implantation, and the risk ratio of tooth loss in the NDI group was comparable to that of the SDI group (RR, 1.00; 95% CI, 0.98, 1.02; I²: 28.37 %; *P* = 0.252). In addition, the survival rates in the 2 groups were also measured using meta-analysis and the results showed the survival rates in the 2 groups of NDI and SDI were almost equal. In the SDI group, the survival rate was equal to 94% (95% CI, 90%-98%), and in the NDI group, it was equal to 94% (95% CI, 92%- 98%).

Conclusion: Based on the results of the present meta-analysis, the survival rates in the both NDI and SDI groups were almost equal.

Keywords: Survival Rate, Narrow Diameter Implants, Standard Diameter Implants, Meta-Analysis

Conflicts of Interest: None declared

Funding: Kurdistan University of Medical Sciences supported this work (Ethical Code: IR.MUK.REC.1401.223). Funders had no role in the design and conducting of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

*This work has been published under CC BY-NC-SA 1.0 license.

Copyright© Iran University of Medical Sciences

Cite this article as: Ganji K, Rostamzadeh M, Talimkhani I, Moradi Y. The Comparison of Survival Rates between Narrow Diameter Implants and Standard Diameter Implants: An Updated Meta-analysis. *Med J Islam Repub Iran.* 2023 (9 Feb);37:5. <https://doi.org/10.47176/mjiri.37.5>

Introduction

Dental implants (DI) are stabilizers used as a substitute for the root of a lost natural tooth. Nowadays, implants are considered as a suitable treatment and their use are expanding due to their advantages such as not needing to grind adjacent teeth and preventing bone loss (1, 2). Considering the increase in demand for this treatment, investi-

gation of the factors affecting this treatment process is inevitable (3). Also, examining and recognizing the differences between different implant methods can be highly important to determine and choose the appropriate and satisfactory one (4). As stated by the results of published studies, factors related to the patients' general health, in-

Corresponding author: Dr Yousef Moradi, Yousef.Moradi@muk.ac.ir

¹ Department of Prosthodontics, Faculty of Dentistry, Kurdistan University of Medical Sciences, Kurdistan, Iran

² Department of Oral and Maxillofacial Surgery, School of Dentistry, Besat Hospital, Hamedan University of Medical Sciences, Hamedan, Iran.

³ Social Determinants of Health Research Center, Research Institute for Health Development, Kurdistan University of Medical Sciences, Sanandaj, Iran

⁴ Department of Epidemiology and Biostatistics, Faculty of Medicine, Kurdistan University of Medical Sciences, Sanandaj, Iran

↑What is “already known” in this topic:

One of the main goals is to update information so that treatment and care recommendations can be made based on study findings. Thus, this study was conducted as a meta-analysis and aimed to compare the survival rate of narrow dental implants (NDI) with standard (SDI) ones.

→What this article adds:

The results of this meta-analysis showed that the survival rate in narrow implants was almost equal to that in standard implants and there was no significant difference between the 2 groups, but the mean marginal bone loss in narrow implants was significantly lower than that of standard implants.

cluding metabolic, hematological, and hormonal diseases, the quality and volume of remaining bone, age, sex, life-style and diet, parafunctional habits, culture and occupation, smoking, and alcohol consumption, and the oral hygiene status are among the basic factors affecting the success or failure of the implant (5-8). In addition, regarding the implant itself, factors such as the shape, length, and diameter of the implant selected according to the type of bone and anatomical areas of the jaws can affect the durability and survival of the teeth (9, 10). Increasing the length or diameter of the implant is one of the factors that increase the overall surface area of the implant. In 1977, the standard diameter for the implant was considered to be 3.75 mm, but later, based on the need, implants with a diameter of 4 or 5 mm were also used. The standard length or diameter can reduce the stress on the bone by standard distribution of occlusal force and increasing its area. On the other hand, increasing the diameter or length without considering the introduced standards can be too destructive for the tooth bone (11). Extensive studies have been conducted in the world to investigate the implant diameter effect on the treatment success rate, such as the survival rate and durability of the tooth, but their results are very contradictory and different. The results of some studies indicate the success of treatment following the use of implants with a diameter of 5 mm, while other studies have reported an increase in the treatment failure rate when using implants with a diameter of 5 mm compared with 3.75 or 4 mm (12, 13). Due to the fact that one of the most important methods of replacing lost teeth is implants with a narrow thickness, and with the expansion of studies and research in order to know the biomechanical properties of the mouth and teeth, the implant components have undergone many changes in terms of external geometry and microstructures. Therefore, different studies are needed to compare different methods and types of implants. On the other hand, updating information to develop treatment and care guidelines using the results of studies are also considered as one of the important goals. Thus, this meta-analysis study aimed to compare the survival rate of narrow dental implants (NDI) with standard (SDI) implants.

Methods

Search Strategy and Screening Articles

In this meta-analysis, the search databases included PubMed (Medline), Scopus, Web of Sciences, and Em-base (Elsevier), and the search date was from January 1,

2000, to the end of July 2022. To conduct the search, first the main study keywords, including "survival rate," "narrow-diameter implants," and "standard implants" were determined; then their synonyms were found in Mesh (PubMed), Thesaurus (Scopus), and Emtree (Web of Sciences). In the next step, the search strategy was developed in the mentioned databases using "AND" and "OR" search operators. In order to find and retrieve all related articles up to the desired date, references of all selected and final articles were manually searched, and if there were related articles, they were included in the analysis. In the next step, all the search results were entered into the Endnote software Version 9, and duplicate articles were removed. Then, the remaining studies were respectively screened based on the title, abstract, and full text considering the inclusion criteria.

The inclusion criteria in the present meta-analysis were based on the PECOT structure, and studies which met all the desired structures and criteria listed in Table 1 were included in the present meta-analysis. The meta-analysis eliminated review studies, letters to the editor, and other articles with different structures as well as those that did not fit the aforementioned criteria or whose target effect size was not mean or percentage of survival. For studies whose full texts were not available, an email was first sent to their first author. In case of not receiving a suitable answer from the authors, the article was removed from the study because of the lack of access to the full text.

All screening steps were independently performed by two authors. In case of disagreement, the cases were referred to the third person.

Data Extraction

To extract information, first, a checklist was designed based on the results of selected studies and the opinion of experts participating in the present meta-analysis. This checklist included questions about the author, publication year, study type, sample size, country, number of implants, survival rate, mean bleeding, marginal bone loss (MBL), probing pocket depth (PPD), location of implantation, and duration of follow-up in the studies.

