Splinting vs Not Splinting Four Implants Supporting a Maxillary Overdenture: A Systematic Review

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Purpose: To investigate the influence of splinted vs unsplinted designs for a maxillary overdenture supported by four implants in terms of the outcome measures implant survival, overdenture longevity, and patient satisfaction. ***Materials and Methods:*** A systematic search, complemented by a handsearch, was carried out in the Embase, MEDLINE (PubMed), and Web of Science databases from 2000 to 2018. The PRISMA statement and a PICO approach were adopted. Free-text words were used in the strategy search, including "4-implant-retained overdenture," "4-implant-supported overdenture," "implant-supported overdenture," "implant-retained overdenture," "maxillary overdenture," "splinted design," "un-splinted design," and their combinations. All selected articles provided at least a 1-year follow-up, 10 fully edentulous patients, and at least one of the following clinical outcomes: survival rate of implants, survival rate of overdentures, and/or patient satisfaction scores. Nonparametric Fisher test for unpaired data was adopted in order to analyze data deriving from the survival rates of implants and overdentures. ***Results:*** The initial electronic search produced a total of 2,922 articles. After applying the inclusion criteria, 14 articles were included. The mean follow-up time after implant placement ranged from 1 to 10 years. No statistical difference was detected in the survival rate of implants between the splinted implant group and the unsplinted implant group ($P = .1$). Only 4 included studies reported an overdenture survival rate of lower than 95%. It is interesting to note that among these 4 studies, 3 employed four splinted implants with a bar anchorage; however, no statistical difference was detected in the survival rate of overdentures between the splinted and unsplinted groups ($P = .47$). High scores were reported by all studies investigating patient satisfaction. ***Conclusion:*** Within the limits of this systematic review, it can be concluded that the survival rates of implants and overdentures and patient satisfaction with a maxillary overdenture supported by four implants were not influenced by the overdenture design, and no statistical difference was detected between the splinted and unsplinted groups. *Int J Prosthodont 2019;32:509–518. doi: 10.11607/ijp.6333*

The maxillary implant-retained overdenture (MIOD) is a comfortable and functional prosthetic rehabilitation based on an optimal cost-benefit ratio.[1,2] To date, the lack of randomized controlled studies (RCTs) reporting on the treatment outcomes of MIODs has precluded the establishment of specific guidelines regarding the number of implants supporting a maxillary overdenture.[3–5] However, there are similar tendencies regarding the number of implants required to support an MIOD.[3–5] In particular, several systematic reviews have recommended that a minimum of four implants is required to support an MIOD in order to obtain high success rates.[1–7] Moreover, the choice of the number of implants supporting an MIOD depends on the presence or absence of several factors.

Risk factors such as compromised quality and quantity of bone, an off-ridge relationship, high applied forces, maxillary sinus extension, arch shape (V shape or U shape), and palatal coverage may influence the choice of number of implants and necessitate the consideration of placement of more than four implants.

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In the case of a U shape, the choice of number of implants is less constrained than the V shape, as there are more spaces that can be used in the arch and a larger transversal diameter in the anterior area.[3,4] For a design without palatal coverage, a minimum of four implants is required.[3] As far as mesial extension of the maxillary sinus, the tendency is to consider this extension the posterior limit of the implant position unless sinus lift or short implants are employed.[3,4] Regarding the interarch relationship, Angle Class III malocclusion is the most limited for implant placement. In this case, the anterior region should be employed in order to limit the sagittal discrepancy and unfavorable biomechanics.[3] In the case of Angle Classes I and II, the implant location is less constrained, as it is linked only to the residual bone volume, the extension of the maxillary sinus, and the shape of the arch.[3] When risk factors do not occur, four implants can be considered the optimal number in terms of morbidity, the prosthetic procedure, and cost-effectiveness.[1-4]

Several systematic reviews have shown that splinted and unsplinted overdenture attachment systems achieved similar results in terms of implant survival, overdenture longevity, and patient satisfaction.[5–9] However, the data of these reviews included results of treatment both in the maxilla and in the mandible, not focusing on the number of implants or the maxilla in particular. Then, the question as to whether four splinted implants or four unsplinted implants supporting an MIOD may produce better results in terms of implant survival rate, overdenture survival rate, and patient satisfaction is still an object of discussion.[2,4,10] Thus, the aim of this systematic review was to investigate the influence of splinted vs unsplinted designs when an MIOD is supported by four implants on the treatment outcomes implant survival, overdenture longevity, and patient satisfaction.

