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Single implants in dorsal areas – A systematic review

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Key words *delayed loading, delayed placement, immediate loading, immediate placement, posterior quadrant, single implant*

Aim: This study evaluated the efficacy of replacing single missing teeth in the posterior quadrants of the maxilla and/or mandible with an implant-supported dental prosthesis.
Material and methods: Three scientific literature databases – Medline (Pubmed), Ovid Medline and Cochrane Central Register of Controlled Trials (CENTRAL) – were used to perform a search of publications over a period from 1985 to 2014. One hundred and forty one (141) articles were reviewed; 36 articles met the inclusion criteria and were included in the final review.
Results: The survival rates, success rates and mean bone loss for immediate implant placement were 96.9%, 100% and 0.85 mm, respectively. The survival rates, success rates and mean bone loss for delayed implant placement were 96.8%, 94.1% and 0.55 mm respectively. The survival rate, success rate and the mean bone loss in studies comparing immediate versus delayed implant placement showed 96.8% and 96.3%, 85.8% and 93.3%, and 0.57 ± 0.57 mm and 0.55 ± 0.37 mm, respectively.
Conclusion: The prognosis for single molar implants provides a viable treatment option for replacing a single missing tooth in the posterior quadrants of the maxilla and mandible. There does not appear to be a significant difference in the survival rates of immediately placed implants compared with delayed implant placement. However, the success rates were slightly higher with delayed loading protocols than immediate loading protocols.

Conflict-of-interest statement: *Authors report no conflicts of interest.*

Introduction

Implant-retained dental prostheses have provided new treatment options for restoring dental arches with missing teeth or completely edentulous mouths. It is well known that endosseous implants show remarkable ability for osseointegration and are effective in supporting numerous dental prosthetic designs[1,2]. However, the efficacy of placing an implant in the posterior regions of the jaws has not been well addressed. Urban and his colleagues have looked into risk factors for implant failure in the molar and pre-molar regions such as smoking, buccal dehiscence and infection[3]. While studies have examined implant placement techniques and associated complications, there is heterogeneity with publications reporting on the survival and success rates of implant placement in the posterior region.

Furthermore, the various staging and loading protocols to manage the implant after placement remain controversial. Brånemark's traditional protocols for implants used a staged approach. After

extraction of tooth/teeth, a healing period of 3 to 6 months was permitted, followed by implant placement, and another healing period of 3 to 6 months, followed by second stage surgery to expose the implant, and finally loading of the implant with a prosthetic restoration. This traditional protocol has longer treatment times and more surgical steps requiring multiple recovery times. As research on dental implants has progressed over the decades, specifically by modification of the implant surface roughness and macro-design, clinical researchers have started to look toward immediate implant placement following tooth extraction. Advantages of immediate implant placement following extraction are reduced number of procedures, shortened treatment times, and therefore fewer recovery periods with less discomfort for the patients. Another possible benefit is found in studies showing that immediate implant placement in fresh extraction sockets may limit the bone remodelling which typically takes place with the alveolar ridge after tooth extraction[4].

Several studies have shown that there is no difference in survival rates between immediate implant placement and delayed implant placement[5]. The immediate placement of implants have shown survival rates between 95% to 100% and success rates of 89% to 98%, irrespective of the loading protocols. The loading protocols in the studies varied from the traditional, delayed approach to early loading and immediate loading. However there seems to be more failures with both immediate and early loading than with delayed loading[6].

The aim of this review is to study the efficacy of implant placement in the posterior region with different placement (immediate and delayed) and loading protocols (immediate, early and delayed).

Materials and methods

PICO (P - patient problem or population, I - intervention, C - comparison, O - outcome[s])

- Patients requiring extraction of molar teeth.
- Intervention: immediate implant placement/ delayed implant placement.
- Comparison: no comparison required/delayed implant placement.
- Outcome: implant success and survival.

Search strategy

A search strategy was conducted using Pubmed, Ovid Medline and Cochrane Central databases using a combination of Medical Subject Heading (MeSH) terms and [ALL Fields] were used for searching the literature for studies relevant to the topic. A manual search was also conducted from the reference list of the selected articles. The search was limited to only articles that met the inclusion criteria. The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) protocol has been used as a guide when reviewing the selection of the articles. Total number of articles found are 138 with initial search terminology: Immediate [All Fields] AND Implants [All Fields] AND Delayed [All Fields] AND Implants [All Fields] AND („Molar" [MeSH Terms] OR „Molar" [All Fields]) AND („Tooth" [MeSH Terms] OR „Tooth" [All Fields] OR „Teeth" [All Fields]).

