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EVALUATE THE EFFECT OF SPLINT USE ON THE ACCURACY OF DENTAL IMPLANT SURGERY: A SYSTEMATIC REVIEW AND META-ANALYSIS

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Abstract

Background and aim: the aim of this study was to evaluate the effect of splint use on the accuracy of dental implant surgery.

Method: In present systematic review and meta-analysis, information about splint use on the accuracy of dental implant surgery in all articles published until the end of July 2023 through searching in databases PubMed, Scopus, Science Direct, ISI, Web of Knowledge, Elsevier, Wiley, and Embase and Google Scholar search engine were extracted using keywords and their combinations by two trained researchers independently. Data analysis was done using the fixed effects model in meta-analysis, by STATA (version 17); P-value less than 0.05 was considered significant.

Result: A total of nine studies were included in the meta-analysis process. the mean of horizontal coronal deviation for tooth and mucosa was 0.59mm (MD: 95% CI, 0.24mm to 0.93mm; I^2=0; p=0.47) and 0.84mm (MD: 95% CI, 0.47mm to 1.20mm; I^2=2.08; p=0.38), respectively. the mean of angular deviation for tooth and mucosa was 0.95mm (MD: 95% CI, 0.75mm to 1.14mm; I^2=42.77; p=0.14) and 3.38mm (MD: 95% CI, 1.51mm to 5.25mm), respectively.

Conclusion: Based on the present meta-analysis, no statistically significant difference was observed in any of horizontal coronal deviation, horizontal apical deviation, or vertical deviation, except angular deviation, compared to tooth-supported splints and mucosa-supported splints.

Keywords: splint support, dental implant, computer-assisted surgery, accuracy, implant placement

Introduction

During the last decade, computer-aided dentistry has been of great interest and rapid progress has been made in it; This progress has also affected the dental implant treatment approach(1). The CBCT images are processed with the help of Implant planning software processes and show the pre-operative view of the anatomical structures related to the future prosthesis(2). One of the most basic needs of implant treatments in dentistry is to make prostheses with tension-free adaptation(3). The implant is planned in the ideal 3D position based on prosthodontic designing, and this virtually planned position is subsequently transferred to the patient using a milled or 3D-printed surgical splint equipped with or without precision metal sleeves(4). Based on the findings of the studies, the actual position of the implant with the planned position can undergo changes in the coronal and apical part as well as in the angulation and it varies depending on the accuracy of guided surgical systems(5, 6). The findings of studies show that placing implants through a surgical splint can provide better and more accurate results(7). Splints have different types according to the supporting tissues of tooth, mucosa, or bone. In a study, it has been shown that mucosal support splints showed significant angular, coronal and apical deviations compared to bone support splints. However, there was no statistically significant difference between mucosal and dental splints for any of the measured parameters(8). Previous meta-analyses have been conducted in relation to splints, however, the type of splint support has not been well investigated, therefore the aim of this study was to evaluate the effect of splint use on the accuracy of dental implant surgery.

Method

Search strategy

In present study, in order to obtain scientific documents and evidence related to effect of splint use on the accuracy of dental implant, articles published in international databases such as PubMed, Web of Science, Scopus, Science Direct, Web of Knowledge, EBSCO, Wiley, ISI, Elsevier, Embase and Google Scholar search engine were used. The search process until July 2023 in PubMed database was done using MeSH keywords: (((((("Splints"[Mesh])) AND ("Dental Implants"[Mesh] OR "Dental Implantation"[Mesh])) AND "Surgery, Computer-Assisted"[Mesh]) AND ("Data Accuracy"[Mesh] OR "Radiotherapy, Image-Guided"[Mesh])) OR ("Denture Precision Attachment"[Mesh] OR "Dental Clasps"[Mesh]). In addition, the reference list of the obtained articles was checked to identify the used articles that were not obtained using the above methods. Databases were searched with high sensitivity. To avoid bias, the search was done by two researchers independently.

Study selection criteria

Inclusion criteria: use of the PICO (patient/population, intervention, comparison, and outcome) strategy to construct the research question is specified in Table 1; age of patients ≥18 years, Sample size above ten patients, and splints with dental. studies with incomplete results; in-vitro, in-vivo, animal studies, case reports and review articles were excluded.