MATERIALS AND METHODS

The PRISMA statement was adopted as a guideline to carry out the review, according to Moher et al.[11] The PICO (population, intervention, comparison, outcome) question was: "In fully edentulous patients (P) who require a maxillary four-implant–retained overdenture (I), is there a difference between splinted and unsplinted implants (C) in terms of implant survival, overdenture longevity, and the patient's quality of life (O)?"

Search Strategy

Free-text words were used in the search strategy, including: "4-implant-retained overdenture," "4-implant-supported overdenture," "implant-supported overdenture," "implant-retained overdenture," "maxillary overdenture," "splinted design," "unsplinted design," and their combinations. The search was carried out on PubMed, Web of Science, and EMBASE databases to find all relevant articles published between 2000 and 2018. In addition, a manual search of the bibliographies of the most recent systematic reviews and of all the selected full-text articles was employed in order to identify additional eligible studies.

Quality Assessment

The quality of the included studies was evaluated independently by two reviewers (F.D., A.L.). The Cochrane Risk of Bias tool, investigating selection, performance, detection, attrition, reporting, and other biases, was employed to analyze the included RCTs.[12] The quality of nonrandomized clinical studies was assessed using the Newcastle-Ottawa Scale (NOS).[13] This scale uses a star system by which a study is judged on three broad perspectives: the selection of the study groups (up to 4 points), the comparability of the groups (up to 2 points), and exposure or outcome of interest for case-control or cohort studies, respectively (up to 3 points). Studies that met five or more of the NOS score criteria were considered as good quality and included in the study. For other types of studies, the quality assessment was evaluated using a tool focusing on eight items developed by den Hartog et al.[14] The studies scoring five or more plus signs were considered acceptable.

Inclusion Criteria

Studies that met the following criteria were included:

- Studies investigating at least 10 fully edentulous patients rehabilitated with a maxillary four-implant–retained overdenture
- Studies analyzing at least one of the following clinical outcomes: survival rate of implants, survival rate of overdentures, and scores of patient satisfaction in relation to the four-implant–retained overdentures
- Articles providing at least a 1-year follow-up
- RCTs and prospective and retrospective studies
- Studies published in English

Exclusion Criteria

The following studies were excluded:

- Clinical studies that did not clearly report the relationship between the treatment with a maxillary four-implant–retained overdenture and the outcome measures
- Clinical studies that did not clearly define at least one of the following clinical parameters: survival rate of implants, survival rate of overdentures, and/or patient satistfaction scores
- In vitro studies

Data extraction from the included studies and data checking were performed by two reviewers (F.D., G.D.), respectively.

Due to the heterogeneity of the included studies concerning study design, patient selection, surgical and prosthetic methods, follow-up time, loading protocol, and outcome assessment, a meta-analysis was not performed. Only one study by Zou et al[16] reported the comparison between a splinted group and an unsplinted group. However, descriptive statistics were used to report all the data. Data were divided according to the splitting technique, and nonparametric Fisher test for unpaired data was employed in order to compare the survival rates of implants and overdentures in a splinted group and an unsplinted group.

RESULTS

Selection of Studies

The flowchart of the literature review process is shown in Fig 1. The search results in PubMed, Web of Science, and EMBASE databases produced a total of 2,922 articles published from 2000 to 2018. Duplicate studies were removed. All obtained titles were screened by two independent reviewers (F.D., G.D.) in order to remove articles that clearly failed to meet the inclusion criteria. After analyzing the titles, 542 abstracts were identified. Analysis of the abstracts excluded articles that did not report at least one of the desired outcomes; therefore, 117 full-text articles were selected. In addition, a manual search of the bibliographies of the most recent systematic reviews and of all articles that were selected for full-text evaluation produced 8 studies, resulting in a total of 125 articles. The application of the inclusion criteria and quality assessment criteria were performed by the two independent reviewers (F.D., A.L.). Finally, 14 full-text articles satisfied the inclusion criteria, resulting in 6 prospective studies, 5 retrospective studies, and 3 RCTs, as reported in Table 1.

Outcomes of the quality assessment of the included studies are reported in Tables 2 through 4.

The scores of the five nonrandomized studies eligible for the NOS ranged from 6 to 8 with a mean score of 7.4, as described in Table 3. All three RCTs revealed a high risk of bias in two key domains—one showed unclear risk of bias in two key domains, while two showed unclear risk of bias in one key domain (Table 2). According to authors' definitions,[12] the overall ranking revealed no studies with a low risk of bias. For the other six studies, evaluated with a quality assessment tool by den Hartog et al,[14] all articles had a score of 5 or more (Table 4).