From 141 articles (138 electronic, 3 manual), 52 articles were available for review with the search limited to clinical trials, comparative studies, controlled clinical trials, randomised clinical trials, meta analyses, reviews and systematic reviews. The following combination of words were used to limit the study: (Immediately [All Fields] AND Implants [All Fields] AND Delayed [All Fields] AND Implants [All Fields] AND („Molar" [MeSH Terms] OR „Molars" [All Fields]) AND („Tooth" [MeSH Terms] OR „Tooth" [All Fields] OR „Teeth" [All Fields]) AND ((Clinical Trial [ptyp] OR Review [ptyp] OR Systematic [sb] OR Randomized Controlled Trial [ptyp] OR Meta-Analysis [ptyp] OR Controlled Clinical Trial [ptyp] OR Comparative Study [ptyp]) AND „Humans" [MeSH Terms])

After reviewing all the manuscripts, 36 articles were included for this review.

Inclusion criteria

- Prospective case series.
- Randomised clinical trials.
- Retrospective studies.

- May have an implant placed immediately after extraction, irrespective of the loading protocols.
- May or may not have delayed placement group.
- Must have included at least one of the following outcomes: a) survival rate and b) success rate.
- Articles that were published in English.

Exclusion criteria

- Case reports (reporting on < 5 patients).
- Studies that included medically compromised patients.
- Non-compliant patients.
- Non-stable implants at the time of primary placement.

Data extraction

The data were extracted from all eligible studies and were recorded on a prefabricated data extraction table. All studies reviewed for the collection of data met the inclusion criteria. Information retrieved from the studies pertained to the study design, inclusion and exclusion criteria, intervention performed and the outcome. The effectiveness of interventions was assessed in terms of its effect on the outcomes: 1) the implant survival rate and 2) the implant success rate.

Success of the implant is based on the following assessment criteria:

- mean marginal bone loss;
- bleeding on probing around the implants;
- probing depths around the implant.

The data were obtained by calculating the mean of all the means from various studies.

Results

The study selection and number of articles (36) were included in the primary assessment with the final review based on different outcomes:

- Ten immediate implant placement studies reporting survival rate as an outcome.
- Three immediate implant placement studies reporting success rate as an outcome.
- Three immediate implant placement studies measuring bone loss as an outcome.

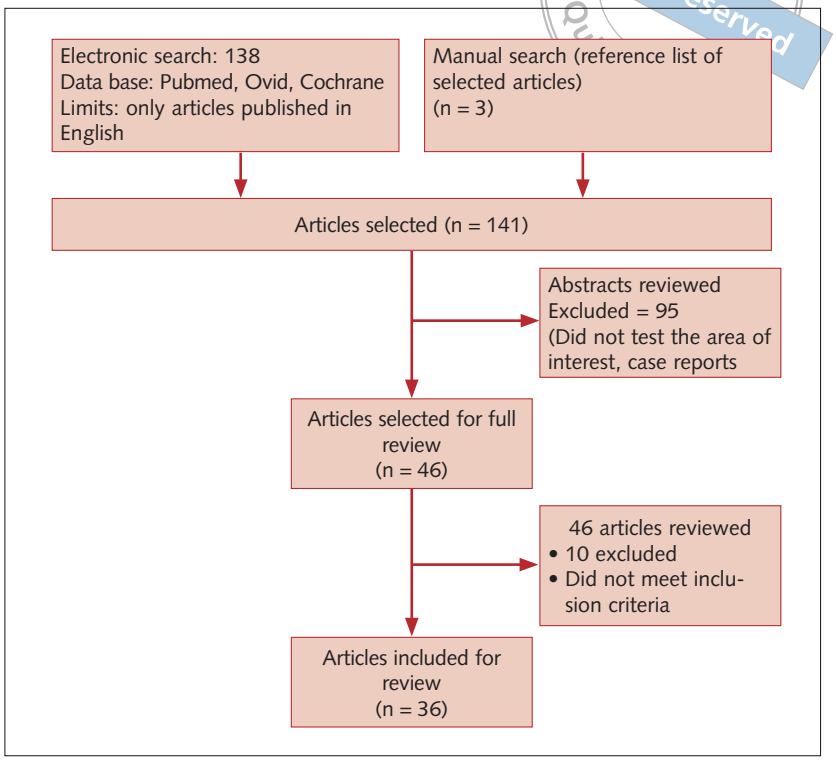

Fig 1 Search strategy.

