Placement and Loading Protocols for Single Implants in Different Locations: A Systematic Review

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Purpose: To analyze the effect of implant placement and loading protocols (protocol types) on the survival of single implant tooth replacements in different locations. ***Materials and Methods:*** An electronic search was conducted to identify clinical trials regarding outcomes of single implants subjected to different treatment protocols. A weighted mean survival rate for each protocol type in the anterior maxilla, anterior mandible, posterior maxilla, and posterior mandible was calculated. Study design, sample size, and outcome homogeneity were used to evaluate the validation of each protocol type in different locations. ***Results:*** A total of 45 publications (13 RCTs, 21 prospective studies, and 11 retrospective studies) were included. The anterior maxilla was the most reported site (35 studies, 1,391 implants, weighted survival rate: 97.5% to 99.6%). Immediate placement + conventional loading (Type 1C) and late placement + immediate restoration/loading (Type 4A) were scientifically and clinically validated (SCV). For the posterior maxilla (19 studies, 567 implants, weighted survival rate: 85.7% to 100%), Type 1C was SCV. The anterior mandible was the least-reported site (three studies, 42 implants, weighted survival rate: 98.5% to 100%). For the posterior mandible (13 studies, 447 implants, weighted survival rate: 95.0% to 100%), late placement + conventional loading (Type 4C) was SCV. It was not possible to perform a meta-analysis due to the limited number of controlled studies that had the same comparison and considerable heterogeneity in study design. ***Conclusion:*** Differences were found in the level of scientific evidence between the anterior and posterior and the maxilla and mandible, indicating that location is a consideration when selecting treatment protocol for a single implant. *Int J Oral Maxillofac Implants 2021;36:e72–e89. doi: 10.11607/jomi.8750*

Keywords: dental implants, placement and loading protocol, single implant

Implant dentistry has been advancing continuously toward the reduction of patient morbidity, overall treatment times, and treatment complexity while providing predictable treatment outcomes. Implant placement and implant loading protocols have been clinically applied as defined by the International Team for Implantology (ITI) Consensus Statements published in 2004,[1–5] 2009,[6–10] and 2014.[11–15] For decades, implant placement protocols and implant loading protocols were addressed independently from one another. With the healing of the alveolar socket post-extraction, the implant placement protocol and the surgical technique are determining factors for selection of an appropriate implant loading protocol; these should be considered as codependent variables. Moreover, it is important that treatment planning should commence once the indication for tooth extraction has been confirmed, and the implant placement and loading protocol should both be planned prior to the extraction of the tooth.[16]

A recent systematic review investigated the clinical outcomes with implant fixed dental prostheses treated with various combinations of timings of implant placement and implant loading in partially dentate patients.[17] Placement and loading protocols were permuted and combined into 12 well-differentiated protocol types. A new comprehensive classification and treatment philosophy was proposed to underline the importance of assessing outcomes by combining implant placement and loading protocol variables as a single denominator for implant survival and success.

In the previous systematic review,[17] a broad search was conducted relating to all protocol types, including

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studies on single- and multiple-unit implant prostheses. Single implant tooth replacements are subject to different biomechanical forces compared with implant prosthodontic configurations with multiple splinted implants, for example, short-span fixed prostheses, as well as larger prostheses where dissipation of occlusal forces may be influenced by cross-arch stabilization and stress shielding. Thus, single implant restorations may be subjected to higher masticatory forces without additional support from adjacent implants.[18] Other variables include the presence of adjacent teeth, probability of tissue deficiencies, and implant-prosthodontic designs, which are also critical when implant tooth replacements are performed in the esthetic zone. Combining heterogenous data of single- and multiple-unit implants can increase the risk of bias. To have a better understanding and correct interpretation of the outcomes from the previous systematic review, this review focuses on treatment protocols for single tooth replacement with dental implants.

Furthermore, implant placement and loading are influenced by the recipient site/location, which presents different functional requirements (esthetics, mastication, phonetics), different local anatomy (bone quality, primary stability achievement, need for augmentation, root configuration), and different treatment complexity (intraoperative visibility, ease of manipulation). In reviewing the studies, different locations demonstrated different levels of scientific evidence because of the aforementioned challenges.

The aims of this review were to present, analyze, and summarize the clinical and scientific evidence of single implants of each protocol type in different locations, and to evaluate their validation.

Table 1 Classification of Implant Placement and Loading Protocols

Protocol type	Description
Type 1A	Immediate placement + immediate restoration/loading
Type 1B	Immediate placement + early loading
Type 1C	Immediate placement + conventional loading
Type 2A	Early placement with soft tissue healing + immediate restoration/loading
Type 2B	Early placement with soft tissue healing + early loading
Type 2C	Early placement with soft tissue healing + conventional loading
Type 3A	Early placement with partial bone healing + immediate restoration/loading
Type 3B	Early placement with partial bone healing + early loading
Type 3C	Early placement with partial bone healing + conventional loading
Type 4A	Late placement + immediate restoration/loading
Type 4B	Late placement + early loading
Type 4C	Late placement + conventional loading

MATERIALS AND METHODS

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA),[19] the Cochrane Handbook for Systematic Reviews of Interventions,[20] and the Standards for Developing Trustworthy Clinical Practice Guidelines[21] were adhered to in the design and conduct of this systematic review. The review was registered with the PROSPERO database (CRD42019124719).

The classification of implant placement and loading protocols utilized in this review are presented in Table 1. The placement definitions established by the ITI Treatment Guide Vol. 3[22] and loading definitions established by the 4th ITI Consensus Conference[10] were used for this review (Fig 1).

Information Source

The focus question was developed according to PICO (population, intervention, comparison, and outcome; Table 2). The electronic search was conducted within the systematic database of PubMed/Medline to identify all types of dental publications in English up to December 2020. Combinations of controlled terms (MeSH and EMTREE) and keywords were used whenever possible (Table 2). The same search terms were reformulated for Embase and CENTRAL searching. The search results were exported and organized utilizing specialized bibliographic software (EndNote X8, Version 8.1, Thomson Reuters).

Inclusion and exclusion criteria are summarized in Table 2. Where several publications reported on the same patient population and intervention, only the most recent study with the longest follow-up was included. Studies that reported on both single- and multiple-unit implant prostheses were only included when survival/success data were clearly identifiable for single-implant restorations.

Two calibrated reviewers (W.Z. and A.H.) completed the title and abstract screening independently, followed by a full-text screening for final inclusion. A third reviewer (G.G.) was consulted in the event of reviewer disagreement. Data were extracted manually through careful full-text reading for all included studies and recorded on standardized forms. Authors were contacted through emails as needed for clarification or missing information.

Quality Assessment

All included comparative studies were assessed for methodologic quality. The risk of bias for randomized