The qualitative synthesis of data extracted from the included studies is reported in Table 5. Furthermore, extracted data were divided into a group of four splinted implants (Table 6) and a group of four unsplinted implants (Table 7). Subsequently, data were statistically analyzed according to the splinting technique, as reported in Fig 2. However, some studies included in the analysis reported a comparison between maxillary overdentures supported by four or six implants in the anterior region or in the posterior region.[20,21,23,26,27,29] In these studies, only outcomes in relation to four-implant–retained overdentures were reported, as shown in Table 6.

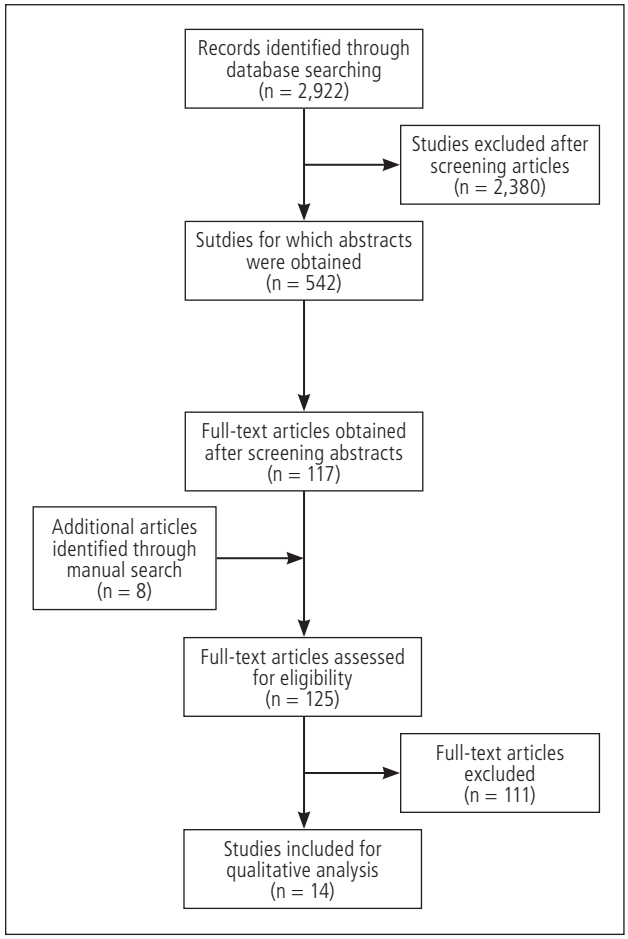

Fig 1 Flowchart of search strategy.

Survival of Implants

Comparing the results of papers analyzing four splinted implants[15–19] to those of studies that examined four unsplinted implants,[16,20–27] the survival rate of implants appeared higher in the unsplinted group, as shown in Fig 2; thus, studies analyzing four splinted implants showed a higher number of lost implants. However, it is interesting to note that although the studies investigating MIODs on four splinted implants revealed a lower implant survival, almost all studies investigating this type of treatment reported a survival rate of implants higher than 97%.[16,20–27]

Table 1 Features of Included Studies

Study	Year	Study design	Follow-up (mo)	No. of patients	Anchorage system
Offord et al[15]	2017	Retrospective	14	11	Unsplinted
Wang et al[19]	2016	Retrospective	56	26	Unsplinted
Slot et al[20]	2016	RCT	60	50	Splinted
Frisch et al[17]	2015	Retrospective	66	20	Unsplinted
Slot et al[27]	2014	RCT	12	66	Splinted
Mangano et al[22]	2014	Prospective	36	28	Splinted
Zou et al[16]	2013	Prospective	36	30	Splinted and unsplinted
Cordaro et al[18]	2013	Retrospective	12	10	Unsplinted
Slot et al[26]	2013	RCT	12	50	Splinted
Katsoulis et al[23]	2011	Prospective	24	22	Splinted
Mangano et al[24]	2011	Prospective	60	38	Splinted
Akca et al[25]	2010	Prospective	59	11	Splinted
Krennmair et al[21]	2008	Retrospective	42	34	Splinted
Ferrigno et al[28]	2002	Prospective	120	16	Splinted

Table 2 Quality Assessment of Included Randomized Controlled Trials Using the Cochrane Risk of Bias Tool

