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Patient Satisfaction And Survival Of Maxillary Overdentures Supported By Four Or Six Splinted Implants: A Systematic Review

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I. Introduction

Edentulism is acknowledged as a physical impairment that greatly impairs diet, communication, self-esteem, and perceived beauty. Traditionally, patients who have lost all of their teeth have commonly been treated with complete dentures. However, these patients often face challenges such as reduced ability to keep the dentures in place, lack of stability, and difficulty in chewing due to ongoing loss of bone in the upper jaw. These issues have a negative impact on their overall oral health and quality of life [1]. Alternatively, opting for implant-supported overdentures effectively addresses the functional limitations commonly associated with traditional dentures, leading to enhanced patient satisfaction, comfort, and chewing ability [2]. Both maxillary and mandible implant-supported overdentures are recommended as the preferred treatment for patients who have ongoing concerns about the retention and durability of their traditional dentures, as well as inadequate support from their remaining oral tissues [2, 3].

Within this particular framework, various systematic evaluations have indicated that Multiple Implant Overdentures (MIODs) ought to be reinforced by a minimum of four implants [3–9]. However, additional research also supports the utilization of six implants to support MIODs when there is an adequate amount of bone, as this improves the stability and longevity of the prosthesis [10, 11]. In addition, the use of splinted implants has been proposed for MIOD design in cases where there is a lack of parallelism among implants, palateless overdentures are used, short implants are employed, or the opposing arch consists of natural teeth or a fixed implant-supported prosthesis [4, 5, 12, 13].

Advantages Of Implant Supported Overdenture:

1. The approach exhibits several attributes such as its efficacy, predictability, and dependable treatment procedure, as demonstrated in websites where the prosthesis are below average and stable, and with a pronounced gag reflex [7]. ISO improves the effectiveness and comfort of denture treatment compared to traditional methods [8].
2. Oral implant treatment was found to aid in the preservation of alveolar bone, hence supporting the condition of edentulism.
3. Several instances demonstrate that ISO not only enhances the bone level revolving about the implant control but also improves its vertical bone height [9].
4. Another benefit of implant-supported overdentures is the enhancement of occlusion, including improved occlusal load direction, intensified operation of occlusion, and better management of its vertical dimension.
5. ISO offers a superior ability to retain classical dentures that utilize attachments such as a bar, ball, magnet, or locator.
6. The implant retained overdenture had a notable cumulative success rate of approximately 95.4%, surpassing the satisfaction rate in the mandible when compared to the maxilla [6].

II. Materials And Method

The PRISMA declaration was utilized as a guideline to conduct and document this systematic review [15]. The PICO research question was: "Among fully edentulous patients (P) in need of a maxillary implant-

supported overdenture (I), does the use of four splinted or six splinted implants (C) result in varying levels of patient satisfaction, implant and overdenture survival, and prosthodontic complications (O)?"

Searches:

An electronic search was conducted between January 2000 and December 2020 using the Cochrane's Central Register of Controlled Trials (CENTRAL), MEDLINE (via PubMed), and EMBASE databases. The search method included a combination of the following keywords: (4-implant-retained OR 4 implant-supported OR 6-implant-retained OR 6-implant-supported OR implant-supported OR implant-retained) AND (maxillary overdenture OR splinted overdenture OR overdenture). Furthermore, the reference lists of the most recent relevant systematic reviews were examined to identify any additional qualifying research.

Data Selection, Extraction And Analysis

The titles and abstracts were evaluated independently by two reviewers (F.D. and G.D.) in triplicate to ascertain their initial eligibility for inclusion.

For studies, the ensuing inclusion and exclusion criteria were chosen:

• Four or six splinted implants support the entire edentulous patients who are at least 10 times more likely to have MIOD.

• In connection to MIOD supported on four or six splinted implants, at least one of the following clinical parameters—such as patient satisfaction scores, implants survival rate, overdentures survival rate, and prosthoodontic complications—was recorded.

• A minimum of a year of follow-up following the installation of prosthesis.

• Prospective studies, retrospective studies, and human randomized controlled trials (RCTs) were deemed appropriate.

• In vitro and animal research were not included.

• Research with implants that weren't splinted was disregarded.

The exclusion criteria did not take publishing status or language into account.

The first independent reviewer (F.D.) and the third independent reviewer (CM.C.) respectively realized data extraction from the included studies and data checking to ensure data extraction correctness. Specifically, for the examination of implant and overdenture survival rates, data were split based on the number of inserted splinted implants per prosthesis.