- Three immediate vs delayed implant placement studies reporting survival rate as an outcome.
- Four immediate vs delayed implant placement studies reporting success rate as an outcome.
- Four immediate vs delayed implant placement studies measuring bone loss as an outcome.
- Fifteen delayed implant placement studies reporting survival rate as an outcome.
- Five delayed implant placement studies reporting success rate as an outcome.
- Ten delayed implant placement studies measuring bone loss as a primary outcome.

Out of 36 articles, 11 were case series studies involving immediate implant placement, five were retrospective or prospective case studies comparing immediate versus delayed implant placement, and 20 examined delayed implant placement with varying loading protocols. The total number of patients reported in immediate implant placement case series studies was 974. The total number of patients reported in case series studies comparing immediate versus delayed implant placement was 267 with a mean study size of 53. The total number of patients reported in delayed implant placement

studies was 2905 with a mean study size of 145. In total, 1077 implants were included in the immediate implant placement case series studies with a mean of 98 implants per study. One hundred and thirty-seven immediate implants and 201 delayed implants were included in the case series studies reporting immediate and delayed implant placement protocols. Three thousand six hundred and forty-six implants were included in the delayed implant placement studies with a mean of 182 implants per study. Of the 3646 implants in the delayed placement studies, 618 underwent immediate loading while 3028 underwent delayed loading. The follow-up times for the immediate implant placement case series studies ranged from 4 to 96 months, whereas the delayed implant placement studies ranged from 5 to 144 months. The retrospective case series studies and randomised control trials comparing immediate vs delayed implant placement had average follow-up periods of 12 months.

Details of intervention

The aim of the review is to study the efficacy of implant placement in the posterior region. As a result, all of the studies included evaluated placement of implants in the molar region. The case series articles reporting on immediate implant placement also varied in their research design as 10 out of the 11 were prospective and one was retrospective. It must also be noted that one of the case series articles reported data from immediate loading, whereas the other 10 studies reported delayed loading of implants after placement. Additionally, the method by which success was determined varied between the articles. Success rate of implants was assessed in the majority of articles reviewed, by using radiographic analysis to measure changes in marginal bone level with the exception of one study that used implant stability quotient (ISQ) measurements[7], another study which used measurements from the Periotest[8], and another study, which used both radiographs and Periotest[9] measurements. The majority of studies used the Albrektsson et al[2] success criteria. According to the success criteria for currently used implant systems, the inserted implants must be immobile at clinical examination and the radiographs must show absence of peri-implant radiolucency. After 1 year of functional loading of the implant, annual vertical bone loss must be less than 0.2 mm and there must be absence of irreversible and/or persistent signs or symptoms of pain, infection, neuropathies, paresthesia or violation of the mandibular canal. At the end of 5 and 10 year periods of observation, an 85% and 80% success rate, respectively must be reached. However, three studies[10-12] based implant success on the Buser clinical and radiological criteria for success: absence of clinically detectable implant mobility, pain or any subjective sensation, recurrent peri-implant infection and continuous radiolucency around the implant after 3, 6 and 12 months of loading[13]. All 16 articles that reported marginal bone loss used radiographic evaluation. The studies all used similar preoperative and postoperative protocols with standard antibiotic regimens.

Primary outcomes

For this review, the two primary outcomes of implant survival and success were evaluated. Out of the 11 case series articles evaluating immediate implant placement, 10 articles measured survival rate as a primary outcome, with a mean survival rate of 96.87% (82.64% to 100%; Table 1). Only three case series articles regarding immediate implant placement measured success rate as a primary outcome with a mean success rate of 100% (100%; Table 2). As one of the criterias for success, the three articles reporting success rate also reported on average bone loss. The Prosper et al[14] study indicated average bone loss results of 1.31 ± 0.44 mm and 1.01 ± 0.59 mm for immediate and delayed loading, respectively, while the overall mean bone loss between the three studies was 0.85 mm (Table 3).

Out of the five immediate versus delayed implant placement studies, three measured survival rates as a primary outcome, with a mean survival rate of 96.8% for immediately placed implants and 96.3% for implants with a delayed placement (Table 4). Four of the studies measured success rate as a primary outcome, with a mean success of 85.8% for immediately placed implants and 93.3% for implants undergoing delayed placement (Table 5). All of the studies involving immediate and delayed placement of implants, with the exception of the Polizzi study, reported the average amount of bone loss, with a

Table 1 Immediate implant placement studies reporting survival rate as an outcome.