Study	Random sequence generation	Allocation concealment	Blinding (participants and personnel)	Blinding (outcome assessment)	Incomplete outcome data addressed	Selective reporting	Other bias
Slot et al,[20] 2016	High	Unclear	High	Unclear	Low	Low	No
Slot et al,[27] 2014	High	Low	High	Unclear	Low	Low	No
Slot et al,[26] 2013	High	Low	High	Unclear	Low	Low	No

Table 3 Quality Assessment of Included Nonrandomized Clinical Studies Using Newcastle-Ottawa Scale (NOS)

Study	Selection (max score: ****)	Comparability (max score: **)	Outcome (max score: ***)	Total score
Offord et al,[15] 2017	***	*	**	6
Zou et al,[16] 2013	****	*	***	8
Katsoulis et al,[23] 2011	****	*	***	8
Krennmair et al,[21] 2008	****	*	**	7
Ferrigno et al,[28] 2002	****	**	**	8

Studies that met five or more of the NOS score criteria were considered as good quality.

Table 4 Quality Assessment of Included Studies Using a Tool Developed by den Hartog et al[14] Focusing on Eight Items

Study	Wang et al,[19] 2016	Frisch et al,[17] 2015	Mangano et al,[22] 2014	Cordaro et al,[18] 2013	Mangano et al,[24] 2011	Akca et al,[25] 2010
1. Are the characteristics of the study group clearly described?	+	+	+	+	+	+
2. Is there a high risk of selection bias? Are the inclusion and exclusion criteria clearly described?	+	+	+	+	+	+
3. Is the intervention clearly described? Are all patients treated according to the same intervention?	+	+	+	+	+	+
4. Are the outcomes clearly described? Are adequate methods used to assess the outcome?	+	+	+	+	+	+
5. Is blinding used to assess the outcome?	?	–	+	–	?	–
6. Is there a sufficient follow-up?	+	+	+	+	+	+
7. Can selective loss to follow up sufficiently be excluded?	+	+	+	–	+	+
8. Are the most important confounders or prognostic factors identified and are these taken into consideration with respect to the study design and analysis?	–	–	–	–	–	+

Studies scoring five or more pluses were considered acceptable.

Table 5 Clinical Features of the Included Studies

Study	No. of implants, anchorage system	Total no. of OVDs	OVD design	Opposing arch	System used for estimation of patient-reported results (score range)
Offord et al,[15] 2017	4, Locator	11	Partial palatal coverage	ND	OHIP-14 (0–56; mean 3.3)
Wang et al,[19] 2016	4, Locator	26	Partial palatal coverage	Natural teeth (ND) Implant-retained OVD	ND
Slot et al,[20] 2016	4, bar	50	Partial palatal coverage	Implant-retained overdenture	10-point rating scale (> 8)
Frisch et al,[17] 2015	4, double crown	20	Palateless	Fixed reconstruction (7) Removable partial denture (13)	ND
Slot et al,[27] 2014	4, bar	66	Palateless	Implant-retained OVD	10-point rating scale (> 8)
Mangano et al,[22] 2014	4, bar	28	Palateless	Implant-retained OVD	ND
Zou et al,[16] 2013	4, bar 4, Locator 4, double crown	30	ND ND ND	ND ND ND	Likert scale (0–2 range; mean 2)
Cordaro,[18] 2013	4, Locator	10			ND
Slot et al,[26] 2013	4, bar	50	Palateless	Implant-retained OVD	Rating scale (0–10; mean > 8)
Katsoulis et al,[23] 2011	4, bar	22	Palateless	Tooth-implant–supported fixed prosthesis (ND) Natural teeth (ND)	ND
Mangano et al,[24] 2011	4, bar	38	Palateless	Implant-retained OVD	ND
Akca et al,[25] 2010	4, bar	11	ND	Implant-supported overdenture (implants: 4) Implant-supported fixed prosthesis (implants: 1) Tooth-supported removable partial denture (teeth: 1) Tooth-supported fixed prosthesis (teeth: 4) Natural teeth (teeth: 1)	ND
Krennmair et al,[21] 2008	4, bar	34	Palateless	Implant-retained OVD (implants: 13) Fixed partial denture (teeth: 10) Natural teeth (teeth: 11)	Likert scale 1–5 (> 4.6)
Ferrigno et al,[28] 2002	4, bar	16	ND	ND	ND

OVD = overdenture; ND = not determined; OHIP-14 = Oral Health Impact Profile;

Conversely, only one study investigating MIODs on four splinted implants reported an implant survival rate of lower than 90%.[28] However, in this study,[28] a longer follow-up compared to the other included studies (10 years) could have negatively influenced implant survival. Moreover, no statistical difference was detected in the survival rate of implants between the splinted and unsplinted groups ($P = .1$), as described in Fig 2.