Risk Of Bias And Quality Assesment Of Studies

The reviewers (F.D. and G.D.) evaluated the caliber of the included studies in duplicate and independently. To analyze the included RCTs, the Cochrane's Risk of Bias Version 2 (RoB 2) method was used. This tool evaluates the randomization process, deviations from intended interventions, missing outcome data, measurement of the outcome, and selection of the reported result [16]. The Newcastle–Ottawa Scale (NOS) was used to evaluate the caliber of nonrandomized clinical trials [17]. Using a star system, this scale rates studies from three major angles: the choice of study groups (up to 4 points), the groups' comparability (up to 2 points), and exposure to the result of interest (up to 3 points for cohort studies, and up to 4 points for case-control studies). Studies were deemed to be of high quality if they satisfied five or more of the Newcastle–Ottawa Scale score requirements. The quality-assessment for different kinds of studies was assessed using a den Hartog et al. tool that focused on eight items [18]. Studies that received five pluses or higher were deemed acceptable.

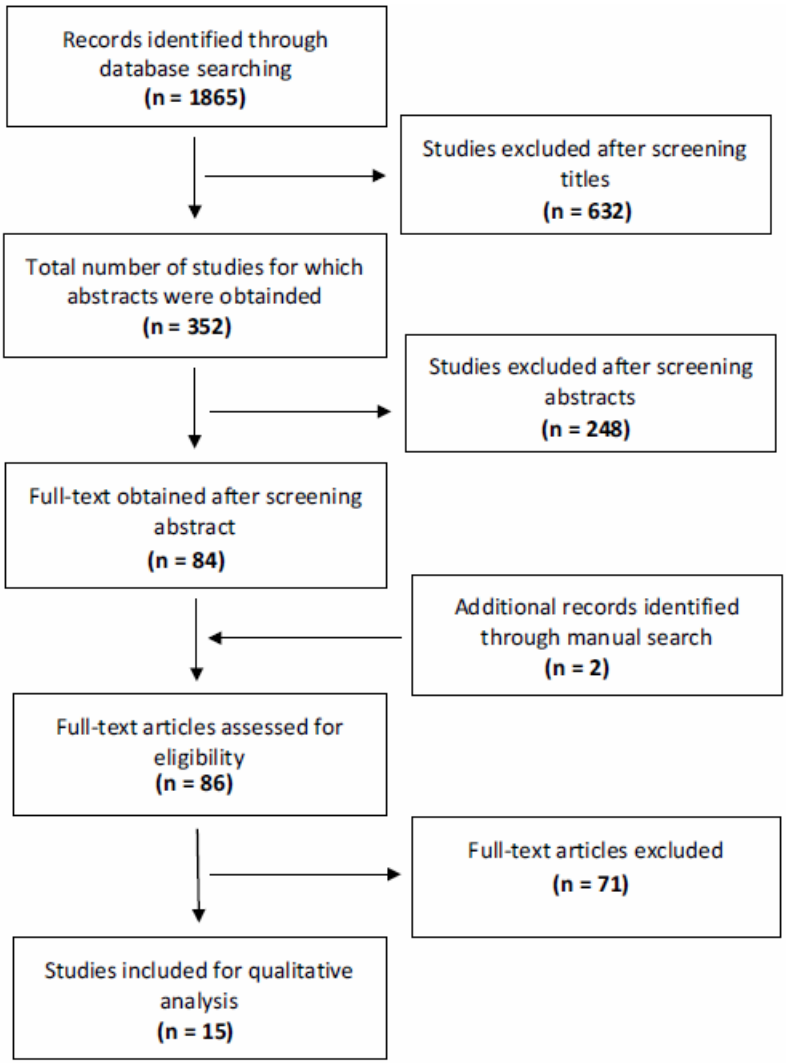
Statistical Analysis

To measure inter-examiner agreement, Cohen's Kappa (κ) was used. Coefficients of κ greater than 0.5 were deemed acceptable during the selection and rule-of-body stages of the evaluation. The survival rates of dental implants and overdentures were reported as mean percentages (M%) and standard errors (SE) for continuous data, and as risk ratios (RR) or risk differences (RD) with 95% confidence intervals (CI) for dichotomous data. The survival rates of implants and overdentures were examined by random-effects meta-analysis using the Mantel–Haenszel method for dichotomous data and the non-parametric unpaired Fisher's test for continuous data due to the methodological and visually visible heterogeneity between studies. Forest plots were created using The Cochrane Collaboration's Review Manager (RevMan) software version 5.2. A difference was considered statistically significant when it was $P < 0.05$.