Evaluation of the Risk of Bias

The NOS (Newcastle-Ottawa Quality Assessment Scale) checklist was used to evaluate the quality of the articles. This checklist is designed for the qualitative evaluation of cohort studies. Each of these items is given a score of 1 if observed in the studies. The maximum score

Table 1. Criteria for inclusion of studies in the present meta-analysis

Population (P)	Exposure (E)	Comparison (C)	Outcome (O)	Type of Study (T)
The target population in this meta-analysis had no special restrictions.	The target exposure in this meta-analysis included the use of NDI. The time period considered in this meta-analysis was 12 months after implantation. Desired definition: To define the type of implants, Klein et al.'s classification providing a more comprehensive and specific definition was used. In this classification, NDI are placed in three categories of less than 3, 3 to 3.25 and 3.30 to 3.50 mm.	The comparison group included people who used SDI. The time period considered in this meta-analysis was 12 months after implantation.	The desired outcomes included the survival rate, mean bleeding, MBL and PPD.	All retrospective and prospective cohort studies

for each study is 9. This step was independently conducted by 2 authors, and in case of disagreement, the cases were referred to the third researcher.

Statistical Analysis

The desired effect size in this meta-analysis included the risk ratio and the weighted mean differences (WMD) of bleeding, MBL and PPD in 2 groups of NDI and SDI users. For meta-analysis of the risk ratio, first, the logarithm and standard deviation of the logarithm of the risk ratio of each of the selected studies were calculated and then combined using the fixed effect model. The weighted mean difference index was also used to calculate the mean difference. In this way, the mean difference after the intervention in the both groups were calculated in each of the selected studies and then they were combined using the fixed effect model. To check the heterogeneity and variance between the selected studies, Cochran's Q and I² tests were used. To evaluate publication bias, Egger test was applied. STATA Version 17 software was used to perform all analyses.

Results

In the present meta-analysis, after searching the relevant databases, 2251 articles were retrieved. After removing the duplicates in Endnote software Version 9, a total of 1760 studies were entered into the screening step based on the title and abstract. In this stage, 1466 articles were removed and 294 entered into the next step for evaluation based on the full text. Finally, after removing 286 studies, 8 studies that met the meta-analysis criteria remained (Figure 1).

Out of 8 cohort studies (retrospective or prospective), 5 were conducted in European countries, 2 in America and

Brazil, and 1 in Saudi Arabia. Of the total number of performed implants, 960 were narrow and 486 were standard implants. In the most of the studies, implants were performed in the posterior location. In all studies, the survival rate (by risk ratio) and the mean MBL (by weighted mean difference) in the 2 groups were reported (Table 2).

Risk of Bias

In terms of the article quality evaluation based on the NOS checklist, the results are reported in Table 3. The evaluation results revealed that among the 8 selected studies, 2 scored 9 points, 2 scored 8 points, 2 scored 7 points, and 2 scored 6 points. Therefore, it can be claimed that the majority of the selected studies fall within the category of low risk of bias (Table 3).

Quantitative Results

Survival Rate

All 8 selected cohort studies in the present meta-analysis reported the survival rate in the 2 groups. Only the study of Schiegnitz et al in 2021 reported 5-year and 10-year survival rates, and the rest of the studies reported the survival rate on the duration of their study. Considering the survival percentage and calculating the number of remaining healthy teeth in the 2 groups, the risk ratio was calculated and combined in the selected studies. The lowest risk ratio was related to the study of Arabiam et al in 2019 (RR: 0.94; 95% CI: 0.88, 1.01) and the highest risk ratio was seen in the study of Pieri et al in 2019 (RR: 1.05; 95% CI: 0.97, 1.14). After combining these studies, the pooled risk ratio for healthy teeth was equal to 0.99 in NDIs compared with SDIs.