According to the data analysis of the above-mentioned studies, the type of anchorage does not have a significant influence on the survival rate of implants when a maxillary overdenture is supported by four implants. This finding has also been corroborated by the results of other systematic reviews.[1,2,4,5,7,8]

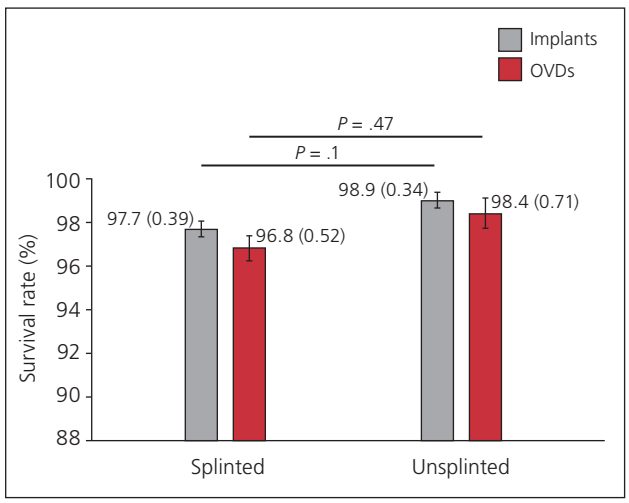

Fig 2 Comparison of results of papers examining four splinted implants vs four unsplinted implants. There was no statistical difference in the survival rates of implants ($P = .1$) or the survival rates of overdentures ($P = .47$). Survival rates are reported as percent (standard error of the mean).

Survival of Overdentures

Most of the included studies reported an overdenture survival rate of 100% both for four splinted implants[16,20,21,23,24,26,27] and for four unsplinted implants.[16–18] Only four included studies reported an

Table 6 Analysis of Survival Rates of Implants and Overdentures with Four Splinted Implants

Study	No. of implants, location	Pre-implant bone augmentation	Anchorage system	Bar fabrication	Follow-up (mo)	Total no. of implants	Total no. of lost implants	Survival rate of implants (%)	Total no. of OVDs	Survival rate of OVDs (%)
Slot et al,[20] 2016	4, anterior region	No	Milled titanium egg-shaped bar with distal extensions	Abutment level	60	100	0	100	50	100
Slot et al,[27] 2014	4, posterior region	Sinus floor	Milled titanium bar with mesial extensions and gold retentive clips	Abutment level	12	132	0	100	66	100
Mangano et al,[22] 2014	4, anterior region	No	Cobalt-chrome bar, without extensions and gold retentive clips	Abutment level	36	112	3	97.4	28	93.3
Zou et al,[16] 2013	4, ND	No	Dolder gold bar	Abutment level	36	40	0	100	10	100
Slot et al,[26] 2013	4, anterior region	No	Milled titanium egg-shaped bar with distal extensions	Abutment level	12	100	0	100	50	100
Katsoulis et al,[23] 2011	4, ND	No	Titanium or dolder gold bar with distal extension	Implant level	24	88	1	98.9	22	100
Mangano et al,[24] 2011	4, anterior region	No	Egg-shaped dolder gold bar with or without distal extensions	Abutment level	60	152	4	97.4	38	100
Akca et al,[25] 2010	4, ND	No	Egg-shaped dolder gold bar with distal extensions	Implant level	59	44	1	97.7	11	88
Krennmair et al,[21] 2008	4, anterior region	No	Titanium or gold bar with distal extensions and retentive clips	Abutment level	42	65	1	98.4	34	100
Ferrigno et al,[28] 2002	4, anterior and posterior regions	Some sinus floor	Dolder bar	ND	120	64	6	86.9	16	87.5

OVD = overdenture; ND = not determined.