Steps of data selection as follows:

Fig.1 displays the data selection flowchart. Electronic searches turned up a total of 1865 published articles. F.D. and G.D., two impartial reviewers, conducted the screening and selection of the studies. A total of

352 publications were chosen for abstract reading once all titles had been verified. Then, 268 articles that did not meet the qualifying requirements were eliminated from the examination of the abstracts. 84 full-text articles were identified as a result. Furthermore, examining the most current systematic reviews' reference lists turned up two full-text studies, for a total of 86 papers. Eventually, eight prospective studies, one retrospective research, and six RCTs were produced from the fifteen full-text papers that met the inclusion criteria. Mainly, these were the grounds for exclusions: not evaluating overdentures supported by implants, not contrasting four versus six implants, and not using various outcome metrics. During the selection process, the reviewers (F.D. and G.D.) attained an inter-examiner agreement of $\kappa = 0.8$.



Then, data were divided and analyzed into the group of 4 splinted implants (Table 2) and the group of 6 splinted implants (Table 3), respectively. Subsequently, data were statistically analyzed according to the number of implants placed, as reported in Figs. 2, 3 and 4. Only studies directly comparing the use of 4 versus 6 implants for supporting maxilla overdentures were included in the meta-analysis [10, 19–23, 28].

Table 1 Main Characteristic Extracted From The Included Studies

Study	Year	Study design	No. implants for patient, anchoragesystem	No. patients	OVD design	Opposing arch	System used for estimation of patient-reported results (Score range)
Boven et al. [23]	2020	RCT	4, bar	24	Palateless	Implant-retained overdenture	10-point rating scale(>8)
Park et al. [31]	2019	RCT	4, bar	16	Full palatal coverage	ND	10-point rating scale(>9)
Slot et al. [19]	2019	RCT	4, bar	29	Palateless	Implant-retained	10-point rating

							scale
			6, bar	31	Palateless	overdenture Implant-retained overdenture	(>8) 10-point rating scale(>8)
Slot et al. [20]	2016	RCT	4, bar	24	Partial coverage	Implant-retained	10-point rating scale
			6, bar	22	Partial coverage	overdenture Implant-retained overdenture	(>8) 10-point rating scale(>8)
Slot et al. [21]	2013	RCT	4, bar	24	Palateless	Implant-retained	10-point rating scale
			6, bar	25		overdenture	(>8) 10-point rating scale(>8)
Slot et al. [22]	2014	RCT	4, bar	33	Palateless	Implant-retained	10-point rating scale
			6, bar	33	Palateless	overdenture Implan-retained overdenture	(>8) 10-point rating scale(>8)
Boven et al. [24]	2017	Prospective	6, bar (anterior)	25	Palateless	Natural teeth	10-point rating scale
			6, bar (posterior)	25	Palateless	Natural teeth	(>8) 10-point rating scale(>8)
Krennmair et al. [25]	2008	Retrospective	4, bar	16	Palateless	Implant-retained	Likert scale 1–5 (> 4.6)

Patient Satisfaction

When patient satisfaction was measured in eight of the included studies, all of them had high scores [19–26]. In order to assess patients' perceived comfort with their prosthesis when wearing it or masticating with it, the majority of studies used the Vervoorn et al. questionnaire for denture satisfaction [19–24]. This questionnaire uses a scale of complaints and is frequently used in conjunction with a "chewing ability" [19–22] or OHIP-49 [23, 24] questionnaire. The satisfaction surveys were conducted in all prospective studies prior to and during the installation of the overdenture, with additional controls administered between six and twelve months following delivery. For MIODs supported on both four and six splinted implants, Slot et al. observed general satisfaction scores more than 8 points (on a 10-point rating scale) at both the 1- and 5-year follow-up [19–22] in four RCTs. In two RCTs, Boven et al. found that, at the 1- and 5-year follow-up, MIODs supported by four [23] and six splinted implants [24] had an overall satisfaction score higher than 8 points (on a 10-point rating scale). For patients rehabilitated with MIODs supported on four splinted implants, Krennmair et al. [25] and Zou et al. [26] found scores higher than 4.5 (Likert scale with score 1-4) and higher than 1 (Likert scale with score 0–2), respectively. The examined studies' results show that whether four or six splinted implants are used to support maxillary overdentures, patient satisfaction is consistently excellent.