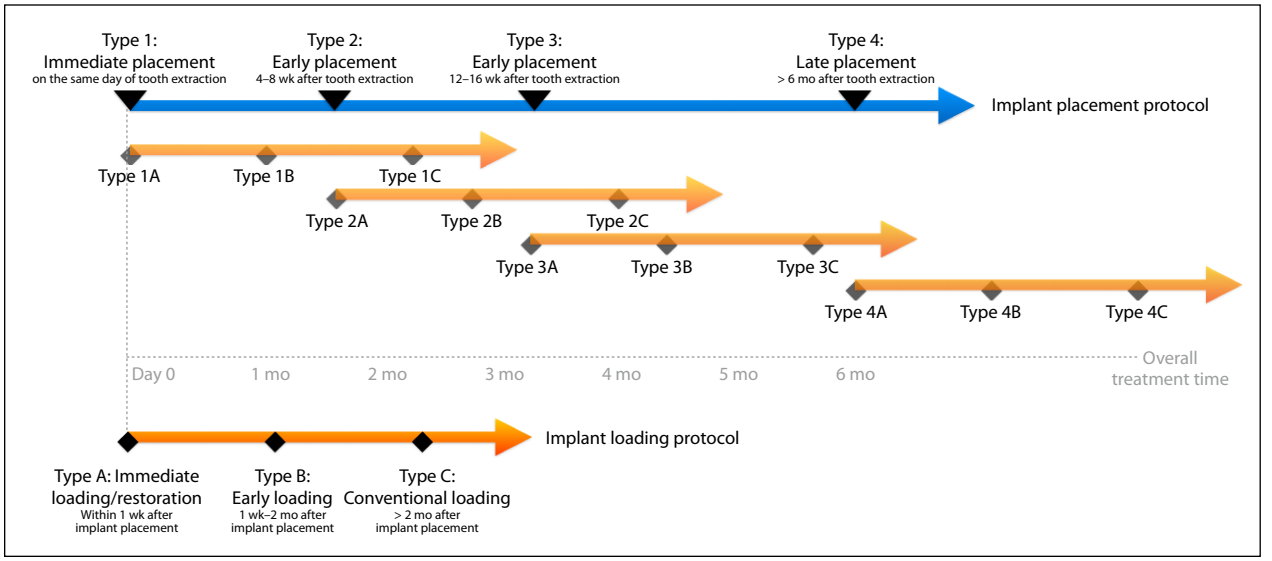

Fig 1 Diagram of the timeline based on the definition of implant placement protocol and implant loading protocol.

Table 2 Focus Question, Search Strategy, and Selection Criteria

Focus question	In patients treated with single implants in different locations, do immediate or early placement and loading protocols have different implant-prosthodontic survival and success from conventional protocol?
PICO	P (population): patients treated with single implants in different locations I (intervention): immediate/early placement and loading protocols (Type 1A, 1B, 1C, 2A, 2B, 2C, 3A, 3B, 3C, 4A, 4B) C (comparison): late placement and conventional loading protocol (Type 4C) O (outcome): implant-prosthodontic survival and success
Search terminology (PubMed/Medline)	(dental implantation, endosseous[MeSH] OR dental implants[MeSH] OR implantation OR implant OR implants) AND (denture, partial, fixed[MeSH] OR dental prostheses, implant supported[MeSH] OR fixed partial denture OR FPD OR FPDs OR fixed dental prosthesis OR fixed dental prostheses OR crown) AND (immediate implant OR immediate implantation OR immediate implant placement OR immediate placement OR immediate OR early OR placement OR time OR timing OR fresh extraction sockets OR immediate extraction sockets OR post-extraction implant placement OR post-extractive OR early implantation OR early implant placement) AND (immediate dental implant loading[MeSH] OR function OR time OR immediate OR early OR load) AND (English[Language])
Inclusion criteria	Clinical trials At least 10 participants per protocol type per location Partially dentate patients treated with single implants Time of implant placement and loading were specifically reported Implant location was specifically reported Minimum follow-up period of 12 months Root form or cylindrical implant with rough surface
Exclusion criteria	Animal or in vitro studies Studies on zirconia implants Studies on short implants (≤ 6 mm in length) Studies on implant diameter < 3 mm or > 6 mm Studies on implant-supported multiple-unit prostheses, full-arch restorations, or removable appliances Studies on implants placed in irradiated bone or alveolar clefts Insufficient information provided on type of implant superstructures Insufficient information to identify success criteria Data retrieved from chart reviews or questionnaires

controlled trials (RCTs) was rated using the Cochrane quality assessment tool for RCTs.[20] The quality of controlled clinical trials (CCTs) was assessed utilizing the Newcastle-Ottawa scale (NOS). Quality assessment was not performed for prospective cohort studies (PC) and retrospective cohort studies (RC).

Validation Criteria

Validation criteria for single implants were modified from previous studies[7,17] to propose clinical recommendations and formulate conclusions for all protocol types (Fig 2). Each type was graded based on the design of the study, number of implants, and homogeneity of reported outcomes. Outcome homogeneity was defined

Scientifically and clinically validated (SCV)	Systematic reviews of RCTs ≥ 2 RCTS + ≥ 100 implants + OH(+) One RCT and ≥ 2 prospective studies + ≥ 150 implants + OH(+)
Clinically well documented (CWD)	One RCT and ≥ 2 prospective studies + ≥ 40 implants + OH(+) No RCTs but ≥ 3 prospective studies + ≥ 60 implants + OH(+) No RCTS but ≤ 2 prospective studies + ≥ 100 implants + OH(+)
Clinically documented (CD)	No RCTs but ≥ 2 prospective studies and any retrospective studies + ≥ 40 implants + OH(±) No RCTs but any retrospective studies + ≥ 60 implants + OH(±)
Clinically insufficiently documented (CID)	None of the above, expert opinion or case report only

Fig 2 Validation criteria used to evaluate the level of scientific evidence for each protocol type.

as positive (OH+) when the range of implant survival rates for the same protocol type was ≤ 10%, and negative (OH–) when the differences in reported outcomes was higher than 10%.

Statistical Analysis

Cohen's kappa statistical analysis was used to assess the level of agreement between the reviewers. The implant survival and success rates for the various protocol types were reported with descriptive statistics. For each of the protocol types, an average cumulative survival rate was computed and weighted by the number of implants and the duration of patient follow-up. The weighted mean survival rate was calculated as follows:

$$\bar{x} = \frac{X_1 t_1 n_1 + X_2 t_2 n_2 + \ldots + X_k t_k n_k}{t_1 n_1 + t_2 n_2 + \ldots \text{tknk}} \times 100$$

where X = survival rate; t = follow-up period; and n = number of implants.

RESULTS

The initial search identified a total number of 5,444 titles/publications after discarding duplicate references. Following title screening, 1,282 abstracts and 613 full-text articles were selected for inclusion. A Kappa score of 0.97 was calculated for the interrater reliability. Ninety-nine articles were selected for data extraction. Forty-five publications met the inclusion criteria and were finally included, which featured 13 RCTs, 21 PCs, and 11 RCs (Fig 3). Four RCTs[37,47,51,57] were analyzed as PCs, as the comparison was not between different protocol types. Fifty-four articles had to be excluded from the final analysis for the reasons listed in Table 3.

Quality Assessment for Including Comparative Studies

The risk of bias for the RCTs included in this review is displayed in Fig 4. Random sequence generation was not clearly reported in three studies.[27,28,31] There was unreported allocation concealment in five studies,[23,31–33,35] and one study had a high risk of bias during patient allocation.[29] Due to the nature of the comparisons, blinding of the investigators and the patients was not possible. With regard to blinding of outcome assessment, four studies presented a high risk of bias[24,27,28,30] and in five studies, there was lack of information to determine the risk.[25,29,31,34,35] Incomplete outcome data were detected in one study due to a large proportion of dropouts[23] and one study being unclear as to the number of dropouts or excluded participants.[34] Selective reporting was found in six studies.[23,29,30,32–34]

No CCT was included, so the quality assessment for CCT was not conducted. All included studies defined specific success criteria; however, the definitions of success varied between the studies, making comparisons between success outcomes of the different treatment protocols not possible. Furthermore, although the studies reported a definition of their success criteria, many of the studies only reported survival rates as an outcome measure. Therefore, a singular definition of "success" was not proposed in this review, but followed the definitions and reported success rates from each of the original publications.

Outcome Analysis of Each Protocol Type in Different Locations

The data extraction was summarized for RCTs (Table 4) and noncomparative data (PCs and RCs, Table 5). For each protocol type, the distribution of implant location and failure are listed in Table 6. On this basis, Table 7 aggregates all the data and demonstrates detailed outcomes per protocol type per location in terms of number of studies, accumulated number of implants, mean follow-up period, weighted mean survival, range of reported survival rates, and their validation level.

Anterior Maxilla

The anterior maxilla was the most reported site, which involved 35 studies (7 RCTs, 17 PCs, and 11 RCs) reporting 1,391 implants. Thirty failures were reported, of which 12 were early failures, 14 were late failures, and 4 were unknown. The weighted survival rate of different protocol types ranges from 97.5% to 99.6%.