Table 7 Analysis of Survival Rate of Implants and Overdentures in Case of Four Unsplinted Implants

Study	No. of implants for patient	Anchorage system	Follow-up (mo)	Total no. of implants	Total no. lost implants	Survival rate of implants (%)	Total no. of OVDs	Survival rate of OVDs (%)
Offord et al,[15] 2017	4	Locator	14	42	0	100	11	ND
Wang et al,[19] 2016	4	Locator	56	104	1	95.2	26	92
Frisch et al,[17] 2015	4	Double crown	66	80	1	98.7	20	100
Zou et al,[16] 2013	4	Locator	36	40	0	100	10	100
Zou et al,[16] 2013	4	Double crown	36	40	0	100	10	100
Cordaro et al,[18] 2013	4	Locator	12	40	0	100	10	100

OVD = overdenture; double crown = telescopic crowns on implants; ND = not determined.

overdenture survival rate of less than 95%.[19,22,26,28] It is interesting to note that among these four studies, three employed MIODs on four splinted implants with a bar. However, no statistical difference was detected in the survival rate of overdentures between the splinted and unsplinted groups (P = .47), as reported in Fig 2. The outcomes of the above-mentioned studies indicate that the high survival rate of maxillary four-implant–retained overdentures is not significantly influenced by the design of the overdenture.

Patient Satisfaction

High scores were reported by all studies investigating patient satisfaction. Slot et al showed overall satisfaction scores higher than 8 points on a 10-point rating scale at both 1- and 5-year follow-ups for MIODs supported by four splinted implants.[20,26] Similarly, Krennmair et al found scores higher than 4.5 on a 1 to 5 Likert scale for different items (general satisfaction, chewing ability, denture stabilization, esthetic results, and speech) for patients rehabilitated with MIODs on four splinted

implants.[21] On the contrary, Offord et al, reporting satisfaction of patients rehabilitated with MIODs supported by four unsplinted implants, showed an extremely low mean OHIP-14 score of 3.3, justifying a very high level of patient satisfaction following the treatment.[15] Zou et al, employing three different anchorage systems such as bar, Locator, and telescopic crowns supporting a four-implant maxillary overdenture, showed no differences among different anchorage systems after 3 years of function.[16] According to the outcomes of these studies, patient satisfaction is constantly high and was not influenced by the type of anchorage system used to support a maxillary four-implant–retained overdenture.

DISCUSSION

When a maxillary overdenture has been planned, the most frequent tendency is to place at least four implants (typically four or six) in order to ensure a higher implant survival rate.[1–3] Placing fewer than four implants may compromise implant survival, especially in long-term follow-up.[2,4] However, when risk factors such as compromised quality and quantity of bone, an off-ridge relationship, high applied forces, and maxillary sinus extension do not occur, four implants can be considered the optimal number in terms of cost-effectiveness.[1–4] In light of these considerations, when four implants are placed in order to support an MIOD, a splinted or unsplinted design can be employed. At present, no specific guidelines exist concerning the type of anchorage necessary to support an MIOD on four implants. Several systematic reviews have proposed that implants supporting maxillary overdentures should be splinted to ensure a biomechanical advantage, enable better force balance, provide cross-arch stabilization, and avoid potential overloading of single implants.[2,3,7,29,30] However, although three systematic reviews[1,2,4] showed that the risk of implant loss increases when an MIOD is supported by four unsplinted implants, several of the analyzed studies investigating MIODs on four unsplinted implants reported an implant survival rate higher than 95%.[15–19] According to the data analyses of this systematic review, no statistical difference was detected in the survival rate of implants between the splinted and unsplinted groups. Moreover, the issue of splinting or not splinting four implants supporting a maxillary overdenture still requires further investigation.[7,8,10,31] This is due to the lack of prospective RCTs with a low risk of bias comparing maxillary overdentures supported by four implants with different types of attachments. In particular, there was only one study[16] comparing a group of four splinted implants to a group of four unsplinted implants in this systematic review.

As far as survival of the overdenture is concerned, data analysis of the included studies showed a high survival rate for MIODs both on four splinted implants and four unsplinted implants. These results indicate that there is not such a strong link between the survival rates of maxillary overdentures on four implants and the type of anchorage. However, more than analyzing the survival of the prosthesis—which is always high and not sufficiently linked to the number of implants and the type of anchorage—it is important to analyze the success of the prosthesis influenced by the prosthetic complications. Osman et al showed that prosthodontic maintenance requirements of maxillary implant overdentures are a direct consequence of the attachment systems and the number and distribution of implants.[32] Long-term complications of implant-supported/retained prostheses are influenced by the passive fit of prostheses and access for at-home oral hygiene care. The attachment systems and the number and distribution of the implants can influence the frequency of oral hygiene regimens.