Table1. PICO strategy.

PICO strategy	Description
P	Population: dental implant patients

I	Intervention: static-guided splint
C	Comparison: Tooth, mucosa, or bone supporting tissues
O	Outcome: accuracy of dental implant surgery

Data collection

a checklist was designed based on the objectives, and information from the selected articles was entered into the checklist (Table 2).

Risk assessment

Cochrane Collaboration tool to assess risk of bias for randomized controlled trials. Bias is assessed as a judgment (high, low, or unclear)(9-15). The risk of bias tool covers six domains of bias: selection bias, performance bias, detection bias, attrition bias, reporting bias, and other. The scores of this tool are between 0 and 6, and higher score showed higher quality of study; the scoring of each item is 1 for low risk and 0 for high and unclear risk.

Newcastle-Ottawa Scale (NOS) (10) used to assessed quality of the cohort and cross-sectional studies, case-control and case series studies, This scale measures three dimensions (selection, comparability of cohorts and outcome) with a total of 9 items. In the analysis, any studies with NOS scores of 1-3, 4-6 and 7-9 were defined as low, medium and high quality, respectively.

Data analysis

Meta-analysis was performed using mean differences with 95% confidence interval. To estimate the heterogeneity of the studies, the index I^2 (<25%: weak heterogeneity, 25-75%: moderate heterogeneity, and more than 75%: high heterogeneity) was used. The results were combined using the fixed effect model (Inverse–variance method) in meta-analysis. The publication bias was checked by Egger test and data analysis was done using STATA/MP. v17 software. A p-value of less than 0.05 was considered significant.

Result

After searching with related keywords, 414 studies were obtained. Endnote.X8 software was used to organize the studies. By using the mentioned software and reviewing the title and abstract of the articles, 81 duplicate studies were eliminated. Then the abstracts of 319 articles were examined by the researchers. 285 studies that did not meet the inclusion criteria or were excluded due to weak or unrelated relevance to the study objective (if after reading the title and abstract, it was not possible to make a decision about the article, the full text was referred to). The full text of 34 articles was carefully reviewed by two independent researchers, and 25 studies were excluded due to the inconsistency of study objectives; Finally, nine articles were selected (Figure 1).