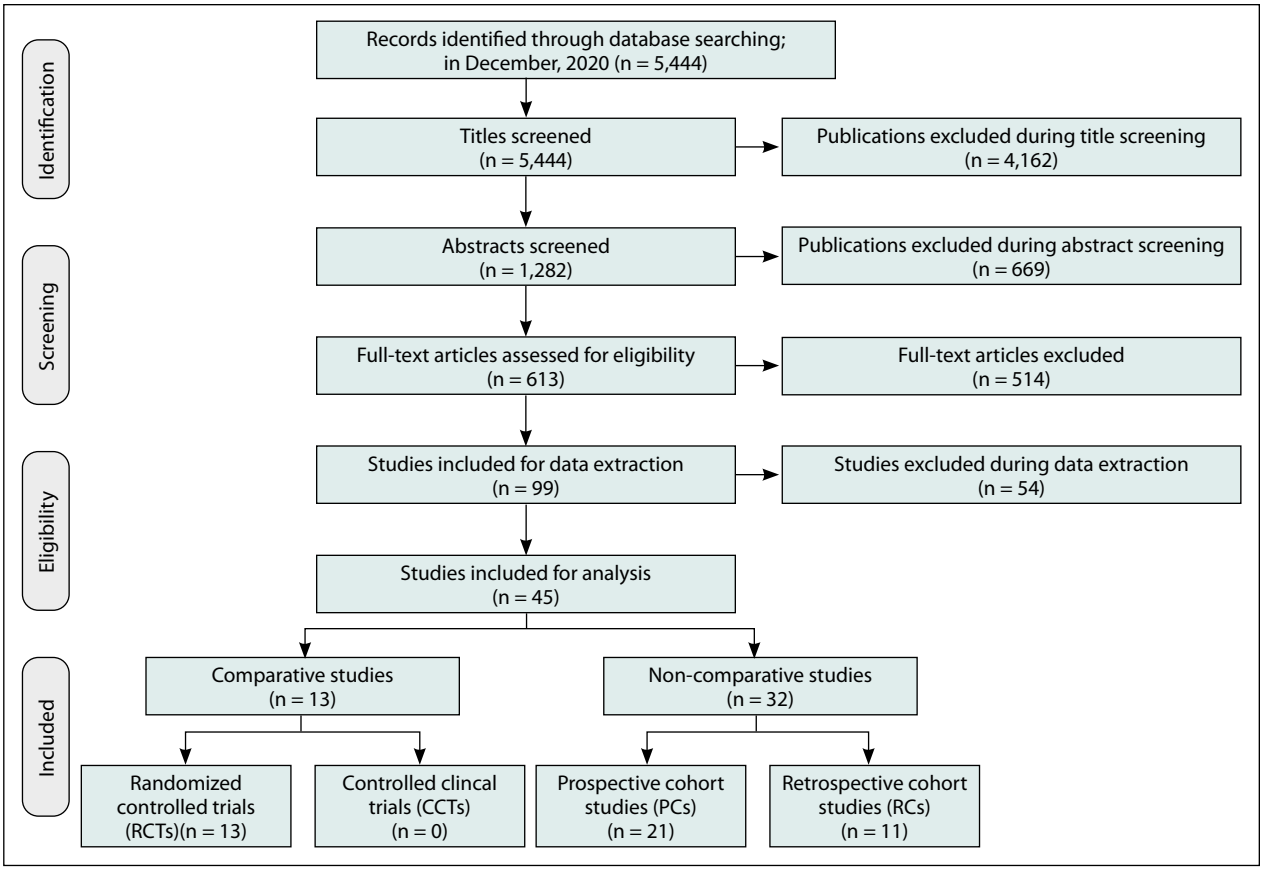

Fig 3 Search flow diagram.

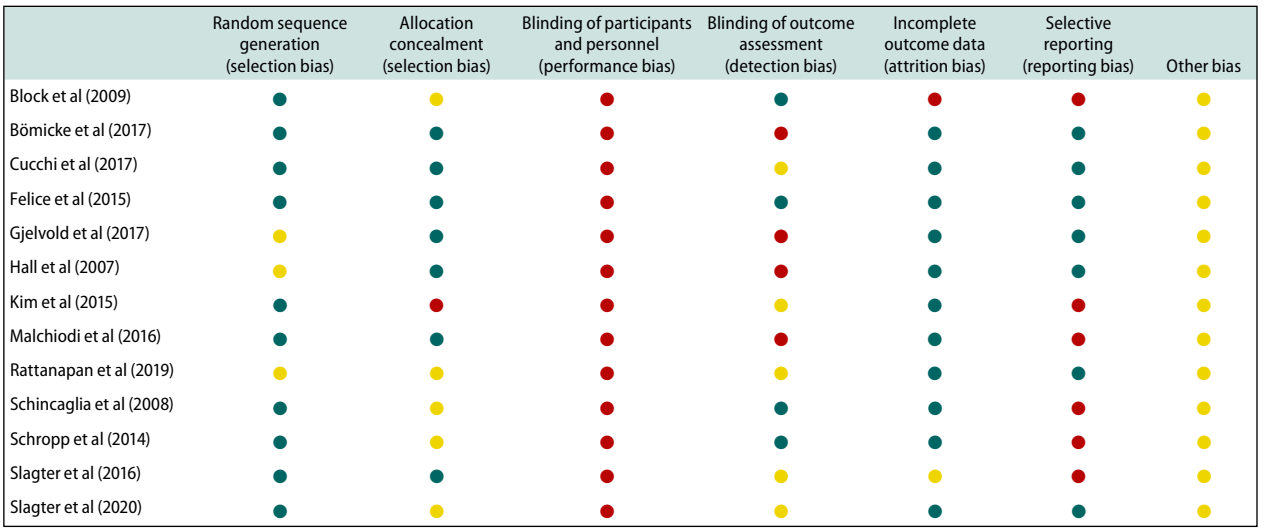

Fig 4 Risk of bias assessment for each included RCT.

Twenty-one studies (three RCTs, nine PCs, and nine RCs) focused on the Type 1A implants in the anterior maxilla. The surgical and prosthodontic details and the criteria of immediate placement and immediate loading are listed in Table 8.

According to the validation criteria, Types 1C and 4A were scientifically and clinically validated. Types 2-3C and 4C were clinically well documented. Type 1A was clinically documented. Types 1B, 2-3A, 2-3B, and 4B were clinically insufficiently documented.

Posterior Maxilla

Nineteen studies (6 RCTs, 13 PCs) reported on the outcomes of 567 implants in the posterior maxilla. Twenty-

Table 3 Excluded Studies

Reason for exclusion	No. of studies	Studies
Primary data could not be separate between implant-supported single-crown and other types of prostheses	22	Akca et al (2013), Boon et al (2020), Bornstein et al (2013), Boroat et al (2008), Del Fabbro et al (2009), Farronato et al (2020), Ganeles et al (2008), Heinemann et al (2013), Hsiao et al (2020), Karabuda et al (2011), Merten and Steveling (2011), Montero et al (2019), Mura (2012), Nicolau et al (2019), Noelken et al (2014), Noelken et al (2018), Ostman et al (2008), Prati et al (2020), Sener-Yamaner et al (2017), Shi et al (2018), Spinato et al (2019), Vogl et al (2019)
Insufficient information on prosthesis type	3	Blus et al (2010), Meizi et al (2014), Prosper et al (2003)
Insufficient information on implant location for each protocol type	14	Barone et al (2016), Cooper et al (2019), De Angelis et al (2011), Donos et al (2018), Grandi et al (2014), Han et al (2018), Lang et al (2014), Ma et al (2019), Meloni et al (2016), Schibly et al (2010), Stacchi et al (2018), Valentini et al (2008), Vandeweghe et al (2013), Wittneben et al (2020)
Insufficient information on the location of the failed implant	1	Siddiqui et al (2008)
Less than 10 participants per protocol type per location	2	Donos et al (2019), Oyama et al (2012)
Study scope focusing on grafting techniques	3	Lang et al (2015), Siormpas et al (2014), Urban et al (2012)
Multiple studies on the same population	9	Buser et al (2003), Buser et al (2008), Buser et al (2009), Buser et al (2011, Buser et al (2013), Kan et al (2003), Mangano et al (2012), Schropp et al (2005), Schropp et al (2008)

six failures were reported, of which 10 were early failures, 14 were late failures, and 2 were unknown. The weighted survival rate of different protocol types ranges from 85.7% to 100%.