Study	No. of implants	DL or IL	Survival	Follow-up (months)
Prosper et al[14]	120	IL-60, DL-60	96.67%	72
Urban et al[15]	92	DL	82.64%	12
Cafiero et al[16]	82	DL	100%	12
Artzi et al[17]	12	DL	100%	6
Fugazzotto[18]	341	DL	99.00%	72
Fugazzotto[19]	83	DL	100%	12-18
Hamouda et al[9]	20	DL	95.00%	18
Jiansheng et al[8]	162	DL	99.40%	12-56
Block et al[7]	35	DL	100%	4
Schwartz-Arad et al[20]	56	DL	89.3%	15
	Total = 1003		**Mean survival = 96.87%**	**Range: 4-72**

DL: Delayed Loading, IL: Immediate Loading

Table 2 Immediate implant placement studies reporting success rate as an outcome.

Study	No. of implants	DL or IL	Success	Follow up (months)
Hayacibara et al[21] (retrospective)	74	DL	100%	12-96
Artzi et al[17]	12	DL	100%	6
Fugazzotto[19]	83	DL	100%	72
	Total = 169		**Mean success = 100%**	**Range: 6-96**

DL: Delayed Loading, IL: Immediate Loading

Table 3 Immediate implant placement studies measuring bone loss as an outcome.

Study	No. of implants	DL or IL	Bone loss (mm)
Prosper et al[14]	120	IL-60, DL-60	1.31 ± 0.44 (IL), 1.01 ± 0.59 (DL)
Urban[15]	92	DL	0.48
Hamouda et al[9]	20	DL	0.6 ± 0.4
	Total = 232		**Mean bone loss = 0.85**

DL: Delayed Loading, IL: Immediate Loading

Table 4 Immediate vs delayed implant placement studies reporting survival rate as an outcome.

Study	No. of implants	Immediate placement	Delayed placement	DL or IL	Survival (IP)	Survival (DP)
Vandeweghe[22]**	93	69	24	IL and DL	95.70%	95.80%
Peñarrocha[31]	123	35	88	DL	97.10%	95.50%
Annibali et al[32]	41	20	21	DL	100%	100%
	Total = 257	**Total = 124**	**Total = 133**		**Mean survival = 96.8%**	**Mean survival = 96.3%**

** Bone loss ≤ 1.5mm during the first year was considered a success and if > 1.5mm then considered part of survival group.

DL: Delayed Loading, DP: Delayed Placement, IL: Immediate Loading, IP: Immediate Placement.

Table 5 Immediate vs delayed implant placement studies reporting success rate as an outcome.

Study	No. of implants	Immediate placement	Delayed placement	DL or IL	Success (IP)	Success (DP)
Atieh et al[23] (prospective)	24	12	12	IL	66.70%	83.30%
Vandeweghe[22]**	93	69	24	IL and DL	86.20%	93.50%
Annibali et al[5]	41	20	21	DL	95.00%	100%
Polizzi et al[24]	57	1	56	DL	100%	92.90%
	Total = 215	**Total = 113**	**Total = 102**		**Mean = 85.8%**	**Mean = 93.3%**

** Bone loss ≤ 1.5mm during first year was considered a success and if > 1.5mm then considered part of survival group.

DL: Delayed Loading, DP: Delayed Placement, IL: Immediate Loading, IP: Immediate Placement.

Table 6 Immediate vs delayed implant placement studies measuring bone loss as an outcome.

Study	No. of implants	Immediate placement	Delayed placement	Bone loss (IP) (mm)	Bone loss (DP) (mm)
Vandeweghe[22]	93	69	24	0.41 ± 1.19	0.61 ± 0.63
Peñarrocha[10]	123	35	88	0.56 ± 0.22	0.67 ± 0.17
Atieh et al[23]	24	12	12	0.41 ± 0.57	0.04 ± 0.46
Annibali et al[5]	41	20	21	0.90 ± 0.30	0.88 ± 0.20
	Total = 240	**Total = 116**	**Total = 124**	**Mean bone loss = 0.57 ± 0.57**	**Mean bone loss = 0.55 ± 0.37**

DP: Delayed Placement, IP: Immediate Placement.

Table 7 Delayed vs immediate loading studies with delayed implant placement comparing and reporting survival rate as an outcome.