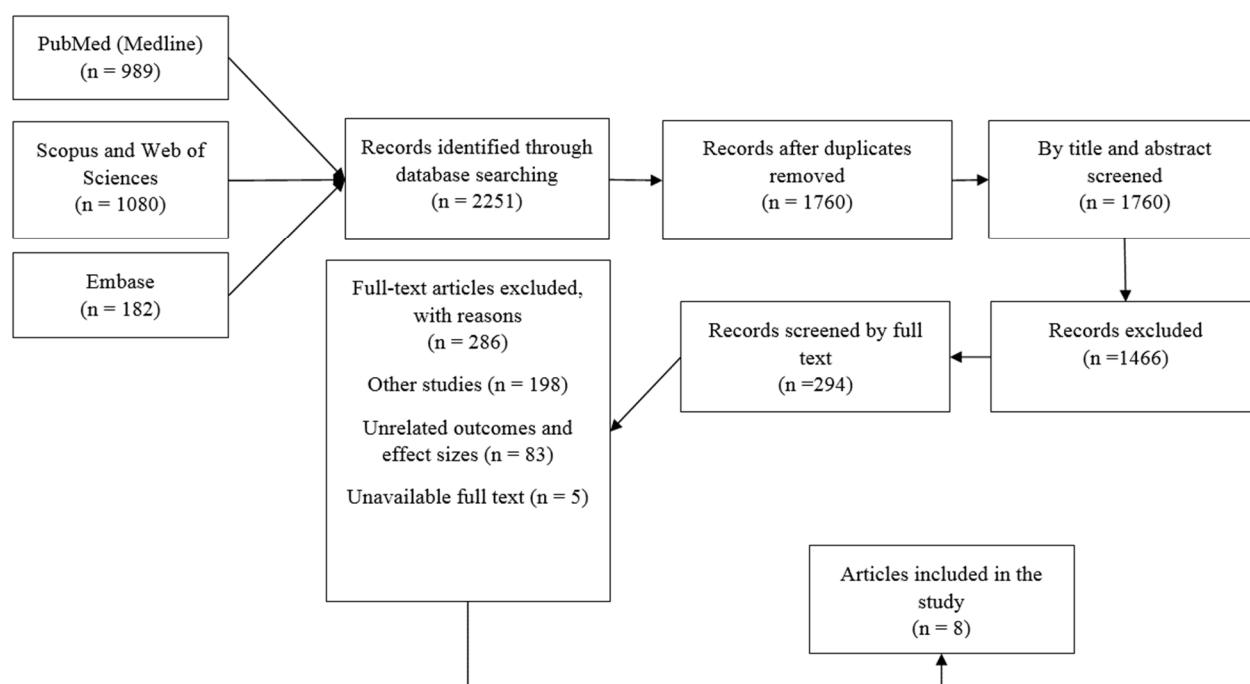


Figure 1. The flowchart of search strategy and article screening results

Survival Rates in Narrow and Standard Diameter Implants

Table 2. Characteristics of included studies in meta-analysis

Authors (Years) (R)	Design (Country)	Total No. Patients (Male/Female), Age (Mean)	Total No. Im-plant (N)		Survival Rate (%) \ success rate%		Location; Follow up(years)	Length	MBL	PPD	Bleeding
			NDI	SDI	NDI	SDI					
Schiegnitz, et al (2021)	Retrospective (Germany)	NDI: 272 (119-153) 64 SDI: 83 (33/50) 60	579	180	5 (Y): 94.3%	5 (Y): 97.0%	Maxilla (5 and 10)	NDI: 8-14mm SDI: 6-16mm	NDI: -0.33 ± 0.8 mm [MMB: -0.31 ± 0.8 ; DBL: -0.35 ± 0.9] SDI: -0.47 ± 1.2 mm [MMB: -0.49 ± 1.2 ; DBL: -0.46 ± 1.2]	NR	NR
Ghazal, et al. (2019)	Prospective (USA)	NR	24	23	100% NR	100% NR	Anterior (1)	NR	NDI: -0.27 ± 0.34 SDI: -0.48 ± 0.67	NR	NR
Souza, et al. (2018)	Prospective (Brazil)	22 (12/10) 53.4	22	22	100% 95%	100% 95%	Posterior (1 and 3)	6-12mm	NDI: -0.58 ± 0.39 SDI: -0.53 ± 0.46 (3 Y follow up) NDI: -0.49 ± 0.27 SDI: -0.42 ± 0.24 (1 Y follow up)	NDI: 5 % SDI: 0 % (3 Y follow up) NDI: 4.5 % SDI: 0 % (1 Y follow up)	NDI: 15 % SDI: 10 % (3 Y follow up) NDI: 9 % SDI: 9 % (1 Y follow up)
Nilsson, et al. (2017)	Prospective (Sweden)	52 (23/29) 22	59	10	100% NR	100% NR	Posterior (5)	NR	NDI: 0.36 ± 0.03 mm SDI: 0.78 ± 0.48 mm	NR	NR
Pieri, et al. (2016)	Retrospective (Italy)	107 (33/74) 61	49	58	97.9% NR	93.1% NR	Posterior (5)	11-15mm	NDI: 0.22 ± 0.33 SDI: 0.27 ± 0.28 (Loading) NDI: 0.95 ± 0.84 SDI: 1.23 ± 0.86 (5 Y follow up)	NR	NR

Table 2. Continued

Authors (Years) (R)	Design (Country)	Total No. Patients (Male/ Female), Age (Mean)	Total No. Implant (N)		Survival Rate (%) \ success rate%		Location; Follow up(years)	Length	MBL	PPD	Bleeding
			NDI	SDI	NDI	SDI					
Zweers, et al. (2015)	Retrospective (Netherlands)	119 (48/71) 69	75	44	100% NR	100% NR	Posterior (1 and 3)	8-12mm	NDI: 3.53 ± 0.54 mm [MMB:3.59±0.53; DBL:3.46±0.61] (1 Y follow up) NDI: 3.84 ± 0.49 mm [MMB:3.80±0.56; DBL:3.89±0.49] (3 Y follow up) SDI: 3.59±0.55 mm [MMB:3.66±0.59; DBL: 3.52±0.56] (1 Y follow up) SDI: 3.73±0.65 mm [MMB:3.71±0.98; DBL: 3.75±0.69] (3 Y follow up)	NDI:1.7 ± 0.58 mm SDI:1.9 ± 0.59 mm (1 Y follow up) NDI:1.6 ± 0.50 mm SDI:1.7 ± 0.65 mm (3 Y follow up)	NR
Bereste, et al. (2021)	Retrospective (Turkey)	28 (15/13) 34	38	28	100% NR	100% NR	Posterior (3)	10-13mm	NDI: 0.84±0.81 mm [MMB:0.80±0.85; DBL: 0.87±0.84] SDI: 0.44±0.65 mm [MMB:0.40±0.75; DBL: 0.48±0.68]	NDI:2.26 ± 0.48 mm SDI:2.27 ± 0.57 mm	NDI: 58 % SDI: 56 %
Arabian, et al. (2019)	Retrospective (Saudi Arabia)	NDI:71 (48/23) 36.9 SDI: 65 (39/26) 41.4	114	121	91.5 % NR	96.9 % NR	NDI:14:(61anterior,53posterior) SDI:121(74anterior,47posterior) (2 to 6)	10-12mm	NDI: 1.3±0.1 mm [MMB:1.1±0.1; DBL: 1.4±0.2] Anterior SDI: 1.6±0.3 mm [MMB:1.3±0.2; DBL: 1.7±0.3] Anterior NDI: 1.4±0.2 mm [MMB:1.2±0.1; DBL: 1.5±0.3] Posterior SDI: 1.7±0.5 mm [MMB:1.5±0.1; DBL: 1.7±0.2] Posterior	NDI:3.1 ± 0.4 mm SDI:3.0 ± 0.8 mm Anterior NDI:3.3 ± 0.6 mm SDI:3.0 ± 0.8 mm Posterior	NDI: 24 % SDI: 28 % Anterior NDI: 35 % SDI: 32 % Posterior

Table 3. Methodological quality scores included in cohort studies using the Newcastle-Ottawa scale

Study	Selection				Comparability	Outcome			Study score /9
	Representativeness of the sample	Selection of the non-exposed cohort	Ascertainment of the exposure	Demonstration that outcome of interest was not present at start of study	The subjects in different outcome groups are comparable, based on the study design or analysis. Confounding factors are controlled.	Assessment of the outcome	Was follow-up long enough for outcomes to occur	Adequacy of follow up of cohorts	
Schiegnitz, et al (2021)	**	*	*	*	*	*	*	*	9
Ghazal, et al. (2019)	*	*	*	*	*	-	-	*	6
Souza, et al. (2018)	-	*	-	*	*	*	*	*	6
Nilsson, et al. (2017)	*	*	*	*	*	*	*	*	8
Pieri, et al. (2016)	*	*	*	*	*	**	*	*	9
Zweers, et al. (2015)	*	*	*	*	*	-	*	*	7
Berceste, et al. (2021)	*	*	*	*	*	*	*	*	8
Arabian, et al. (2019)	*	*	*	*	*	-	*	*	7

Therefore, the probability of healthy teeth in the 2 implant methods can be said not to be significantly different and the risk ratio in the NDI was the same as in the SDI (RR: 1.00; 95% CI: 0.98, 1.02; I2: 28.37%; $P = 0.252$) (Figure 2).