Type 1C was scientifically and clinically validated. Type 4C was clinically well documented. Types 1A and 4A were clinically documented. Types 1B, 2-3A, 2-3B, 2-3C, and 4B were clinically insufficiently documented.

Out of all 19 studies, only one study[29] was specifically designed for implants in the posterior maxilla. All of the 199 Type 1A implants were placed in premolar sites of the esthetic zone.

Anterior Mandible

The anterior mandible was the least-reported site, which involved three studies (two PCs and one RC) reporting 42 implants. One early failure was reported, and the weighted survival rate was 98.5% for Type 1A and 100% for Type 1C. All protocol types were clinically insufficiently documented.

Posterior Mandible

Thirteen studies (six RCTs and seven PCs) reported on the outcomes of 447 implants in the posterior mandible. Six early failures and 10 late failures were reported. The weighted survival rate of different protocol types ranges from 95.0% to 100%.

Type 4C was scientifically and clinically validated. Type 4A was clinically well documented. Type 1C was clinically documented. Types 1A, 1B, 2-3A, 2-3B, 2-3C, and 4B were clinically insufficiently documented.

Four studies[24,31,32,39] were specifically designed for implants in the posterior mandible, two of which[32,39] were to investigate the use of wide implants with a Type 4A approach to restore a single mandibular molar.

Meta-analysis was not possible due to the limited number of controlled studies that had the same comparison and the considerable heterogeneity in study design.

DISCUSSION

The present systematic review sought to appraise the clinical and scientific evidence for single implant tooth replacements performed with different treatment protocols. Moreover, considering that the specific requirements of implants in different locations may play an active role in the protocol selection, the outcomes of each protocol type were interpreted in accordance with the implant location. The question raised here is: What treatment protocol should be favored according to the implant location in patients treated with single implants? Do immediate or early placement and loading protocols have different implant-prosthodontic success and survival compared with conventional protocols?

While there are numerous reviews on either the implant placement protocol or implant loading protocol, only a handful of them combined the two treatment protocols, and those reviews normally focused on one particular protocol type, such as Type 1A.[69–71] The present study reviewed all the literature of single implants, which clearly reported the timing of implant placement

Table 4 Data Extraction of Included RCTs

Study	Protocol type	Time of placement	Time of restoration/ loading	Mean follow-up (mo)	No. of patients enrolled	No. of patients dropout
Block et al (2009)[23]	Type 1A	≤ 1 day	≤ 1 d	18–24	76	16
	Type 4A	> 4 mo	≤ 1 d			
Bömicke et al (2017)[24]	Type 4A	> 6 wk	≤ 1 d	36	19	0
	Type 4C	> 6 wk	3 mo		19	3
Cucchi et al (2017)[25]	Type 1C	≤ 1 d	3 mo	24.4	52	4
	Type 4C	> 3 mo	3 mo		50	6
Felice et al (2015)[26]	Type 1A	≤ 1 d	≤ 1 d	12	16	0
	Type 4C	> 4 mo	4 mo		21	2
Gjelvold et al (2017)[27]	Type 4A	≥ 4 mo	≤ 1 d	12	25	0
	Type 4C	≥ 4 mo	≥ 4 mo		16	0
Hall et al (2007)[28]	Type 4A	"healed site"	≤ 1 d	12	14	0
	Type 4C	"healed site"	6 mo		16	2
Kim et al (2015)[29]	Type 4A	≥ 6 mo	≤ 1 d	12	21	0
	Type 4C	≥ 6 mo	20–23 wk			0
Malchiodi et al (2016)[30]	Type 1C	≤ 1 day	3 mo	12	11	0
	Type 4C	> 3 mo	3 mo		11	0
Rattanapanich et al (2019)[31]	Type 4A	> 4 mo	≤ 1 d	12	25	0
	Type 4C	> 4 mo	3 mo		25	0
Schincaglia et al (2008)[32]	Type 4A	≥ 4 mo	≤ 1 d	12	15	0
	Type 4C	≥ 4 mo	3–4 mo		15	0
Schropp et al (2014)[33]	Type 2C	10 d	3 mo	120	NR	NR
	Type 3C	3 mo	3 mo		NR	NR
	Type 4C	17 mo	3 mo		NR	NR
Slagter et al (2016)[34]	Type 1C	≤ 1 d	3 mo	12	20	0
	Type 4C	> 3 mo	3 mo		20	0
Slagter et al (2020)[35]	Type 1A	≤ 1 d	≤ 1 d	60	20	2
	Type 1C	≤ 1 d	3 mo		20	3

wk = weeks; mo = months; NR = not reported; BL = bone-level implant; TL = tissue-level implant; DAE = dual acid-etched; SLActive = hydrophilic and chemically active sandblasted, large-grit, acid-etched; RBM= resorbable blast media; – = due to the study design, there were no data for this parameter.
If the study did not report a placement time in days/weeks/months, but clearly stated that the implants were placed into healed recipient sites, it was assigned to the late implant placement group (Type 4).
Data in this table were obtained after subtracting implants with a number less than 10 per protocol per location from the original data.
Implant failure was classified as either early or delayed according to the failure occurring before or after prosthesis delivery, respectively.[36]

No. of implants	Implant type	Implant surface	No. of implants failed	Failure type	Implant survival rate (%)	Implant success rate (%)	Prosthetic success rate (%)
30	Biomet 3i parallel	NR	4	NR	86.7	NR	NR
30			1	NR	96.7	NR	NR
19	Nobel BL tapered	Oxidized	1	Early	94.8	NR	84.2
16			0	–	100	NR	68.8
49	BTK BL tapered	DAE	2	Early	95.9	NR	100
48			0	–	100	NR	100
16	Dentsply	NR	2	Late	87.5	NR	100
19			0	–	100	NR	100
25	BioHorizons tapered	NR	0	–	100	96	100
16			1	Early	93.8	88	100
14	Southern tapered	Rough	1	Early	92.9	NR	92.3
14			0	–	100	NR	85.7
22	Straumann TL parallel	SLActive	3	Early	86.4	NR	NR
24			0	–	100	NR	NR
11	SybronPRO XRT parallel	RBM	0	–	100	100	NR
11			0	–	100	100	NR
25	NDI PW Plus	NR	0	–	100	NR	100
25			0	–	100	NR	100
15	Nobel BL parallel	TiUnite	1	Early	93.3	NR	NR
15			0	–	100	NR	NR
20	Biomet 3i parallel	Osseotite	2	Early	90.9	NR	NR
16			1	Early	95	NR	NR
13			0	–	100	NR	NR
20	NR	NR	0	–	100	NR	NR
20			0	–	100	NR	NR
18	NobelActive BL tapered	TiUnite	0	–	100	NR	88.9
17			0	–	100	NR	88.2