Survival Of Overdentures

Included and examined were overdentures that had been initially applied and were still in place at follow-up. The majority of the included studies [19–22, 24–26, 28, 29, 31] and [10, 20–22, 28, 32] revealed a 100% survival rate for overdentures in both studies utilizing 4 splinted implants and 6 splinted implants. Just five of the included studies—three with four splinted implants [10, 21, 29] and two with six splinted implants [10, 19]—reported an overdenture survival rate of less than 95%. Nonetheless, there were no statistically significant differences between employing 4 versus 6 splinted implants to support maxilla overdentures (P = 0.74), according to the pooled risk differential for overdenture survival (RD = − 0.01; CI = [− 0.04, 0.03]) (Fig. 3). Similarly, the survival rate of overdentures supported by 4 implants (M% = 97.6; SE = 0.36) or 6 implants (M% = 97.9; SE = 0.41) (P = 0.9) did not show any statistically significant variations.

TABLE-2: ANALYSIS OF SURVIVAL RATES OF IMPLANTS AND OVERDENTURES IN CASE OF 4 SPLINTED IMPLANTS

Study	No.implants for patient, location	Pre-implant bone augmentation	Anchorage system	Bar Fabrication	Follow up(months)	Total no. impl	Total no. lost impl	Survival rate of implants (%)	Total no. OVD	Survival rate of OVD (%)
Slot et al. [19]	4, posterior	Sinus floor	Milled titanium	Abutment level	60	116	0	100	29	100

	region		bar with mesial exten-sions and gold retentive clips							
Slot et al. [20]	4, anterior region	No	Milled titanium eggshaped bar with distal extensions	Abutmen t level	60	96	0	100	24	100
Slot et al. [21]	4, posterior region	Sinus floor	Milled titanium bar with mesial exten-sions, and gold retentive clips	Abutmen t level	12	132	0	100	33	100
Slot et al. [22]	4, anterior region	No	Milled titanium eggshaped bar with distal extensions	Abutmen t level	12	96	2	100	24	100
Boven et al. [23]	4, anterior region	Some sinus floor	Milled titanium eggshaped bar with distal extensions	Abutmen t level	12	96	0	97.9	24	100
Krennma ir et al. [25]	4, anterior region	No	Titanium or gold bar with distal extensions and retentive clips	Abutmen t level	42	64	0	100	16	100
Zou et al. [26]	4, ND	No	Dolder gold bar	Abutmen t level	36	40	0	100	10	100
Mangano et al. [27]	4, anterior region	No	Cobalt-chrome bar, without extensions and gold retentive clips	Abutmen t level	36	112	3	97,4	28	93,3
Katsoulis et al. [28]	4, ND	No	Titanium or dolder gold bar with distal extension	Abutmen t level	24	88	1	98,9	22	100
Mangano et al. [29]	4, anterior region	No	Eggshaped dolder gold bar with or without distal extensions	Abutmen t level	60	152	4	97,4	38	100
Akca et al. [30]	4, ND	No	Eggshaped dolder gold bar with distal extensions	Implant level	59	42	1	97,7	11	88
Ferrigno et al. [10]	4, anterior and posterior regions	Some sinus floor	Dolder bar	ND	120	64	6	86,9	16	87,5
Park et al. [31]	4, anterior region	No	Hader bar and bar	Abutmen t level	12	64	1	96.3	16	100

			clips							

Table 3: Analysis Of Survival Rates Of Implants And Overdentures In Case Of 6 Splinted Implants

Study	No.implantsfor patient, location	Pre-implant bone augmentation	Anchorage system	Bar fabrication	Follow up (months)	Total no. implants	Total no.lost implants	Survival rateof implants.(%)	Total No. OVD	Survival rate ofOVD (%)
Slot et al. [19]	6, posterior region	Sinus floor	Milled titanium bar with mesial exten- sions and gold retentive clips	Abutment level	60	186	1	99.5	31	90.9
Slot et al. [20]	6, anterior region	No	Milled titanium eggshaped bar with distal extensions	Abutment level	60	132	1	99.2	22	100
Slot et al. [21]	6, posterior region	Sinus floor	Milled titanium bar with mesial exten- sions and gold retentive clips	Abutment level	12	198	0	100	33	100
Slot et al. [22]	6, anterior region	No	Milled titanium eggshaped bar with distal extensions	Abutment level	12	150	1	99.3	25	100
Boven et al. [23]	6, anterior region	No	Milled titaniumbar	Abutment level	60	150	4	97	25	ND
Boven et al. [24]	6, posterior region	Sinus floor	Milled titaniumbar	Implant level	60	150	1	99.3	25	ND
Katsoulis et al.[28]	6, ND	No	Titanium barwith distal extensions	Implant level	24	6	0	100	1	100
Ferrigno et al.[10]	6, anterior and posterior regions	Some sinus floor	Milled bar	ND	120	114	3	92.2	19	94.7
VanAssche et al.32	6, anterior andposterior regions	No	Dolder bar	Abutment level	24	72	1	98.6	12	100