In addition, the survival rate in the 2 groups was also measured using meta-analysis and its results have been shown in Figure 2. As the results of the present meta-analysis showed, survival in both NDI and SDI groups was almost equal. In the SDI group, the survival rate was equal to 94% with a confidence interval of 90% to 98% and in the NDI group, it was equal to 94% with a confidence interval of 92% to 98% (Figure 2).

Marginal Bone Loss

To compare the mean MBL in the 2 groups, the weighted mean difference was used. The results in Figure 3 showed the mean MBL in the NDI group decreased by 0.19 compared with the SDI group, which was statistically

significant because the desired confidence interval did not include zero (WMD: -0.19; 95% CI: -0.29, -0.08; I2: 72.86%; $P = 0.011$) (Figure 3).

Bleeding

To compare the rate of dental bleeding after implantation in the 2 groups, the risk ratio was used according to the results of selected studies. Among the selected studies, 5 reported the risk ratio of bleeding after implantation. The lowest risk ratio was related to the study of Arabian et al in 2019 and the highest risk ratio was in the study by Souza et al in 2018. After combining the results of these articles, the cumulative risk ratio was equal to 1.02 that meant the risk of bleeding after implantation was 2% higher in the NDI group compared with the SDI group, but it was not statistically significant (RR: 1.02; 95% CI: 0.78, 1.34; I2: 0.00%; $P = 0.960$) (Figure 4).