Table 5 Data Extraction of Included Prospective and Retrospective Studies

Study	Study design	Protocol type	Time of placement	Time of restoration/ loading	Mean follow-up (mo)	No. of patients enrolled	No. of patients dropout	No. of implants
Bianchi and Sanfilippo (2004)[37]	PC	Type 1C	≤ 1 day	3–4 mo	108	116	0	116
Buser et al (2013)[38]	PC	Type 2C	4–8 wk	8–12 wk	84	41	0	41
Calandriello and Tomatis (2011)[39]	PC	Type 4A	≥ 4 mo	≤ 1 day	60	33	NR	40
Calvo-Guirado et al (2015)[40]	PC	Type 1A	≤ 1 day	≤ 1 day	36	53	NR	71
Chappuis et al (2018)[41]	PC	Type 2C	4–8 wk	8–12 wk	120	20	0	20
Clauser et al (2020)[42]	PC	Type 1A	≤ 1 day	≤ 2 days	24	206	37	206
Covani et al (2014)[43]	PC	Type 2C	≤ 1 wk	4 mo	60	NR	NR	36
Cristalli et al (2015)[44]	PC	Type 1A	≤ 1 day	≤ 1 day	12	16	0	16
De Rouck et al (2008)[45]	PC	Type 1A	≤ 1 day	≤ 1 day	12	30	0	30
Eeckhout et al (2020)[46]	PC	Type 4C	>3 mo	3 mo	36	11	NR	11
Esposito et al (2018)[47]	PC	Type 1C	≤ 1 day	4 mo	12	30	0	30
Fugl et al (2017)[48]	PC	Type 4A	≥ 2 mo	≤ 1 day	12	97	10	102
Kan et al (2011)[49]	PC	Type 1A	≤ 1 day	≤ 1 day	48	35	0	35
Malchiodi et al (2013)[50]	PC	Type 1A	≤ 1 day	≤ 1 day	36	58	0	64
Migliorati et al (2015)[51]	PC	Type 1A	≤ 1 day	≤ 1 day	24	48	1	47
Montoya-Salazar et al (2014)[52]	PC	Type 1C	≤ 1 day	4.5 mo	36	NR	NR	36
Pol et al (2020)[53]	PC	Type 4C	≥ 3 mo	3 mo	12	30	0	30
Raes et al (2012)[54]	PC	Type 1A	≤ 1 day	≤ 1 day	12	10	0	10
		Type 4A	"healed site"	≤ 1 day		23	0	23
		Type 4A	"grafted site" 4–5 mo	≤ 1 day		9	0	9
Romeo et al (2002)[55]	PC	Type 4C	> 6 mo	3–6 mo	84	109	6	187
Velaso-Ortega et al (2018)[56]	PC	Type 1A	≤ 1 day	≤ 1 day	48	56	NR	116
Zuiderveld et al (2018)[57]	PC	Type 1A	≤ 1 day	≤ 1 day	12	57	0	57
Becker et al (2011)[58]	RC	Type 1A	≤ 1 day	≤ 3 days	12	100	NR	100
Belser et al (2009)[59]	RC	Type 2C	4–8 wk	6–12 wk	31.4	40	0	40
Bonnet et al (2018)[60]	RC	Type 1A	≤ 1 day	≤ 1 day	48	39	0	39
Brown and Payne (2011)[61]	RC	Type 1A	≤ 1 day	≤ 1 day	12	25	0	26
Fugazzotto (2012)[62]	RC	Type 1C	≤ 1 day	3–7 mo	62	64	NR	128
Hartlev et al (2013)[63]	RC	Type 1A	≤ 1 day	≤ 1 day	33	53	0	53
Kolerman et al (2016)[64]	RC	Type 1A	≤ 1 day	≤ 1 day	29	34	NR	34
Mangano et al (2013)[65]	RC	Type 1A	≤ 1 day	≤ 1 day	31.1	19	0	19
		Type 4A	≥ 6 mo	≤ 1 day	34.4	16	0	16
Noelken et al (2018)[66]	RC	Type 1A	≤ 1 day	≤ 1 day	45	26	0	26
Paul and Held (2013)[67]	RC	Type 1A	≤ 1 day	≤ 1 day	40.8	26	2	31
Van Nimwegen et al (2016)[68]	RC	Type 1A	≤ 1 day	≤ 1 day	48	NR	NR	60

RC = retrospective cohort study; PC = prospective cohort study; NR = not reported; wk = weeks; mo = months; BL = bone-level implant; TL = tissue-level implant; SLA = sandblasted, large-grit, acid-etched; SLActive = hydrophilic and chemically active sandblasted, large-grit, acid-etched; TPS = titanium-sprayed surface; HA = hydroxyapatite; FBR = fast bone regeneration; RBM = resorbable blast media; – = due to the study design, there were no data for this parameter.
Data in this table were obtained after subtracting implants with a number less than 10 per protocol per location from the original data.

Implant type	Implant surface	No. of implants failed	Failure type	Implant survival rate (%)	Implant success rate (%)	Prosthetic success rate (%)
Straumann TL parallel	TPS	0	–	100	100	NR
Straumann TL parallel tapered	SLA	0	–	100	NR	NR
Nobel BL tapered	TiUnite	1	Late	97.5	95	NR
MIS	Rough	0	–	100	NR	NR
Straumann BL	SLActive	0	–	100	NR	NR
Biomet 3i tapered	Osseotite	28	4 early 24 late	86.4	NR	100
Sweden & Martina	NR	1	Late	97.2	NR	NR
Nobel BL tapered	TiUnite	1	Early	93.8	93.8	NR
Nobel BL tapered	TiUnite	1	Late	97	NR	100
Nobel BL tapered	TiUnite	0	–	100	NR	NR
Ticare Inhex parallel	RBM	2	1 early 1 late	93.3	NR	96.7
NR	NR	1	NR	99	97	NR
Nobel BL tapered	HA	0	–	100	100	NR
NR	FBR	0	–	100	100	NR
Straumann BL tapered	SLAcitve	0	–	100	NR	NR
MIS	NR	1	Late	97.2	NR	NR
Nobel BL parallel	TiUnite	0	–	100	NR	100
Dentsply Astra Tech	OsseoSpeed	1	Late	90	NR	NR
		0	–	100	NR	NR
		0	–	100	NR	NR
Straumann TL parallel	TPS	9	3 early 6 late	96.7	93.6	NR
IPX Galimplant	SLA	3	Early	97.4	97.4	100
Nobel BL tapered	TiUnite	2	Early	96.5	96.5	NR
Straumann TL parallel	SLActive	1	Early	99	99	100
Straumann TL parallel	SLA	0	–	100	100	NR
Nobel BL	TiUnite	0	–	100	NR	NR
Co-Axis TL tapered	Rough	0	–	100	NR	92.3
NR	NR	0	–	100	98.2	NR
Nobel BL tapered	TiUnite	1	Early	98.1	NR	100
MIS BL	NR	0	–	100	88	NR
Leone Ortodonzia	NR	0	–	100	100	100
		0	–	100	100	100
Dentsply Astra Tech	OsseoSpeed	0	–	100	69.23	NR
Nobel	NR	0	–	100	100	NR
Biomet 3i	Osseotite	2	Early	96.7	NR	NR