However, controversy still exists in terms of prosthodontic maintenance requirements when comparing splinted and unsplinted designs.[31,32] In the literature, most studies report a combined incidence of prosthodontic complications for maxillary and mandibular overdentures, not allowing any definite conclusion regarding the most effective mode of attachment system.[7,33–35] Few studies have specifically evaluated the influence of prosthodontic design on the long-term maintenance requirements of maxillary overdentures.[36–39] Therefore, a clear, controlled indication of the prosthodontic design required to support a maxillary overdenture on four implants does not exist yet. The question then is what would be the preferred design for better long-term outcomes. The design of the prosthesis should provide the best passive fit, stress distribution, and ease of access for proper oral hygiene. The first order of the prosthesis design consideration will not be the maintenance requirements, but rather the optimal passive fit and stress distribution, especially in type 3 and type 4 bone, along with an appropriate oral hygiene regimen. Thus, from a mechanical point of view, the absence of abutments and the direct screw fixation of the bars at the implant level could appear to be advantageous.[23] However, most of the included studies investigated a bar design at abutment level, reporting the survival of implants and overdentures greater than 97%.[16,20–22,24,26,27] Future studies analyzing prosthodontic complications of MIODs on four implants with different designs are recommended.

In the literature, the data are subject to controversy even when different anchorage systems are analyzed referring to patient satisfaction. Several investigators have demonstrated, in vitro and in vivo, that a splinted design provides more retention than an unsplinted design when subjected to both vertical and oblique forces.[40–44] Elsyad et al, comparing the retention and

stability of Locator and bar attachments for maxillary four-implant–retained overdentures, showed that the unsplinted design was associated with high retention and stability after wear simulation with minimal retention loss.[45] Slot et al highlighted that the anchorage system has a stronger influence on patient satisfaction, supporting the splinted design.[20] However, data analysis of the included studies indicated that patients appear to be equally satisfied both with splinted and unsplinted designs supporting maxillary four-implant–retained overdentures. This finding is in line with several recent studies.[7,8,10,16,46] The reason lies in the concept that the change from the conventional maxillary complete denture to an implant-supported denture was perceived by patients as significant, independent of the anchorage system of the overdenture. Although de Albuquerque Júnior et al[47] showed no significant differences regarding patient satisfaction between MIODs on four splinted implants with and without palatal coverage, the patients usually require an overdenture without palatal coverage to obtain comfort, taste, swallowing, and phonation. It seems that the minimum favorable number in the literature to support an MIOD without palatal coverage is four splinted implants.[2,20,26,47,48] This concept is in line with several studies included in this review, reporting a survival rate of implants of greater than 97%.[21–24,26,27] Moreover, other studies have revealed satisfactory results that justify the use of MIODs on four unsplinted implants without full palatal coverage extension.[17,49–52] For some authors, it is evident that the total palatal coverage, as well as the splinted design, has a more favorable pattern of tension dissipation in implant-supported overdentures.[6,21,53,54] However, an interesting in vivo study evaluating the contribution of the palate in overdentures supported by four implants distributed in the maxilla concluded that the palate provided limited support to the base of the prostheses.[55] Furthermore, the influence of implant placement on the stress generated in palateless MIODs is a topic still to be discussed. It has been believed that the planned distribution of maxillary implants provides a more favorable load distribution to implants and peri-implant tissues, but there are few studies indicating the location of the implants in palateless MIODs. By increasing the inter-implant distance between anterior and posterior implants, a more retentive prosthesis for the palateless maxillary overdenture can be achieved.[49–52]

Then, although there are established differences in the retentive strengths of various attachment systems, there is a lack of conclusive clinical evidence that demonstrates the superiority of one particular attachment system over another.[34,35] Factors such as desired retention, opposing dentition, distribution and parallelism of implants, hygiene abilities, possible implant failure, interocclusal distance, and ease of maintenance should be considered when choosing the appropriate attachment system. The clinical evidence found in this systematic review suggests that the choice of the anchorage system supporting a maxillary overdenture on four implants does not seem to be directly related to the clinical parameters evaluated. Thus, the choice seems to be linked to other factors, such as hygiene abilities, available space between the arches, and operator skills. Unsplinted designs require less space within the prosthesis, may be easier to clean and more economical, may compensate for possible implant failure, offer greater ease for maintenance or repair, and be less technique sensitive and easier when compared to a splinted design. However, a splinted design should be chosen when nonparallelism among implants can occur, short implants are employed, or the antagonist arch is represented by natural teeth or a fixed prosthesis on implants.