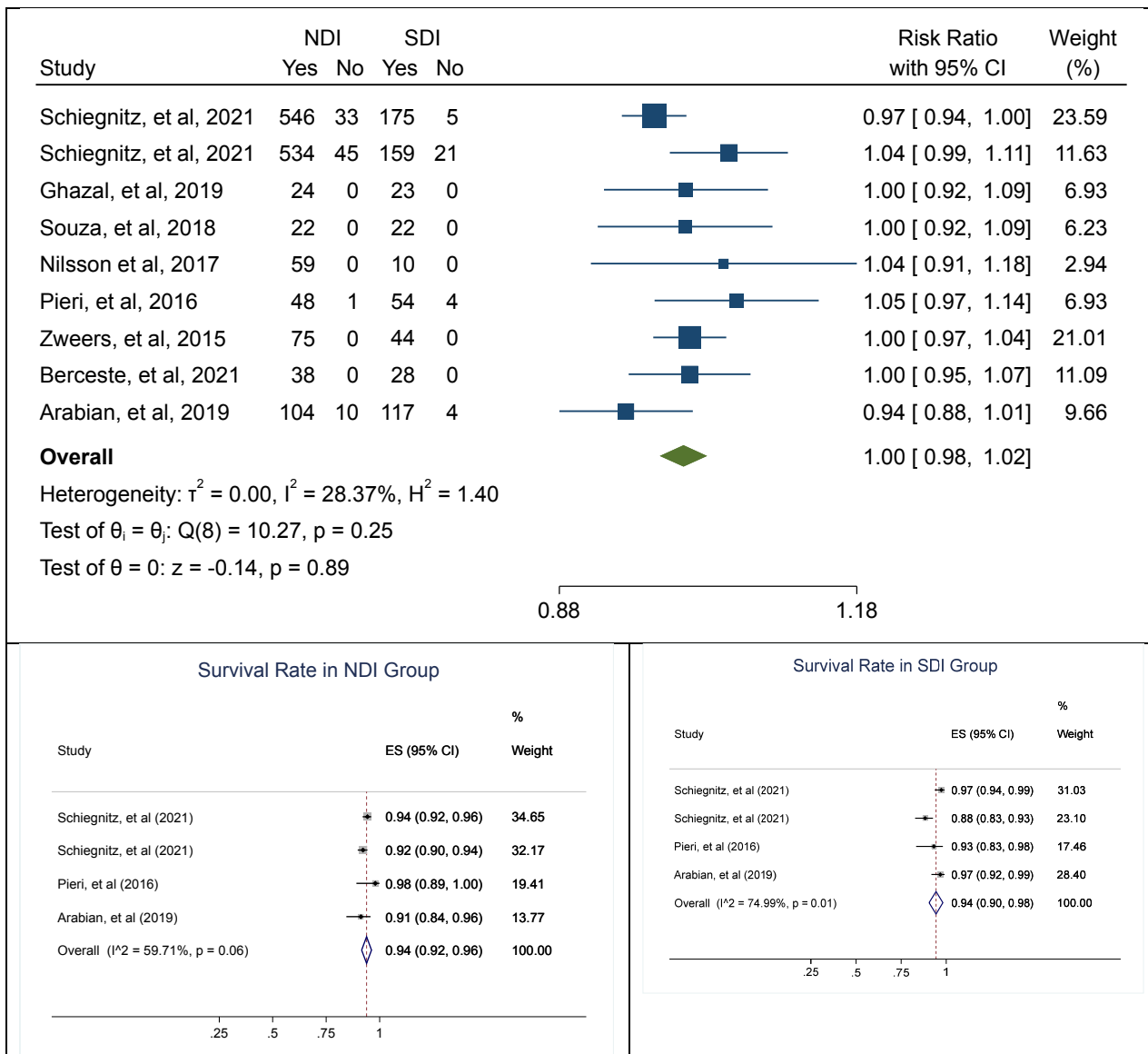
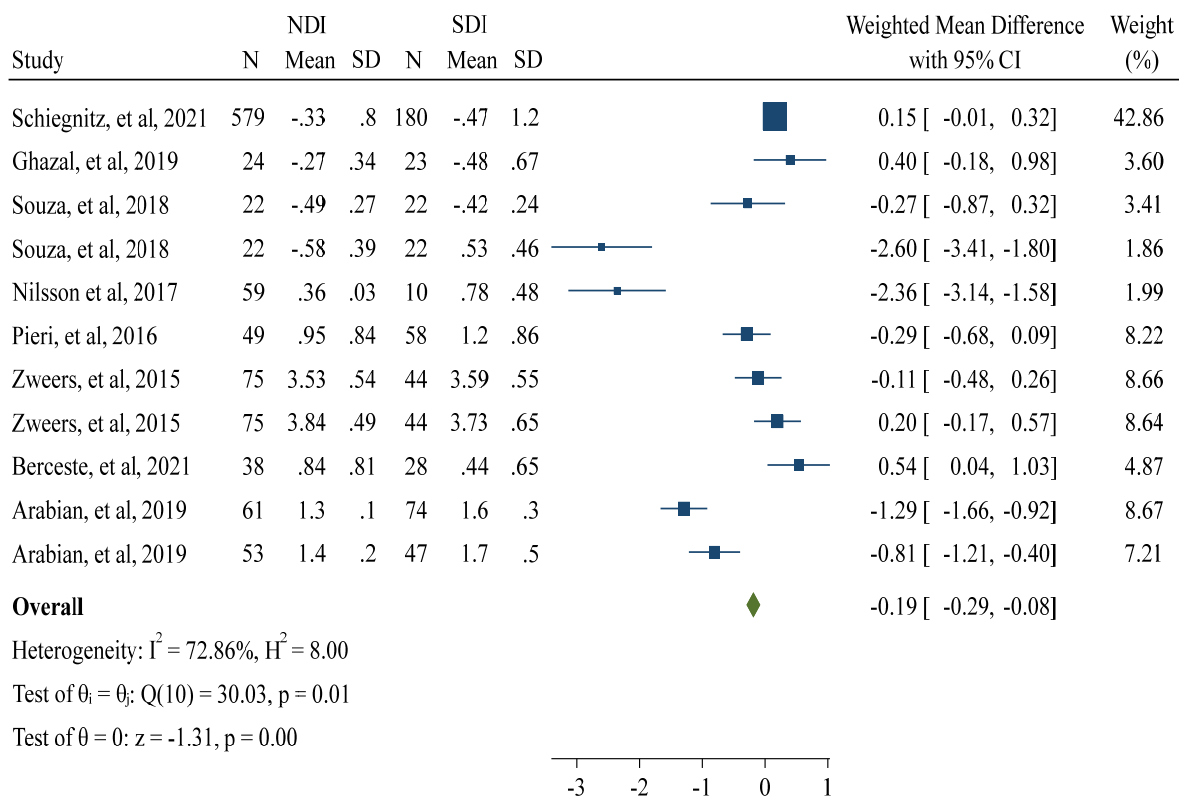
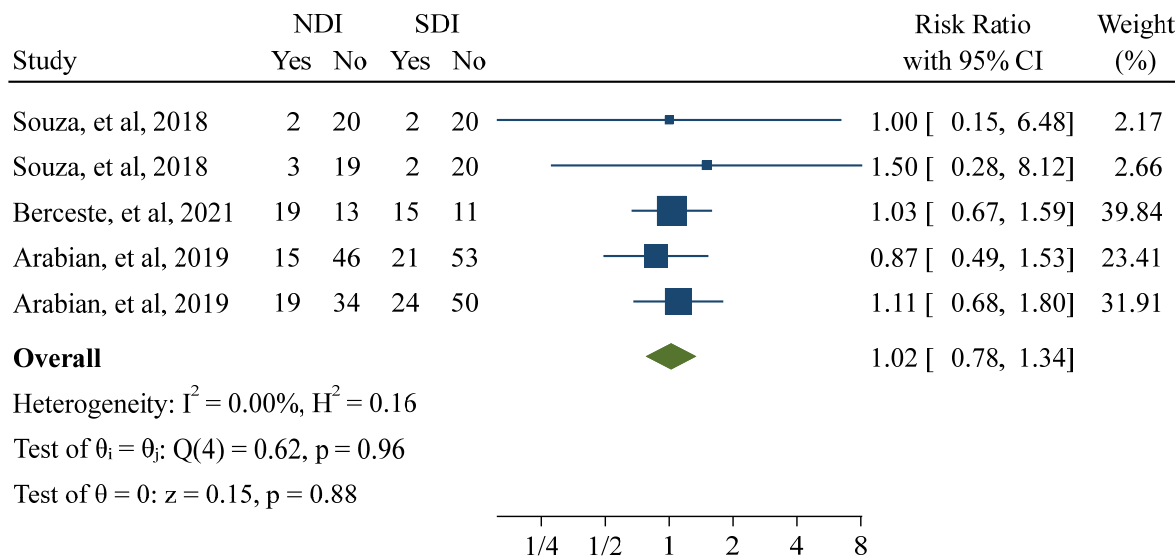


Figure 2. Forest plot presenting comparison the survival rate in narrow diameter implants (NDI) with standard diameter implants (SDI)



Fixed-effects inverse-variance model

Figure 3. Forest plot presenting comparison the weighted mean difference of MBL in narrow diameter implants (NDI) with standard diameter implants (SDI)



Fixed-effects inverse-variance model

Figure 4. Forest plot presenting comparison the bleeding in narrow diameter implants (NDI) with standard diameter implants (SDI)

Probing Pocket Depth

The weighted mean difference was used to compare PPD in the NDI group compared with the SDI group. Five studies reported the mean PPD in the 2 groups after the implantation. After combining the results of these studies,

the weighted mean of PPD in the NDI group was 0.01 higher than that in the SDI group, but this difference was not statistically significant (WMD: 0.01; 95% CI: -0.16, 0.18; I2: 57.17%; $P = 0.051$) (Figure 5).