Table 6 Implant Distribution and Survival Rate for Each Protocol Type

Study	Study design	Protocol type	Implant distribution (survival rate %)				Failed implant position (No. of failures)
			Anterior maxilla	Posterior maxilla	Anterior mandible	Posterior mandible	
Block et al (2009)[23]	RCT	Type 1A	13 (69.2%)	17 (100%)	0	0	Anterior maxilla (n = 4)
		Type 4A	16 (100%)	14 (92.9%)	0	0	Posterior maxilla (n = 1)
Bömicke et al (2017)[24]	RCT	Type 4A	0	0	0	19 (94.7%)	Posterior mandible (n = 1)
		Type 4C	0	0	0	16 (100%)	–
Cucchi et al (2017)[25]	RCT	Type 1C	0	25 (92%)	0	24 (100%)	Posterior maxilla (n = 2)
		Type 4C	0	18 (100%)	0	30 (100%)	-
Felice et al (2015)[26]	RCT	Type 1A	16 (87.5%)	0	0	0	Anterior maxilla (n = 2)
		Type 4C	19 (100%)	0	0	0	–
Gjelvold et al (2017)[27]	RCT	Type 4A	13 (100%)	12 (100%)	0	0	–
		Type 4C	16 (93.8%)	0	0	0	Anterior maxilla (n = 1)
Hall et al (2017)[28]	RCT	Type 4A	14 (92.9%)	0	0	0	Anterior maxilla (n = 1)
		Type 4C	14 (100%)	0	0	0	–
Kim et al (2015)[29]	RCT	Type 4A	0	22 (86.4%)	0	0	Posterior maxilla (n = 3)
		Type 4C	0	24 (100%)	0	0	–
Malchiodi et al (2016)[30]	RCT	Type 1C	0	11 (100%)	0	0	–
		Type 4C	0	0	0	11 (100%)	–
Rattanapanich et al (2019)[31]	RCT	Type 4A	0	0	0	25 (100%)	–
		Type 4C	0	0	0	25 (100%)	–
Schincaglia et al (2008)[32]	RCT	Type 4A	0	0	0	15 (93.3%)	Posterior mandible (n=1)
		Type 4C	0	0	0	15 (100%)	–
Schropp et al (2014)[33]	RCT	Type 2-3C	22 (95.5%)	14 (85.7%)	0	0	Anterior maxilla (n = 1) and posterior maxilla (n = 2)
		Type 4C	0	0	0	13 (100%)	–
Slagter et al (2016)[34]	RCT	Type 1C	20 (100%)	0	0	0	–
		Type 4C	20 (100%)	0	0	0	–
Slagter et al (2020)[35]	RCT	Type 1A	18 (100%)	0	0	0	–
		Type 1C	17 (100%)	0	0	0	–
Bianchi and Sanfilippo (2004)[37]	PC	Type 1C	20 (100%)	47 (100%)	10 (100%)	39 (100%)	–
Buser et al (2013)[38]	PC	Type 2-3C	41 (100%)	0	0	0	–
Calandriello and Tomatis (2011)[39]	PC	Type 4A	0	0	0	40 (97.5%)	Posterior mandible (n = 1)
Calvo-Guirado et al (2015)[40]	PC	Type 1A	50 (100%)	21 (100%)	0	0	–
Chappuis et al (2018)[41]	PC	Type 2-3C	20 (100%)	0	0	0	–
Clauser et al (2020)[42]	PC	Type 1A	75 (85.3%)	104 (87.5%)	0	27 (85.2%)	Anterior maxilla (n = 11), posterior maxilla (n = 13), and posterior mandible (n = 4)
Covani et al (2014)[43]	PC	Type 1C	13 (100%)	23 (95.7%)	0	0	Posterior maxilla (n = 1)
Cristalli et al (2015)[44]	PC	Type 1A	0	16 (93.8%)	0	0	Posterior maxilla (n = 1)
De Rouck et al (2008)[45]	PC	Type 1A	30 (96.7%)	0	0	0	Anterior maxilla (n = 1)
Eeckhout et al (2020)[46]	PC	Type 4C	0	0	0	11 (100%)	–
Esposito et al (2018)[47]	PC	Type 1C	14 (92.9%)	16 (93.8%)	0	0	Anterior maxilla (n = 1) and posterior maxilla (n = 1)
Fugl et al (2017)[48]	PC	Type 4A	35 (100%)	67 (98.5%)	0	0	Posterior maxilla (n = 1)
Kan et al (2011)[49]	PC	Type 1A	35 (100%)	0	0	0	–
Malchiodi et al (2013)[50]	PC	Type 1A	64 (100%)	0	0	0	–
Migliorato et al (2015)[51]	PC	Type 1A	33 (100%)	15 (100%)	0	0	–
Montoya-Salazar et al (2014)[52]	PC	Type 1C	20 (95%)	16 (100%)	0	0	Anterior maxilla (n = 1)
Pol et al (2020)[53]	PC	Type4C	0	12 (100%)	0	18 (100%)	–
Raes et al (2013)[54]	PC	Type 1A	10 (90%)	0	0	0	Anterior maxilla (n = 1)
		Type 4A	19 (100%)	13 (100%)	0	0	–
Romeo et al (2002)[55]	PC	Type 4C	23 (100%)	34 (100%)	0	130 (93.1%)	Posterior mandible (n = 9)
Velasco-Ortega et al (2018)[56]	PC	Type 1A	62 (96.8%)	26 (96.2%)	12 (100%)	16 (100%)	Anterior maxilla (n = 2) and posterior maxilla (n = 1)
Zuiderveld et al (2018)[57]	PC	Type 1A	57 (96.5%)	0	0	0	Anterior maxilla (n = 2)
Becker et al (2011)[58]	RC	Type 1A	80 (100%)	0	20 (95.0%)	0	Anterior mandible (n = 1)
Belser et al (2009)[59]	RC	Type 2-3C	40 (100%)	0	0	0	–
Bonnet et al (2018)[60]	RC	Type 1A	39 (100%)	0	0	0	–
Brown and Payne (2011)[61]	RC	Type 1A	26 (100%)	0	0	0	–
Fugazzotto (2012)[62]	RC	Type 1C	128 (100%)	0	0	0	–
Hartlev et al (2013)[63]	RC	Type 1A	53 (98.1%)	0	0	0	Anterior maxilla (n = 1)
Kolerman et al (2016)[64]	RC	Type 1A	34 (100%)	0	0	0	–
Mangano et al (2013)[65]	RC	Type 1A	19 (100%)	0	0	0	–
		Type 4A	16 (100%)	0	0	0	–
Noelken et al (2018)[66]	RC	Type 1A	26 (100%)	0	0	0	–
Paul and Held (2013)[67]	RC	Type 1A	31 (100%)	0	0	0	–
Van Nimwegen et al (2016)[68]	RC	Type 1A	60 (96.7%)	0	0	0	Anterior maxilla (n = 2)

Anterior region was defined as the segment that contained canines and incisors, and posterior region was defined as the segment that contained premolars and molars in the present system review.

Table 7 Summary Table of Outcomes and Validation of Each Protocol Type in Different Locations

Location	1A	1B	1C	2-3A	2-3B	2-3C	4A	4B	4C
Anterior maxilla	CD *21 studies (3 RCTs) §831 implants #30.7 ± 15.3 mo †97.5% ‡69.2–100%	CID *0 study NA	SCV *7 studies (2 RCTs) §232 implants #50.0 ± 33.6 mo †99.6% ‡92.9%–100%	CID *0 study NA	CID *0 study NA	CWD 4 studies (1 RCT) §123 implants #88.9 ± 41.9 mo †98.8% ‡95.5-100%	SCV *6 studies (3 RCTs) §113 implants #17.2 ± 9.1 mo †99.4% ‡92.9%–100%	CID *0 study NA	CWD *5 studies (4 RCTs) §92 implants #26.4 ± 32.2 mo †99.6% ‡93.8%–100%
Posterior maxilla	CD *6 study (1 RCT) §199 implants #27.5 ± 12.6 mo †93.1% ‡87.5%–100%	CID *0 study NA	SCV *5 studies (2 RCTs) §138 implants #42.1 ± 36.9 mo †98.5% ‡92.0%–100%	CID *0 study NA	CID *0 study NA	CID *1 study §14 implants #120 mo †85.7% ‡85.7%	CD *5 studies (3 RCTs) §128 implants #13.8 ± 4.0 mo †95.9% ‡86.4%–100%	CID *0 study NA	CWD *4 studies (2 RCTs) §88 implants #33.1 ± 34.4 mo †100% ‡100%
Anterior mandible	CID *2 studies §32 implants #30.0 ± 25.5 mo †98.5% ‡95.0%–100%	CID *0 study NA	CID *1 studies §10 implants #108 mo †100% ‡100%	CID *0 study NA	CID *0 study NA	CID *0 study NA	CID *0 study NA	CID *0 study NA	CID *0 study NA
Posterior mandible	CID *1 study §16 implants #48 mo †100% ‡100%	CID *0 study NA	CD *2 studies (1 RCT) §63 implants #66.2 ± 59.1 mo †100% 100%	CID *0 study NA	CID *0 study NA	CID *0 study NA	CWD *4 studies (3 RCTs) §99 implants # 30.0 ± 24.0 mo †97.0% ‡93.3%–97.5%	CID *0 study NA	SCV *9 studies (6 RCTs) §269 implants #38.7 ± 38.3 mo †95.0% ‡93.1%–100%

* = no. of studies; § = no. of included implants; # = mean follow-up; † = weighted mean survival; ‡ = range of survival rate; NA = not available.
SCV = scientifically and clinically validated; CWD = clinically well documented; CD = clinically documented; CID = clinically insufficiently documented.
Due to the limitations in distinct specification of the implant placement time in many clinical studies reported, the early implant placement groups (types 2 and 3) were combined for each loading protocol (Type 2-3A, Type 2-3B, and Type 2-3C).

and loading, and classified them according to the protocol types, after which the level of evidence of each protocol type was graded.