CONCLUSIONS

Within the limits of this systematic review, it can be concluded that the survival rates of implants and overdentures and of patient satisfaction of a maxillary overdenture on four implants was not influenced by the design of the overdenture. Four splinted implants or four unsplinted implants may represent the optimal solution for supporting a maxillary overdenture in order to obtain high implant and overdenture survival rates and high patient satisfaction. However, randomized controlled clinical trials comparing maxillary overdentures supported by four splinted implants or four unsplinted implants are required in order to try setting guidelines on this topic.

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Literature Abstracts

The Effect of Immediate Implant Placement on Alveolar Ridge Preservation Compared to Spontaneous Healing After Tooth Extraction: Radiographic Results of a Randomized Controlled Clinical Trial

The purpose of this study was to radiographically evaluate the effect of immediate implant placement plus alveolar ridge preservation (ARP) with deproteinized bovine bone mineral and a collagen matrix (IMPL/DBBM/CM) as compared to ARP (DBBM/CM) and spontaneous healing (SH) on vertical and horizontal bone dimension changes after 4 months of healing. Thirty patients requiring extraction of one single-rooted tooth or premolar were randomly assigned to IMPL/DBBM/CM, ARP DBBM/CM, or SH. Cone beam computed tomography scans, performed before tooth extraction and after 4 months, were superimposed in order to assess changes in ridge height at the buccal and lingual aspects and in ridge width at 1 mm, 3 mm, and 5 mm apical to the bone crest. Kruskal-Wallis test was applied for comparison of differences between groups. No statistically significant differences between the groups were observed for vertical bone resorption of the buccal and lingual sides, while significant differences were found between SH (–3.37 ± 1.55 mm; –43.2% ± 25.1%) and both DBBM/CM (–1.56 ± 0.76 mm; –19.2% ± 9.1%) and IMPL/DBBM/CM (–1.29 ± 0.38 mm; –14.9% ± 4.9%) in the horizontal dimension at the most coronal aspect. It can be concluded that, when compared to SH, ridge preservation techniques using DBBM and CM reduce the horizontal bone morphologic changes that occur, mostly in the coronal portion of the buccal bone plate. This is true regardless of whether immediate implant placement is performed.

Clementini M, Agostinelli A, Castelluzzo W, Cugnata F, Vignoletti F, De Sanctis M. *J Clin Periodontol* 2019;46:776–786. **References:** 43. **Reprints:** Marco Clementini, mclementini@me.com —*Carlo Marinello, Switzerland*

Bruxism: An Umbrella Review of Systematic Reviews

The purpose of this study was to synthesize the available knowledge about both sleep bruxism (SB) and awake bruxism (AB) from previously published systematic reviews (SRs). SRs investigating any bruxism-related outcome were selected in a two-phase process. Searches were performed in seven main electronic databases, and a partial gray literature search was performed in three databases. Risk of bias of included SRs was assessed using the University of Bristol's tool for assessing risk of bias. From 1,038 studies, 41 SRs were included. Findings from these SRs suggested that *(1)* among adults, prevalence of AB was 22% to 30%, of SB 1% to 15%, and of SB among children and adolescents 3% to 49%; *(2)* factors consistently associated with bruxism were use of alcohol, caffeine, tobacco, some psychotropic medications, esophageal acidification, and secondhand smoke; in addition, temporomandibular disorder signs and symptoms presented a plausible association; *(3)* portable diagnostic devices showed overall higher values of specificity (0.83 to 1.00) and sensitivity (0.40 to 1.00); *(4)* bruxism might result in biomechanical complications regarding dental implants; however, evidence was inconclusive regarding other dental restorations and periodontal impact; and *(5)* occlusal appliances were considered effective for bruxism management, although current evidence was considered weak regarding other therapies. Current knowledge from SRs was mostly related to SB. Higher prevalence rates were found in children and adolescents than in adults. Associated factors and bruxism effects on stomatognathic structures were considerably heterogenous and inconsistent. Overall good accuracy regarding portable diagnostic devices was found. Interventions' effectiveness was mostly inconclusive regarding the majority of available therapies, with the exception of occlusal appliances.

Melo G, Duarte J, Pauletto P, et al. *J Oral Rehabil* 2019;46:666–690. **References:** 66. **Reprints:** Gilberto Melo, melo.gilgerto@hotmail.com —*Carlo Marinello, Switzerland*