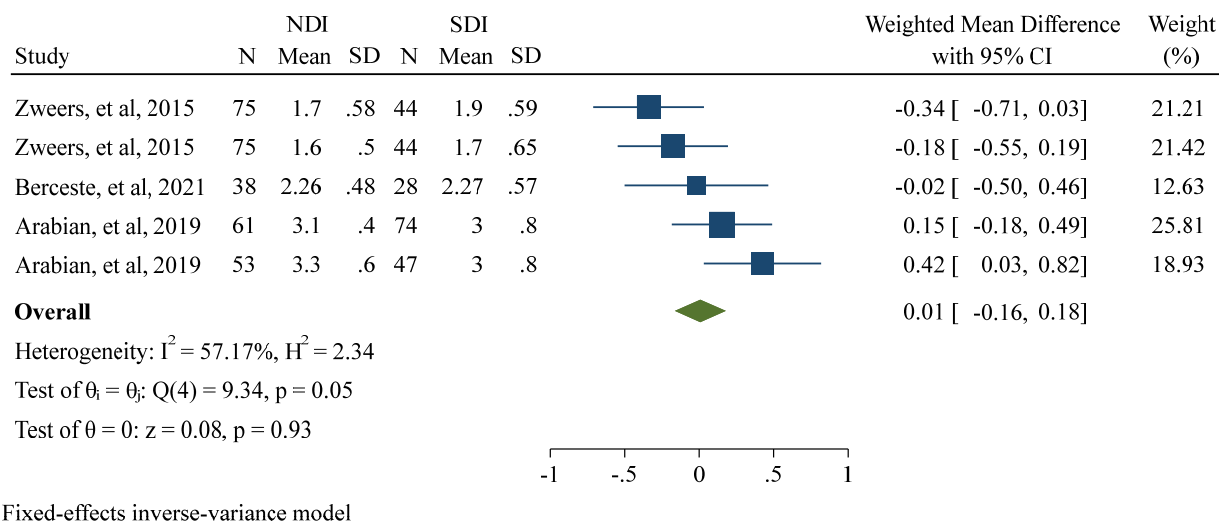


Figure 5. Forest plot presenting comparison the PPD in narrow diameter implants (NDI) with standard diameter implants (SDI)

Table 4. Comparison of weighted mean difference of MBL and risk ratio of survival rate in Narrow Diameter Implants (NDI) with Standard Diameter Implants (SDI) based on time of follow up, bone loss place, and location

Subgroups	Variables	Categorizes	Weighted Mean Difference (95 % CI)	Heterogeneity Assessment		
				I square	Q	P value
MBL (Weighted Mean Difference)	Time of Follow up	1 Year	-0.03 (0.031, 0.25)	31.39 %	2.94	0.231
		3 Year	-0.03 (0.31, 0.25)	45.64 %	8.85	0.095
		5 Year	-0.25 (-0.39, -0.12)	75.45 %	14.33	0.051
	Bone Loss	Mesial	-0.14 (-0.27, -0.02)	16.75 %	3.83	0.210
		Distal	-0.09 (-0.21, 0.03)	33.98 %	7.64	0.097
	Location	Anterior	-0.06 (-0.21, 0.09)	86.06 %	42.91	0.000
Posterior		-0.34 (-0.51, -0.18)	81.56 %	33.88	0.003	
Survival Rate (Risk Ratio)	Time of Follow up	≤3 Year	1.00 (0.98, 1.03)	0.00 %	0.01	0.991
		>3 Year	0.99 (0.96, 1.01)	0.00 %	0.55	0.830
	Location	Anterior	0.98 (0.96, 1.01)	53.77 %	5.49	0.095
		Posterior	1.01 (0.98, 1.04)	0.00 %	1.33	0.860

Subgroup Analyses

Subgroup analysis was performed only for the survival rate and the MBL based on the follow-up duration, bone loss, and location because the number of studies was sufficient in the subgroup analyses of these 2 outcomes. Based on the length of follow-up in a few studies, the weighted mean difference of MBL after 5 years of implantation decreased to 0.25 in the NDI group compared to the SDI group, which was statistically significant (WMD: -0.25; % 95 CI: -0.39, -0.12; I²:75.45 %; $P = 0.095$) (Table 4). This difference in the 5-year follow-up was more than the difference in 1- and 3-year follow-ups.

The mean MBL had a greater decrease in the NDI group compared with the SDI group when the bone loss was of the mesial type (WMD: -0.14; 95% CI: -0.27, -0.02; I²: 16.75%; $P = 0.210$) (Table 4). Also, based on the location, the mean MBL decreased the most in the NDI group compared with the SDI group in the posterior position (WMD: -0.34; 95% CI: -0.51, -0.18; I²: 81.56%; $P \leq 0.001$) (Table 4).

The subgroup analysis results for the survival rate in the both NDI and SDI groups based on the follow-up duration and the desired location were not significantly different, and the survival in the 2 groups was almost equal (Table

4).

Publication Bias

The Egger test was used to assess whether there was any publication bias, and the results proved there was none (B: 1.12; SE: 0.83; $P: 0.178$).

Discussion

The size of the implant determines where it will be placed in the mouth. The SDIs have a diameter between 3.5 and 4.2 mm and are usually used in the post part of the mouth, but the NDIs have a diameter between 2 and 3.5 mm and are used in people who do not have enough space between the teeth roots for implants in the regular size (14-16). Also, this type of implant is used when the patient does not have enough bone density (17). The skill of the DI specialist, posttreatment care, the implant type, and how to care for the teeth are some of the factors affecting the implant success (18). These factors, along with choosing the best implant brand and using the services of the best surgeon and prosthodontist, can bring safe and reliable treatment to the applicants. The advantages of having an implant include naturalness, comfort and ease, natural taste of food, proper nutrition, self-confidence, high re-

sistance, practicality, and extraordinary beauty (19, 20). Considering the increasing demand for implants and their importance, conducting various studies, especially systematic reviews can be very helpful in promoting and increasing knowledge in this field. The purpose of this meta-analysis was to compare the survival rate in the 2 groups of users of NDI and SDI (21, 22).

Implantologists are sometimes challenged by several difficult conditions such as narrow alveolar ridges, narrow interradicular or mesiodistal spaces, and even reduced alveolar height (23, 24). For such clinical conditions, NDIs have been introduced, which have been satisfactory for clients and clinical experts in such a way that these implants have greatly reduced the use of bone grafting and Hyde's surgical method such as the expansion of the alveolar bone crest (25). Clinical research showed the survival and success rates of NDIs were comparable to those of SDIs although there was a possibility of differences between these 2 groups (19, 26). Also, the results of past studies showed NDIs had lower mechanical strength and higher stress level than SDIs. In addition, in NDIs, the risk of creating a prosthesis and its complications and finally the risk of losing the crestal bone were also higher (27-29). However, the results of the present meta-analysis showed that in terms of the survival rate of teeth, narrow implants did not have a statistically significant difference with standard implants and they were almost equal in terms of the survival rate. The use of small diameter implants in edentulous areas with low bone width or a reduced mesiodistal space is considered to be a suitable treatment option compared with ridge widening treatments because it is simpler and less expensive (30-32). On the other hand, using implants with a small diameter, in addition to solving the patient's need for bone width surgery, provides acceptable beauty by delivering the prosthesis to the patient on the day of the surgery (especially if the toothless area is in the anterior) (33). The findings of this meta-analysis showed that using small diameter implants with immediate non-functional loading in the anterior maxillary regions is highly successful in reducing bleeding, MBL, and PPD. Perhaps one of the concerns that made clinicians less likely to choose implants with a smaller diameter was the possibility of implant failure. Also, the survival of teeth in NDIs is not significantly different from the survival in SDIs. Short-term or long-term implant survival and success are related to peri-implant MBL in addition to other key factors. The results of this meta-analysis showed that the weighted mean difference of MBL in the narrow implant group was significantly lower than the one in the standard implant group. Therefore, although the survival in the 2 groups is almost equal, the effective factors that may have an impact on increasing the survival can be said to be more considerable in the narrow implant type.