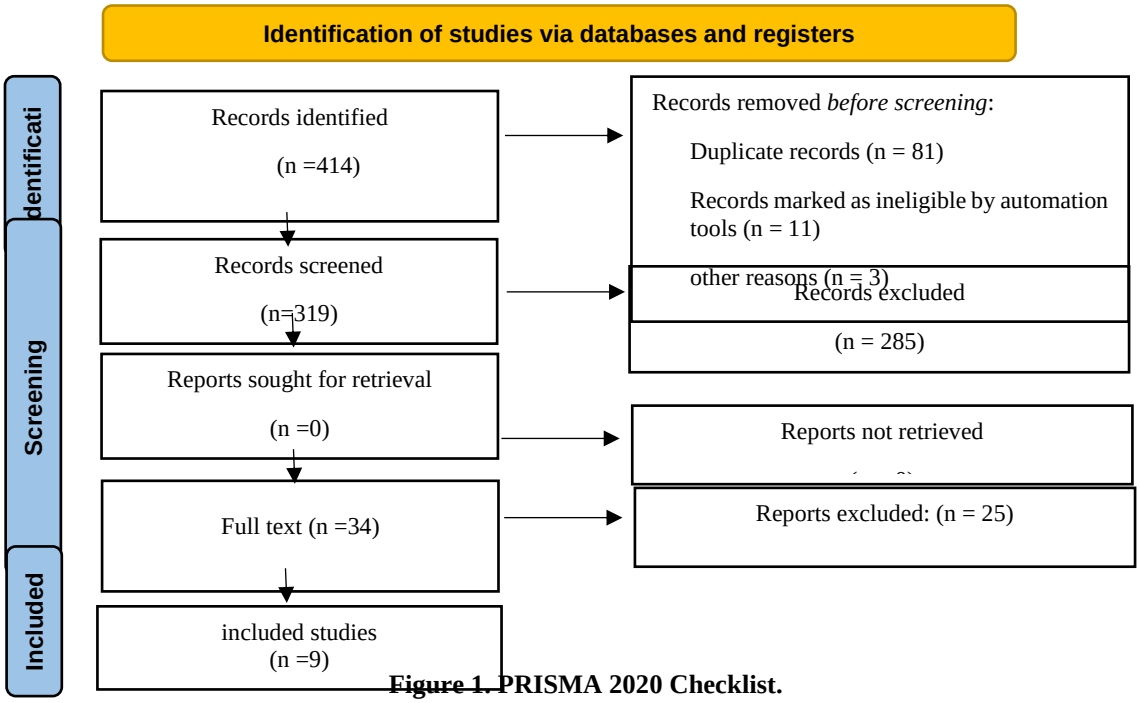

Figure 1. PRISMA 2020 Checklist.

Characteristics of patients

299 (female: 162; male:137) patients included in present study. The number of implants in total was 838 (259 in maxilla and 160 in the mandible). Two studies nor reported placement of dental implants.

Table 2. Characteristics of selected studies.

No.	Study. Years	Number of Patients		Mean of age (years)	Number of Implants	Placement of dental implants	
		female	Male			maxilla	mandible
1	Schnutenhaus et al., 2022 (11)	35	25	59.5	60	42	18
2	Schnutenhaus et al., 2018 (12)	28	28	NR	122	48	74
3	Cassetta et al., 2017 (13)	7	3	57.5	70	NR	NR
4	Schnutenhaus et al., 2016 (14)	9	15	52.2	24	12	12
5	Verhamme et al., 2015 (15)	18	12	NR	104	30	0
6	van de Wiele et al., 2015 (16)	10	6	60	127	NR	NR
7	Fürhauser et al., 2015 (17)	13	14	35	27	27	0
8	Cassetta et al., 2014 (18)	18	6	58	172	13	11
9	ehneke et al., 2012 (19)	24	28	54.2	132	87	45

Horizontal Coronal Deviation

According to subgroup meta-analysis the mean of horizontal coronal deviation for tooth and mucosa was 0.59mm (MD: 95% CI, 0.24mm to 0.93mm; I^2=0; p=0.47) and 0.84mm (MD: 95% CI, 0.47mm to 1.20mm; I^2=2.08; p=0.38), respectively. The mean of horizontal coronal deviation in two type of splint support was 0.71mm (MD: 95% CI, 0.45mm to 0.96mm; I^2=0;

p=0.47). the test of group differences showed no statistically significant differences between tooth vs mucosa support (p=0.33) (Fig.2).

Horizontal Apical Deviation

According to subgroup meta-analysis the mean of horizontal apical deviation for tooth and mucosa was 0.79mm (MD: 95% CI, 0.37mm to 1.22mm; I^2=0; p=0.46) and 1.15mm (MD: 95% CI, 0.51mm to 1.79mm; I^2=16.31; p=0.30), respectively. The mean of horizontal apical deviation in two type of splint support was 0.90mm (MD: 95% CI, 0.55mm to 1.26mm; I^2=0; p=0.44). the test of group differences showed no statistically significant differences between tooth vs mucosa support (p=0.36) (Fig.3).