Study	No. of implants (IL/DL)	IL survival	DL survival	Follow-up (months)
Wolfinger[25]***	250 (30/220)	96.7%	98.2%	36-144
Degidi[26]	100 (10%)	100%		36
Schincaglia[27]	30 (15/15)	93.3%	100%	12
Zollner[28]	197 (197/0)	98.0%		5
Guncu[29]	24 (12/12)	91.7%	100%	12
Romanos[30]	72 (36/36)	94.9%	91.7%	24
Meloni[31]	40 (20/20)	100%	100%	12
Abboud et al[32]	20 (2%)	95.0%		12
Artzi et al[17]	12 (0/12)		100%	6
Rocci et al[33]	121 (121/0)	90.5%		108
Jung et al[34]	305 (0/305)		98.0%	72
Kim[35]	96 (0/96)		91.1%	36
Koo[36]	521 (0/521)		95.1%	60
Misch[37]	1377 (0/1377)		98.9%	120
Simon[38]	126 (0/126)		96.0%	6-120
	Total = 616 (521/95)	**Mean IL survival = 96.1%**	**Mean DL survival = 97.5%**	**Mean follow-up time = 39.6**

***Single molar crowns supported by two implants therefore were not included in total or mean calculations

DL: Delayed Loading, IL: Immediate Loading

Table 8 Delayed vs immediate loading studies with delayed implant placement comparing and reporting success rate as an outcome.

Study	No. of implants (IL/DL)	IL success	DL success	Follow-up (months)
Levine et al[39]	21 (21/0)	100%		60
Cornelini et al[11]	40 (4%)	97.5%		12
Barone et al[12]	12 (6/6)	100%	100%	6
Becker[40]	212 (0/212)		91.5%	47
Becker[40]	70 (0/70)		82.9%	47
	Total = 355 (67/288)	**Mean IL Success = 98.5%**	**Mean DL Success = 89.6%**	**Mean follow-up time = 34.4 months**

DL: Delayed Loading, IL: Immediate Loading

Table 9 Delayed implant placement studies measuring bone loss as a primary outcome.

Study	No. of implants (IL/DL)	IL bone loss (mm)	DL bone loss (mm)
Levine[39]	21 (21/0)	0.58	
Degidi[26]	100 (10%)	0.947	
Schincaglia[27]	30 (15/15)	0.77 ± 0.38	1.20 ± 0.55
Zollner[28]	197 (197/0)	0.81 ± 0.89	
Guncu[29]	24 (12/12)	0.45 ± 0.39	0.68 ± 0.30
Meloni[31]	40 (20/20)	0.83 ± 0.16	0.86 ± 0.16
Abboud et al[32]	20 (2%)	0 ± 0.59 maxilla; 0.03 ± 0.36 mandible	
Becker[40]	212(0/212)		0.09
Becker[40]	70 (0/70)		0.31
Kim[35]	96 (0/96)	0.13	
	Total = 810 (385/425)	**IL Mean bone loss = 0.55 mm**	**DL Mean bone loss = 0.55 mm**

DL: Delayed Loading, IL: Immediate Loading

Table 10 Studies on fixed partial dentures measuring survival and success rate as a primary outcome.

Study	No. of FPDs	Survival	Success rate	Follow-up time (years)
Haff [41] (retrospective)	33	94.0%	73.0%	3.0-13.1
Van Heumen[42]	96	77.5%	71.2%	4.5-8.9
Cenci[43] (longitudinal)	22	81.8%		8
Lops [44]	24	88.9%	81.8%	6
	Total = 175	**Mean survival = 85.6%**	**Mean success = 75.3%**	**Range: 3.0-13.1 years**

FPDs: fixed partial dentures

mean bone loss 0.57 ± 0.57 mm for immediately placed implants and 0.55 ± 0.37 mm for delayed implant placement (Table 6).

Out of the 20 delayed implant placement studies, 15 measured survival rate as a primary outcome, with a mean survival rate of 96.1% for immediately loaded implants and 97.5% for implants undergoing delayed loading (Table 7). Only five studies measured success rate as a primary outcome, with a mean success of 98.5% for immediately loaded implants and 89.6% for implants undergoing delayed loading (Table 8). Ten studies also reported the average amount of bone loss, with a mean bone loss of 0.55 mm for immediately loaded implants and 0.55 mm for implants undergoing delayed loading (Table 9).

The present review also included four retrospective and prospective studies for reporting the survival and success rates of single tooth fixed partial dentures in the posterior region as a comparison for alternate treatment of posterior sites. These studies reported a mean survival rate of 85.6% and mean success rate of 75.3% (Table 10).