The results of some published studies showed NDIs were mechanically weaker than other implants (34-37), but the results of the present meta-analysis showed that this was not the case and this type of implant was not different from standard implants in terms of tooth resistance and survival rate. The results of some preliminary studies

were also in line with the findings of the present meta-analysis. Hirata et al found no significant difference in terms of mechanical reliability between narrow implants and other implants (26). Due to insufficient investigations and reports in primary studies, abutment—whose relationship with implants, especially narrow ones, should be further investigated—has been largely disregarded in many studies, notably the current meta-analysis.

According to the results of published studies, the effect of the implant diameter on the loss of MBL is greater than the effect of its shape and length so that in the SDI, all the forces are distributed equally and in a better way on the tooth, and finally by this method, the possibility of tooth and bone loss is reduced, but in narrow implants, based on the results of studies, the mean marginal bone loss or MBL is below 0.4. Therefore, the mean MBL can be said to be higher in narrow implants. However, the results of the present meta-analysis were completely opposite so that they showed that the mean MBL in narrow implants was significantly lower than that of the standard implants.

Despite the effective clinical results shown for NDI in the present meta-analysis, there is a need for clinical trial studies with a large sample size considering longer follow-up periods, different prosthetic conditions and demographic characteristics of patients such as their body mass index, age, and sex. One of the limitations of the present meta-analysis was the small number of cohort studies, which prevented further subgroup analyzes based on the important variables.

Conclusion

The results of this meta-analysis showed that the survival rate in narrow implants was almost equal that of standard implants and there was no significant difference between the 2 groups, but the mean MBL in narrow implants was significantly lower than that of standard implants. The results of the present meta-analysis based on the results of published retrospective studies only provided the clinical results of NDI based on its physical and mechanical properties and should not be fully relied upon. It is necessary to conduct clinical studies such as clinical trials with a large sample size, taking into account all the affecting variables.

Acknowledgment

Not applicable.

Authors' Contributions

Study concept and design: Y.M. Acquisition, analysis, and interpretation of data: Y.M. and K.G. Drafting the manuscript: K.G., Y.M., M.R. and I.T. Critical revision of the manuscript for the important intellectual content: Y.M. Project administration: Y.M. All authors have approved the final manuscript draft.

Availability of Data and Materials

The data extracted for analyses are available by the corresponding author upon reasonable requests.

Conflict of Interests

The authors declare that they have no competing interests.