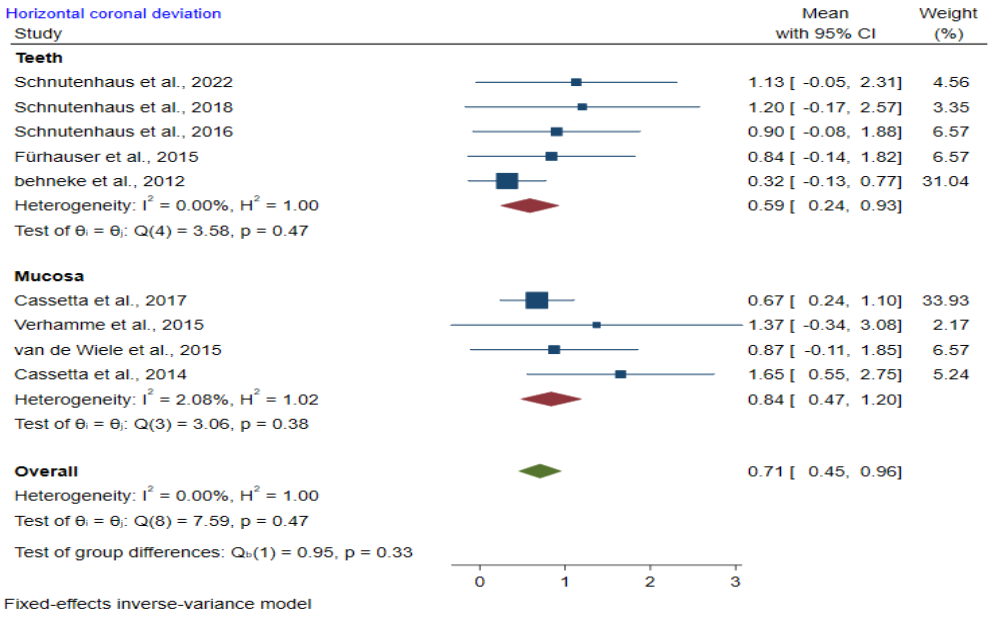

Figure 2. forest plot showed horizontal coronal deviation in two type of splint support

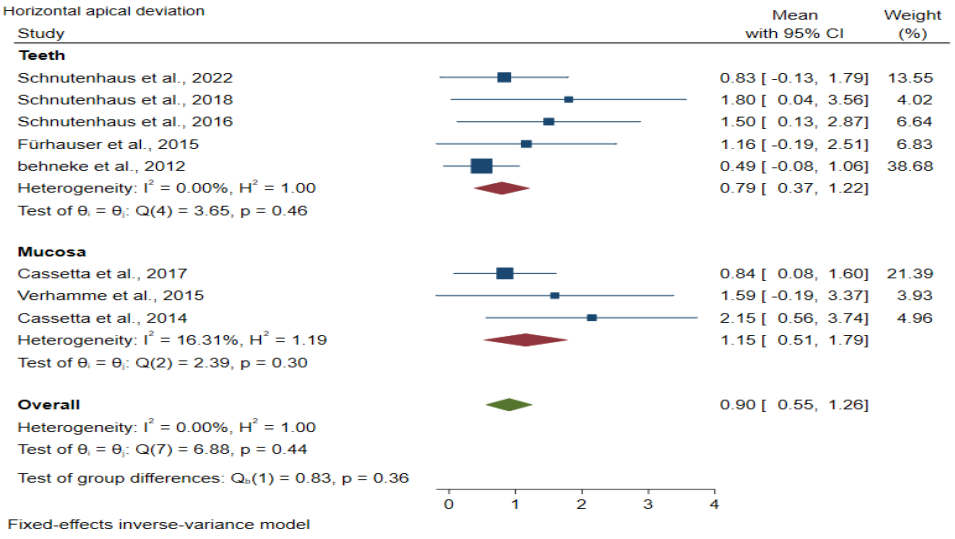

Figure 3. forest plot showed horizontal apical deviation in two type of splint support

Vertical Deviation

According to subgroup meta-analysis the mean of vertical deviation for tooth and mucosa was 0.43mm (MD: 95% CI, -0.10mm to 0.97mm; I^2=0; p=0.72) and 0.84mm (MD: 95% CI, -2.79mm to 4.47mm), respectively. The mean of vertical deviation in two type of splint support was 0.44mm (MD: 95% CI, -0.09mm to 0.97mm; I^2=0; p=0.85). the test of group differences showed no statistically significant differences between tooth vs mucosa support (p=0.83) (Fig.4).

Angular Deviation

According to subgroup meta-analysis the mean of angular deviation for tooth and mucosa was 0.95mm (MD: 95% CI, 0.75mm to 1.14mm; I^2=42.77; p=0.14) and 3.38mm (MD: 95% CI, 1.51mm to 5.25mm), respectively. The mean of angular deviation in two type of splint support was 0.97mm (MD: 95% CI, 0.78mm to 1.17mm; I^2=53.87; p=0.03). the test of group differences showed statistically significant differences between tooth vs mucosa support (p=0.01) (Fig.5).