Discussion

Implant placement in the posterior quadrants has been reported but not studied extensively in the literature. This review was conducted to identify the success and survival rates on implant placement in the posterior quadrant using various loading protocols. We have included both case series and comparative studies in our review. A decision was made to perform a narrative review rather than a meta-analysis, since performing a meta-analysis calculation on this topic was impossible due to the heterogeneity of the studies. The survival and success rates of many of the studies included in the review are similar to the overall survival and success rate reported for conventional delayed implant placement. Urban et al, when

reporting on implant placement in conjunction with bone regenerative procedures to manage residual peri-implant defects, indicated the lowest implant survival rate (83%), while several other studies have shown implant survival rates of 100%.

The 11 immediate implant placement case series studies involving 1077 implants reported overall success rates of 100%. Most studies (10) looked at delayed rather than immediate loading protocol, except one, which included both immediate and delayed loading. The reason for this may be the lower success rates with immediate loading shown in the literature. Hence, more randomised control trials are needed on immediate implant placement and immediate loading protocols for implants in the posterior quadrants of the mouth.

We have also included studies that compared immediate implant placement versus delayed implant placement. The overall survival rate in the immediate placement groups was 96.8% and in the delayed groups it was 96.3%, which is similar to studies by Slagter et al[45] and Lang et al[46], reporting on immediate implant placement in the anterior zone. While the overall success rate in the immediate placement group is 85.8%, it reaches 93.3% in the delayed group, which is similar to findings from Tawse-Smith et al[47], who report on implants in the symphyseal area of completely edentulous mandibles. The drawback of these studies is the dissimilarity in sample size between the groups. The results from these studies should thus be interpreted with caution, as these studies did not include randomisation of the test subjects.

From the 20 studies looking at delayed implant placement, a total number of 2905 patients received implants in the posterior quadrant with either immediate or delayed loading of prostheses. The survival and success rates for immediate loading were slightly lower than that of delayed loading. With the published data over the last 5 to 8 years, the success rates of implants with delayed loading are actually lower[27,29]. However, the difference in survival and success rate between immediate loading and delayed loading was insignificant, which is consistent with the literature[48]. Consequently, we can conclude that the survival and success rates of delayed placement of implants in the posterior quadrant irrespective of loading protocol is comparable to that of implants placed in the anterior regions.

Attention should be drawn to the fact that the survival and success rates of posterior fixed partial dentures (FPDs) were significantly lower than that of implants placed in the posterior region, irrespective of time of placement and loading protocols for dental implants. The use of a single implant to support a single restoration seems to be a superior treatment option to FPDs in the posterior region.

Most of the studies looked at survival rates rather than success rates. This may be because the criteria used to determine success of the implant has not been well defined in the literature. Most of the studies in this review used Albrektsson et al[2] criteria for success. However, the methodology and reference points used to measure marginal bone level changes varied amongst the studies.

This review also showed that there could be marginal bone gain with immediately placed implants. The overall bone gain did not differ significantly between immediate and delayed placement of implants, with mean values of 0.57 ± 0.57 and 0.55 ± 0.37, respectively, which is similar to the reviews published by Lee et al[49] and Pellicer-Chover et al[50]. Of the immediately placed implants, those that underwent delayed loading showed more favourable bone gain than the immediately loaded ones, which seems reasonable since delayed loading allows for longer healing times for both hard and soft tissues in between stage I and II surgeries. Although the data shows fairly conclusive evidence for bone level changes, in response to implant placement, this review is still limited by the number of studies and heterogeneity amongst the included studies. Marginal bone loss and biomechanical immobility were used as a criteria for success but studies used different measurement methods such as intraoral radiographs, Periotest values and ISQ values, which might affect the definition applied to implant success.

■ Conclusion

While survival rates of immediate or delayed implant placements seem similar, the success rates were slightly superior for the latter. Time of loading seems more relevant with immediate loading, leading to less favourable success rates for single implants in the posterior quadrants.

According to four studies included in the present review, the mean survival and success rates of FPDs in the posterior region were 85.6% and 75.3%, respectively. In comparison, the mean survival and success rates of single implants placed in the molar region, irrespective of placement and loading protocols, were 96.7% and 93.4%, respectively. Both the survival and success rates of implants were superior to that of fixed partial dentures in the posterior region. Consequently, we can conclude that placement of implants in the posterior quadrants can lead to better treatment outcomes than using fixed partial dentures.

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