In the anterior maxilla, much has been reported on the Type 1A approach. This is mainly because the anterior maxilla is the main area of the esthetic zone, and a clear clinical benefit is provided: the possibility to rehabilitate the failing tooth with one surgical procedure in 1 day, which is appealing to patients. From a practitioners' perspective, the Type 1A approach helps to preserve the hard and soft tissue morphology around dental implants and may aid in achieving ideal esthetic outcomes.[1,71] Although there was a sufficient number of RCTs and implants investigated, the Type 1A approach in the anterior maxilla was deemed as clinically documented (CD) in the present review due to the negative homogeneity of the implant survival (variation > 10%). This approach has high requirements on the patient's local anatomy and the practitioner's clinical skill. In addition, for the esthetic zone, implant survival is far from enough as an evaluation criterion. Long-term esthetics and function of the implant as well as patient-reported outcomes should be taken into consideration. The latest ITI consensus statement[16] underlined that the Type 1A protocol should only be considered when there are patient-centered advantages, for example, esthetic requirements and reduced morbidity, and when strict anatomical and clinical conditions are met. In almost all of the included studies involving Type 1A implants in the anterior maxilla, the process of minimally invasive tooth extraction was described in detail, and criteria for immediate placement and immediate loading of single implants were reported. The majority of studies also stressed the avoidance of contact during centric occlusion and excursive movement of the immediately loaded provisional restoration.

In the anterior maxilla, Types 1C and 4A were deemed as SCV. Among the seven studies on the Type 1C approach, the reported criteria for immediate placement were relatively less strict compared with the Type 1A approach (Table 9). Implants were immediately placed when there was a defect on the buccal plate of the socket. Studies reporting this treatment approach performed open-flap surgery with guided bone regeneration (GBR) to augment the buccal defect, combined with two-stage submerged healing. In the six studies on the Type 4A approach, the recipient sites were healed sites after either tooth extraction or bone augmentation.

Type 2-3C was deemed as clinically well documented (CWD), as there was four studies with medium- to long-term follow-ups showing favorable implant survival with ideal esthetic outcomes. Type 4C was also deemed as CWD due to relatively fewer implants being

Table 8 Surgical and Prosthodontic Details of Type 1A Implant in Anterior Maxilla

Study	Study design	No. of implants	Failure	Tooth extraction	Criteria for immediate implant placement	Immediate implant placement
Block et al (2009)[23]	RCT	13	4	Atraumatic, degranulation, flapless	Sufficient bone width, ≥ 2 mm of attached or keratinized gingiva	Palatal position, 3 mm apically to the facial gingival margin
Felice et al (2015)[26]	RCT	16	2 late	Atraumatic, degranulation, flapless	< 4 mm vertical buccal bone loss	Underprepare, palatal position, self-tapping implant
Slagter et al (2020)[35]	RCT	18	0	Atraumatic, flapless	< 5 mm vertical buccal bone loss	Surgical template, palatal position
Calvo-Guirado et al (2015)[40]	PC	50	0	NR	Sufficient bone volume, ≥ 3 mm soft tissue thickness	Microthreaded implant, platform switching
Clauser et al (2020)[42]	PC	75	3 early 8 late	Flapless	NR	Placed ≥ 1 mm from the facial wall of the socket; 3–4 mm apically to the facial gingival margin
De Rouck et al (2008)[45]	PC	30	1 late	Minimal flap elevated	Normal to thick-flat gingival biotype, adequate apical bone (≥ 5 mm), intact buccal bone	Underprepare, palatal position, placed 1 mm subcrestal
Kan et al (2011)[49]	PC	35	0	Atraumatic, flapless	Adequate bone and soft tissue volume, intact buccal bone	NR
Malchiodi et al (2013)[50]	PC	64	0	Atraumatic, degranulation, flapless	Normal or thick soft tissue biotype, keratinized mucosa width ≥ 2 mm	Palatal position, longest and widest possible implant
Migliorato et al (2015)[51]	PC	33	0	Atraumatic, degranulation	Adequate bone volume, keratinized mucosa width ≥ 2 mm, intact buccal bone or small dehiscence < 3 mm in height	Palatal position
Raes et al (2012)[54]	PC	10	1 late	NR	Normal or thick-flat gingival biotype, ideal soft tissue level and contour, intact buccal bone, ≥ 3 mm apical bone, implant-to-bone distance < 2.5 mm	Palatal position, placed at the level with the facial osseous crest
Velasco-Ortega et al (2018)[56]	PC	62	2 early	Atraumatic, degranulation, flapless	≤ 5 mm apical bone, intact buccal bone	Palatal position, placed ≥ 4 mm beyond the root apex
Zuiderveld et al (2018)[57]	PC	57	2 early	Atraumatic, flapless	< 5 mm vertical buccal bone loss	Surgical template, placed 3 mm apical to the most apical aspect of the prospective clinical crown
Becker et al (2011)[58]	RC	80	0	NR	≥ 3 mm apical bone	≥ 1 mm inside buccal plate
Bonnet et al (2018)[60]	RC	39	0	Atraumatic, degranulation, flapless	4 intact walls or ≤ 2 mm lost on the buccal plate	Placed 3–4 mm apically to the facial gingival margin
Brown and Payne (2011)[61]	RC	26	0	Flapless	4 mm apical bone, socket with 3 wall dehiscence of < 4 mm	Acrylic surgical stents, implant with angled prosthodontic platform, palatal position, placed 3 mm apical to the buccal mucosal level
Harlev et al (2013)[63]	RC	53	1 early	Degranulation, flapless	< 1 mm buccal bone loss	Palatal position, placed 2–2.5 mm apical to the buccal gingival margin
Kolerman et al (2016)[64]	RC	34	0	Open flap, atraumatic, degranulation	≥ 5 mm apical or palatal bone, compromised buccal bone (thinner than 1 mm, dehiscenced or fenestrated, or combined defect)	Underprepare, palatal position, 2–3 mm apical to the CEJ or to the crown cervical margin of the adjacent teeth
Mangano et al (2013)[65]	RC	19	0	Open flap, atraumatic, degranulation	Intact socket walls, thick gingival biotype	Placed at bone crestal level
Noelken et al (2018)[66]	RC	26	0	Atraumatic, degranulation, flapless	NR	NR
Paul and Held (2013)[67]	RC	31	0	Flapless	NR	Vacuum surgical stent, 16-mm-long scalloped-shaped implant, placed 1.5 mm supracrestally
Van Nimwegen et al (2016)[68]	RC	60	2 early	Minimal traumatic, flapless	No significant soft tissue loss, distance of the contact point to bone level at the adjacent teeth ≤ 5 mm, level of mid-buccal marginal bone < 3 mm apically at the zenith of the tooth, intact buccal bone	Palatal position, placed 3 mm apical to the midfacial soft tissue level, platform switching

IT = insertion torque; ISQ = implant stability quotient; mo = month; PFM = porcelain fused to metal; NR = not reported; DBBM = demineralized bovine bone material; CTG = connective tissue graft; CEJ = cementoenamel junction.