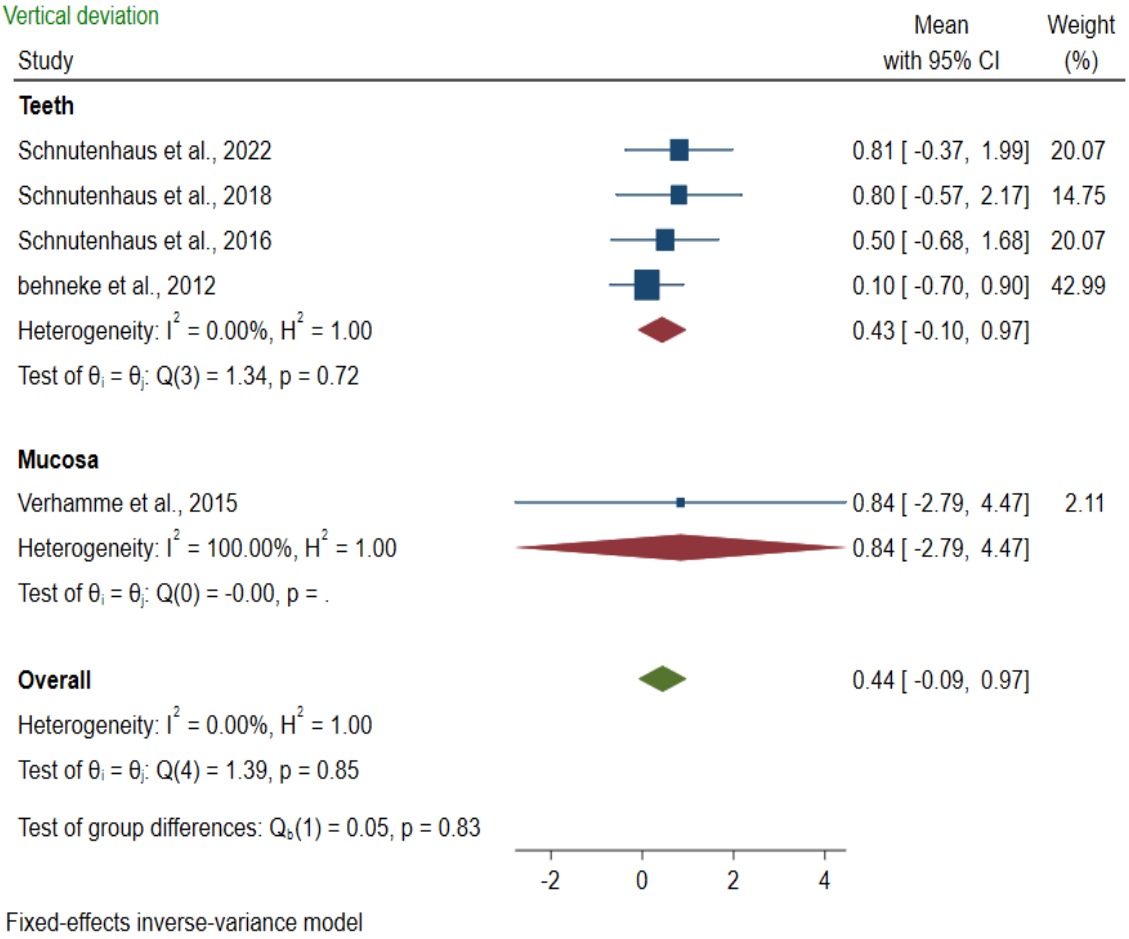

Figure 4. forest plot showed vertical deviation in two type of splint support

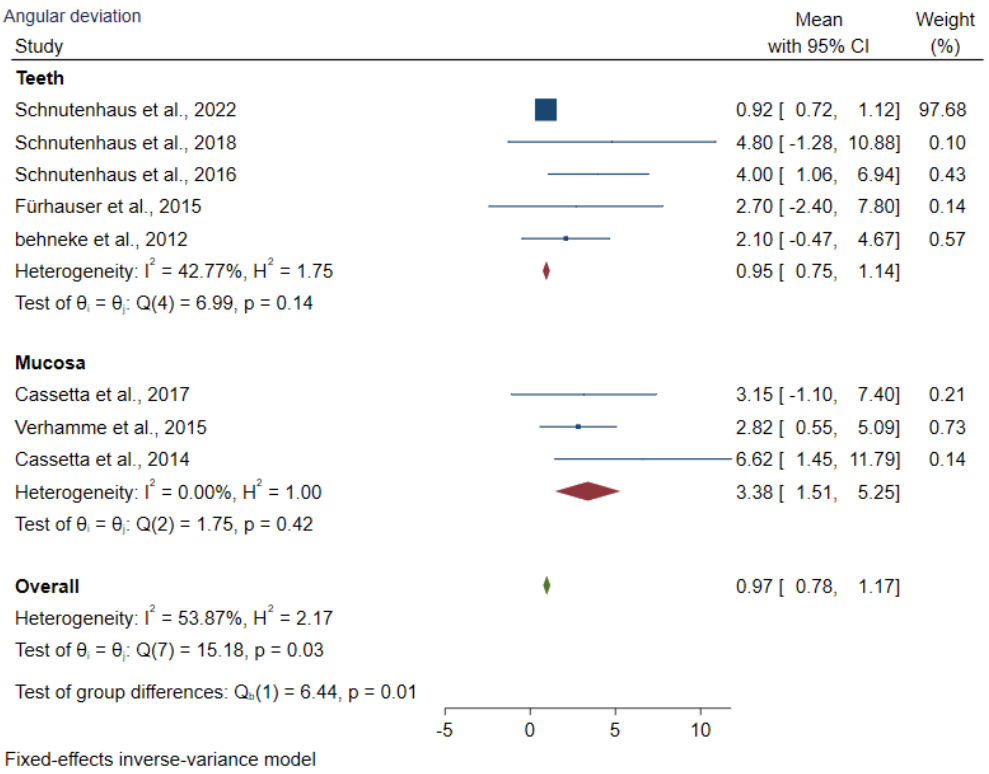

Figure 5. forest plot showed angular deviation in two type of splint support

Discussion

The present meta-analysis showed that there was no statistically significant difference between teeth and mucosa regarding horizontal coronal deviation, horizontal apical deviation, and vertical deviation, but this difference was significant regarding angular deviation. In a study, observed that the angular deviation is 5.73 degrees(20) and 5.5 degrees(21), which compared to the findings of the current study, accuracy referring to angular deviation was less accurate, and this could be due to the fact that guided surgery systems is currently performed compared to the past. The study (22) also reported that horizontal deviations are higher than 7.1 mm for partially guided surgery and compared to the present meta-analysis, the results are similar. Based on the findings of the present study, it is recommended to remain 2 mm in the horizontal apical dimension and 1 mm vertically. The heterogeneity between the studies was small in all parameters except Angular Deviation, so the findings of the present study in this part should be interpreted with caution.

In mucosal support, positioning is less stable due to the resilience of the soft tissues. In addition, in mucosal support, anesthesia influences mucosal morphology, altering correct positioning(8). A new study that has been reviewed that dealt with bone-supported splints was not found, and only old studies were reviewed that did not meet the inclusion criteria(23-25); Therefore, studies need to be done to compare tooth-supported splints with bone-supported splints.

The present study had limitations, there are very few randomized clinical trial studies, and most of the existing studies were conducted as a cohort. Different guided surgery systems were used in the studies.

Conclusion

Based on the present meta-analysis, no statistically significant difference was observed in any of horizontal coronal deviation, horizontal apical deviation, or vertical deviation, except angular deviation, compared to tooth-supported splints and mucosa-supported splints. The accuracy that can be achieved depends on numerous cofactors that have to be assessed individually. However, the values measured also show that computer-assisted surgical procedures can be recommended from a prosthetic point of view.

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