III. Results

The original implants that remained at follow-up were included and examined. According to the included studies' findings, 291 patients who underwent MIOD rehabilitation on four splinted implants lost 18 implants out of a total of 1164 implants, and 193 patients who underwent MIOD rehabilitation on six splinted implants lost 12 implants out of a total of 1158 implants [10, 19–22, 24, 28, 33]. There were no significant differences between the use of 4 versus 6 splinted implants for supporting maxilla overdentures, according to the pooled risk ratio for implant survival (RR = 0.71; CI = [0.34, 1.45]; P = 0.34). Comparatively speaking, the survival rates of 4 implants (M% = 97.7; SE = 0.26) and 6 implants (M% = 98.3; SE = 0.26) seemed to be very equal, and there were no statistically significant differences between the two groups (P = 0.3), as demonstrated.

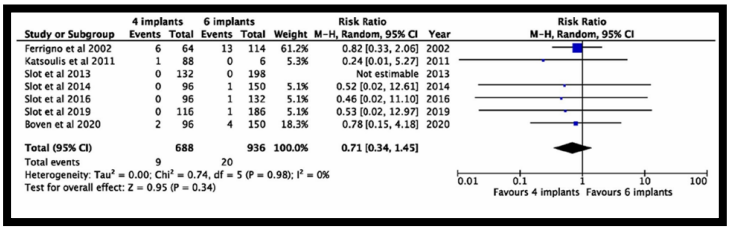


figure 4: forest plot of the dental implants survival risk ratios when using 4 versus 6 splinted implants for supporting overdentures

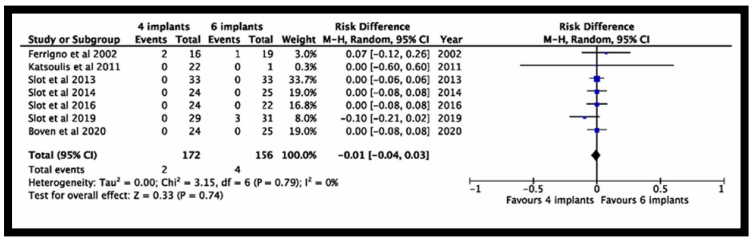


figure 5 : forest plot of the overdentures survival risk differences when using 4 versus 6 splinted implants for supporting them

Table 6: Quality Of Included Randomzed Controlled Trials (Rcts) Using Cochrane's Rob 2 Tool

Study	Randomisation process	Deviations from intended invervention	Missing outcomedata	Measurement of the outcome	Incomplete outcomedata addressed	Selection of the reported result	Overall RoB
Boven et al. [23]	High	Low	Some concerns	Low	Low	Low	High
Park et al. [31]	High	Low	Some concerns	Low	Low	Low	High
Slot et al. [19]	High	Some concerns	Low	Low	Low	Low	High
Slot et al. [20]	High	Some concerns	Low	Low	Low	Low	High
Slot et al. [21]	High	Some concerns	High	Low	Low	Low	High
Slot et al. [22]	High	Some concerns	High	Low	Low	Low	High

Prosthodontic Complications

According to a number of included studies that examined MIODs on four splinted implants, the most common complications were bar clip changes brought on by retention loss or clip loosening or breaking [23, 27, 29, 31]. Comparing MIODs supported by four or six splinted implants put in the anterior region, Slot et al. [20] found that prosthetic problems during a five-year follow-up revealed a modest number of occurrences, most of which were denture base or tooth repair. There was no need to create new overdentures or bars, and there were no notable variations between the two groups. Nonetheless, Slot et al. [19] compared MIODs supported by four or six splinted implants placed in the posterior region at a 5-year follow-up, reporting a 90.9% survival rate of the overdentures. Three new overdentures had to be remade in the six-implant group because of excessive wear on the denture base and teeth. In their analysis of MIODs on six splinted implants after a 2-year follow-up, Van Assche et al. [32] found that only two out of the twelve treated patients had screw untightening.