References

- Aghaloo T, Pi-Anfruns J, Moshaverinia A, Sim D, Grogan T, Hadaya, D. The Effects of Systemic Diseases and Medications on Implant Osseointegration: A Systematic Review. *Int J Oral Maxillofac Implants*. 2019;34.
- Alsaadi G, Quirynen M, Komárek A, Van Steenberghe D. Impact of local and systemic factors on the incidence of oral implant failures, up to abutment connection. *J Clin Periodontol*. 2007 Jul;34(7):610-7.
- Lorusso F, Postiglione F, Delvecchio M, Rapone B, Scarano A. The impact of diabetes in implant oral rehabilitations: A bibliometric study and literature review. *Acta Med*. 2020 Jan 1;36:3333.
- Annibaldi S, Pranno N, Cristalli MP, La Monaca G, Polimeni A. Survival analysis of implant in patients with diabetes mellitus: a systematic review. *Implant Dent*. 2016 Oct 1;25(5):663-74.
- De Angelis F, Papi P, Mencio F, Rosella D, Di Carlo S, Pompa G. Implant survival and success rates in patients with risk factors: results from a long-term retrospective study with a 10 to 18 years follow-up. *Eur Rev Med Pharmacol Sci*. 2017 Feb 1;21(3):433-7.
- Derks J, Schaller D, Håkansson J, Wennström JL, Tomasi C, Berglundh T. Effectiveness of implant therapy analyzed in a Swedish population: prevalence of peri-implantitis. *J Dent Res*. 2016 Jan;95(1):43-9.
- Lorusso F, Postiglione F, Delvecchio M, Rapone B, Scarano A. The impact of diabetes in implant oral rehabilitations: A bibliometric study and literature review. *Acta Med*. 2020 Jan 1;36:3333.
- Carrió CP, Ferrin LM, Oltra DP, Diago MP, Diago MP. Risk factors associated with early failure of dental implants. A literature review. *Medicina Oral*. 2011;16(4):10.
- Snaauwaert K, Duyck J, van Steenberghe D, Quirynen M, Naert I. Time dependent failure rate and marginal bone loss of implant supported prostheses: a 15-year follow-up study. *Clin Oral Investig*. 2000 Mar;4:13-20.
- Van Steenberghe D, Jacobs R, Desnyder M, Maffei G, Quirynen M. The relative impact of local and endogenous patient-related factors on implant failure up to the abutment stage. *Clin Oral Implants Res*. 2002 Dec;13(6):617-22.
- Langer B, Langer L, Herrmann I. The wide fixture: a solution for special bone situations and a rescue for the compromised implant. Part 1. *Int J Oral Maxillofac Implants*. 1993 Jul 1;8(4).
- Shulman LB. Avoiding and coping with surgically related implant problems. *Dent Implantol Update*. 1998 Apr 1;9(4):29-30.
- Aghaloo TL, Misch C, Iacono VJ, Wang HL. Bone Augmentation of the Edentulous Maxilla for Implant Placement: A Systematic Review. *Int J Oral Maxillofac Implants*. 2016 May 2;31.
- Klein MO, Schiegnitz E, Al-Nawas B. Systematic review on success of narrow-diameter dental implants. *Int J Oral Maxillofac Implants*. 2014 Jan 2;29.
- Ma M, Qi M, Zhang D, Liu H. The clinical performance of narrow diameter implants versus regular diameter implants: A meta-analysis. *J Oral Implantol*. 2019 Dec 27;45(6):503-8.
- de Souza AB, Sukekava F, Tolentino L, César Neto JB, Garcez Filho J, Araújo MG. Narrow and regular diameter implants in the posterior region of the jaws to support single crowns: A 3-year split-mouth randomized clinical trial. *Clin Oral Implants Res*. 2018 Jan;29(1):100-7.
- Geckili O, Mumcu E, Bilhan H. Radiographic evaluation of narrow-diameter implants after 5 years of clinical function: a retrospective study. *J Oral Implantol*. 2013 May;39(S1):273-9.
- Anitua E, Errazquin JM, de Pedro J, Barrio P, Begoña L, Orive G. Clinical evaluation of Tiny 2.5-and 3.0-mm narrow-diameter implants as definitive implants in different clinical situations: a retrospective cohort study. *Eur J Oral Implantol*. 2010 Dec 1;3(4).
- Ortega Oller I, Suárez F, Galindo Moreno P, Torrecillas Martínez L, Monje A, Catena A, et al. The influence of implant diameter on its survival: a meta-analysis based on prospective clinical trials. *J Periodontol*. 2014 Apr;85(4):569-80.
- Lambert FE, Lecloux G, Grenade C, Bouhy A, Lamy M, Rompen EH. Less invasive surgical procedures using narrow-diameter implants: a prospective study in 20 consecutive patients. *Oral Implantol*. 2015 Dec;41(6):693-9.
- Bratu E, Chan HL, Mihali S, Karancsi O, Bratu DC, Fu JH, et al. Implant survival rate and marginal bone loss of 6-mm short implants: a 2-year clinical report. *Int J Oral Maxillofac Implants*. 2014 Dec 1;29(6).
- Arusan V, Bölükbaşı N, Ersanlı S, Özdemir T. Evaluation of 316 narrow diameter implants followed for 5–10 years: a clinical and radiographic retrospective study. *Clin Oral Implants Res*. 2010 Mar;21(3):296-307.
- Padial-Molina M, Suarez F, Rios HF, Galindo-Moreno P, Wang HL. Guidelines for the diagnosis and treatment of peri-implant diseases. *Int J Periodontics Restorative Dent*. 2014 Nov 1;34(6).
- Petrie CS, Williams JL. Comparative evaluation of implant designs: influence of diameter, length, and taper on strains in the alveolar crest: A three-dimensional finite element analysis. *Clin Oral Implants Res*. 2005 Aug 1;16(4):486-94.
- Qian L, Todo M, Matsushita Y, Koyano K. Effects of implant diameter, insertion depth, and loading angle on stress/strain fields in implant/jawbone systems: finite element analysis. *Int J Oral Maxillofac Implants*. 2009 Oct 1;24(5).
- Hirata R, Bonfante EA, Anchietta RB, Machado LS, Freitas G, Fardin VP, et al. Reliability and failure modes of narrow implant systems. *Clin Oral Investig*. 2016 Sep;20:1505-13.
- Jung R, Zembic A, Pjetursson BE, Zwahlen M, Thoma D. Systematic review of the survival rate and the incidence of biological, technical, and aesthetic complications of single crowns on implants reported in longitudinal studies with a mean follow-up of 5 years. *Clin Oral Implants Res*. 2012 Oct;23:2-1.
- Sailer I, Makarov NA, Thoma DS, Zwahlen M, Pjetursson BE. All-ceramic or metal-ceramic tooth-supported fixed dental prostheses (FDPs)? A systematic review of the survival and complication rates. Part I: Single crowns (SCs). *Dental Materials*. 2015 Jun 1;31(6):603-23.
- Rabel K, Spies BC, Pieralli S, Vach K, Kohal RJ. The clinical performance of all-ceramic implant-supported single crowns: A systematic review and meta-analysis. *Clin Oral Implants Res*. 2018 Oct;29:196-223.
- Strauss FJ, Siegenthaler M, Hämmerle CH, Sailer I, Jung RE, Thoma DS. Restorative angle of zirconia restorations cemented on non-original titanium bases influences the initial marginal bone loss: 5-year results of a prospective cohort study. *Clin Oral Implants Res*. 2022 Jul;33(7):745-56.
- Rocuzzo A, Imber JC, Lempert J, Hosseini M, Jensen SS. Narrow diameter implants to replace congenital missing maxillary lateral incisors: A 1-year prospective, controlled, clinical study. *Clin Oral Implants Res*. 2022 Aug;33(8):844-57.
- Takahashi T, Kihara M, Oki K, Matsuzaki T, Ayukawa Y, Matsushita Y, et al. Prognosis of Implants with Implant-Supported Fixed Dental Prostheses in the Elderly Population: A Retrospective Study with a 5-to 10-Year Follow-Up. *InHealthcare* 2022 Jul 4 (Vol. 10, No. 7, p. 1250). MDPI.
- de Oliveira Ribeiro MC, Vargas-Moreno VF, Gomes RS, Faot F, Cury AA, Marcello-Machado RM. Implant-supported crowns with locking taper implant-abutment connection: A systematic review and meta-analysis. *J Prosthet Dent*. 2022 Jul 19.
- Marcantonio Junior E, SARTORI IA, Vianna CP, Rocha RS, Caldas W, Trojan LC. Influence of risk factors on the long-term survival of oral rehabilitation with extra-narrow implants: a retrospective study. *J Appl Oral Sci*. 2022 Aug 1;30.
- Freitas MI, Gomes RS, Ruggiero MM, Bergamo ET, Bonfante EA, Marcello Machado RM, et al. Probability of survival and stress distribution of narrow diameter implants with different implant-abutment taper angles. *J Biomed Mater Res*. 2022 Mar;110(3):638-45.
- Diehl D, Winkler M, Bilhan H, Friedmann A. Implant stability of narrow diameter implants in hyperglycemic patients—A 3-month case-control study. *Clin Exp Dent Res*. 2022 Aug;8(4):969-75.
- Bielemann AM, Schuster AJ, Possebon AP, Schinestscck AR, Chagas Junior OL, Faot F. Clinical performance of narrow diameter implants with hydrophobic and hydrophilic surfaces with mandibular implant overdentures: 1-year results of a randomized clinical trial. *Clin Oral Implants Res*. 2022 Jan;33(1):21-32.