Table 7 : Quality Of Included Studies Using The Newcastle-Ottawa Scale (Nos) Tool

Study	Selection****	Comparability**	Outcome***	Score
Boven et al. [24]	****	*	***	8
Krennmair et al. [25]	****	*	**	7
Zou et al. [26]	****	*	***	8
Katsoulis et al. [28]	****	*	***	8
Ferrigno et al. [10]	****	**	**	8

IV. Discussion

The data analysis of the trials included in the research suggests that patients express similar levels of satisfaction with MIODs that are supported by either four or six splinted implants. Furthermore, the majority of the studies included (11 out of 15) documented the utilization of a horseshoe design for overdentures in both groups [19–25, 27–29, 32]. Patients typically need an overdenture without palatal coverage to enhance comfort, taste, speech, pharyngeal control, salivary flow, and oral cleanliness. Another topic of discussion is around the recommended quantity of dental implants needed to support a maxillary overdenture[33]. According to the research, it appears that the minimal number of implants needed to sustain a MIOD without palate covering is either four or six, as indicated by references [4–6, 33–36]. This idea aligns with other studies included in this review, which reported a survival rate of implants equal to or greater than 97%. This applies to both palateless MIOD on 4 splinted implants [19–23, 25, 27–29] and palateless MIOD on 6 splinted implants [20, 21, 25, 26, 28, 29, 32]. The systematic review's clinical evidence supports the suggestion that the decision between using 4 or 6 splinted implants to support a maxillary overdenture can be made. Does not appear to have a direct correlation with the clinical parameters identified. Considering these factors, it was advantageous to use 4 implants instead of 6 implants to decrease treatment costs, morbidity, and the need for augmentation treatments. Nevertheless, inadequate bone strength and quantity, decreased implant length and diameter, and thus, insufficient initial stability may result in implant failure in the upper jaw. In this scenario, utilizing a 6 implant technique can prevent the need for a new surgical procedure in the event of implant loss. Instead, only an adjustment of the overdenture would be required. On the other hand, in cases when an implant is lost using the 4 implants technique, it is typically necessary to replace the lost implant and create a new prosthesis suprastructure before making adjustments to the overdenture [47]. In addition, therapeutic decision-making also involves selecting between an implant-supported overdenture or a full-fixed prosthesis. Within this particular framework, it has been proven that utilizing 4 implants is enough for ensuring the prolonged effectiveness of implant-supported full fixed prostheses [48], as well as attaining notable degrees of patient contentment [49]. However, patients who have lost all of their teeth often have significant deficiencies in both bone and soft tissue. These deficiencies can result in prognathism (protrusion of the jaw), lack of facial support, difficulty with speech, and aesthetic issues that affect the positioning of the smile line and the length of the upper lip. As a result, these patients are unable to use a fixed prosthesis supported by dental implants. Hence, the inquiry arises: "Can the use of 6 splinted implants supporting a MIOD yield superior treatment outcomes compared to 4 splinted implants?" Further investigation is still necessary [13, 14, 19, 20]. This analysis was constrained by the absence of prospective randomized clinical trials with a low risk of bias (RoB) that compared maxillary overdentures supported by either 4 or 6 splinted implants. Additionally, the study considered the potential to address the blinding challenges that have been previously documented. Specifically, this systematic review included five randomized controlled trials (RCTs) [10, 19–22] that compared the outcomes of a group of patients with 4 splints to those with 6 splints. However, out of the five studies mentioned (10, 19–22), it is worth noting that four of them were conducted by the same authors. It seems that these studies actually represent just two separate studies, with data released at 1 year and 5 years respectively (19–22). Therefore, the quantitative analysis could only incorporate three randomized controlled trials (RCTs). Furthermore, significant variation among the studies and insufficient data hindered the ability to conduct a quantitative evaluation of patients' satisfaction. Furthermore, this study is restricted to only two treatment options out of the wide range of therapeutic modalities available for fully edentulous patients who require implant-supported maxillary prostheses. These treatment options include the utilization of 8 or more implants, zygomatic implants, and additional tissue augmentation procedures

V. Conclusion

Based on this systematic study, it can be concluded that the use of four implants to support a bar-supported overdenture is equally effective as using six implants. This conclusion is based on factors such as patient satisfaction, survival rates of implants and overdentures, and prosthodontic complications. Nevertheless, it is imperative to do future research, particularly long-term analysis, to compare maxillary overdentures supported by either 4 or 6 splinted implants. This will provide additional clarity on the matter.

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