Grafting	Criteria for immediate loading	Provisional prosthesis	Definitive prosthesis
Bone-to-implant gap: allograft	ISQ ≥ 70	Screw-retained, non-occlusal	3 mo after, PFM crown, abutment torque 20 Ncm
Bone-to-implant gap: algea-derived bone substitute	IT ≥ 35 Ncm	Cement-retained, non-occlusal	4 mo after
Bone-to-implant gap: autogenous bone + DBBM	IT ≥ 45 Ncm	Screw-retained, abutment torque 20 Ncm	3 mo after, cement- or screw-retained zirconia crown, abutment torque 32 Ncm
NR	ISQ ≥ 60	Cement-retained, non-occlusal or slight occlusal contact	NR
When bone-to-implant gap > 1 mm: autogenous bone+DBBM	IT ≥ 35 Ncm	Screw-retained, non-occlusal, abutment torque 20 Ncm	3 mo after
Bone-to-implant gap: DBBM	IT ≥ 35 Ncm	Screw-retained, non-occlusal, abutment torque 15 Ncm	6 mo after, cement-retained, PFM crown
NR	Primary stability achieved	Cement-retained, non-occlusal	6 mo after, cement-retained, PFM crown
Bone-to-implant gap: autogenous bone chips retrieved from drills if needed	NR	Cement-retained, non-occlusal, abutment torque 20 Ncm	6 mo after, cement-retained, PFM or zirconia-ceramic crown
Bone-to-implant gap: DBBM, CTG with tunnel technique	NR	Screw-retained, non-occlusal	3–4 mo after
NR	IT 50 Ncm	Cement-retained, non-occlusal, abutment torque 15–20 Ncm	3 mo after
No grafting materials or barriers membranes were used	IT ≥ 35 Ncm	Cement-retained	3 mo after, cement-retained, ceramic crown
Bone-to-implant gap: autogenous bone + DBBM (1:1) with/without CTG from maxillary tuberosity region	NR	Screw-retained, non-occlusal, abutment torque 15 Ncm	3 mo after, cement- or screw-retained, zirconia abutment, abutment torque 35 Ncm
NR	IT ≥ 15 Ncm, ISQ ≥ 50	Occlusally protected	2–3 mo after, abutment torque 35 Ncm
Bone-to-implant gap: DBBM, CTG with tunnel technique	IT ≥ 30 Ncm	Screw-retained, non-occlusal	5–8 mo after, cement- or screw-retained, PFM or all-ceramic crown
NR	IT 30–45 Ncm	Screw-retained, non-occlusal, CAD/CAM all-ceramic crown	2 mo after, screw-retained, all-ceramic crown
No grafting materials or barrier membranes were used	IT > 30 Ncm	Definitive individual abutment, abutment torque 10 Ncm, cement-retained, non-occlusal	7 mo after, abutment torque 35 Ncm, cement-retained, PFM or all-ceramic crown
Bone-to-implant gap and exceed the buccal wall: allograft, resorbable collagen membrane, and CTG	IT > 32 Ncm	Non-occlusal, abutment torque 15 Ncm	6 mo after, abutment torque 35 Ncm, cement-retained, zirconia crown
NR	NR	Cement-retained, full contact in centric occlusion	3 mo after, cement-retained, PFM crown
Autogenous bone with/without CTG	NR	Cement- or screw-retained, non-occlusal, splinted to neighboring teeth with a glass fiber ribbon for 8 weeks	3 mo after, cement-retained, zirconia crown and zirconia abutment
When bone-to-implant gap ≥ 2 mm: DBBM + CTG	NR	Screw-retained, non-occlusal	6 mo after, cement-retained
Bone-to-implant gap: autogenous bone + xenograft	IT > 35 Ncm	Screw-retained, non-occlusal	6 mo after, cement-retained, abutment torque 25 Ncm

Table 9 Surgical and Prosthodontic Details of Type 1C Implant in Anterior Maxilla

Study	Study design	No. of implants	Failure	Tooth extraction	Criteria for immediate implant placement	Immediate implant placement
Slagter et al (2016)[34]	RCT	20	0	Open flap, atraumatic, degranulation	Buccal bone defect ≥ 5 mm, adequate palatal bone	Surgical template, palatal position, placed 3 mm apical to prospective crown margin, submerged
Slagter et al (2020)[35]	RCT	17	0	Atraumatic, flapless	Buccal bone defect < 5 mm	Surgical template, palatal position, submerged
Bianchi and Sanfilippo (2004)[37]	PC	20	0	NR	NR	Submerged
Covani et al (2014)[43]	PC	13	0	Atraumatic, degranulation, flapless	Intact buccal wall	Palatal position, placed at the marginal level of the palatal/lingual bone wall, submerged
Esposito et al (2018)[47]	PC	14	1 late	Atraumatic, degranulation, flapless	Adequate bone	Natural or palatal position, submerged
Montoya-Salazar et al (2014)[52]	PC	20	1 late	Open flap, atraumatic, degranulation, irradiated	Adequate quality and quantity of bone	Extended 3–4 mm apically
Fugazzotto (2012)[62]	RC	128	0	Atraumatic, degranulation	Intact buccal wall, or ≤ 5 mm fenestration apically	NR

RPD = removable partial denture; mo = month; NR = not reported; DBBM = demineralized bovine bone material; CTG = connective tissue graft; PFM = porcelain fused to metal.

evaluated, as Type 4C was more often used as the control group in RCT studies. Types 2-3A, 2-3B, 1B, and 4B were deemed as clinically insufficiently documented (CID), as no publications were found reporting on these protocols.

In the posterior maxilla, implant placement has specific risks due to low-density bone, proximity to the maxillary sinus, complex root anatomy, and increased functional load.[72,73] In this location, conventional placement and loading should be considered routine and a primary treatment approach for the majority of clinical situations.[10] In the present systematic review, Type 1C was deemed as SCV, and 4C was deemed as CWD. The documentation for Types 1A and 4A mainly involved the premolar tooth, which was included as a posterior tooth in this study. Premolars can often be located in the esthetic zone, which generated much interest for an immediate treatment modality. However, due to the negative homogeneity of the implant survival, both types were deemed as CD.

The anterior mandible was the least-reported site, which only involved three studies. All protocol types were CID due to a limited number of studies. The anterior mandible presents similarities with the anterior maxilla regarding single rooted teeth; however, unique functional, anatomical, and esthetic challenges are often presented in the anterior mandible. The teeth are considerably smaller than maxillary anterior teeth, which are often accompanied by limited mesiodistal space and a reduced buccolingual dimension of the alveolus. Further investigations are required to assess implant treatment protocols for this location.

Placement and loading of a single implant in the posterior mandible comprises many challenges associated with site-specific anatomical, occlusal, and biomechanical factors. Esthetics might be of minor importance, and the functional loading can be demanding. Thus, an immediate/early treatment approach may only be indicated in the cases where clinical benefits are identified. Primary stability was reported as a key factor for success in the immediate treatment protocol in the posterior mandible. Under preparation, deepening the drilling, and the usage of a wide-body or exceptional macrostructure implant to engage the surrounding bone walls were reported to facilitate the implant primary stability. However, caution must be exercised with excessively large implant sizes in immediate implant placement due to the faciolingual resorption during healing of the ridge, resulting in the potential for exposure of the implant surface. In this review, Type 1C

Grafting	Healing phase	Provisional prosthesis	Definitive prosthesis
Autogenous bone from tuberosity + DBBM, Above implant: soft tissue graft from tuberosity	RPD, stage-two surgery 3 mo after	Screw-retained provisional crown for 3 mo	6 mo after implant placement, cement- or screw-retained, abutment torque 32 Ncm
Bone-to-implant gap: autogenous bone + DBBM Above implant: free oval soft tissue graft from palate	Stage-two surgery 3 mo after	Screw-retained provisional crown for 3 mo	6 mo after implant placement, cement- or screw-retained zirconia crown, abutment torque 32 Ncm
Above implant and under the vestibular and palatal residual keratinized mucosa: CTG from palate, tuberosity and edentulous ridges	Stage-two surgery 3 mo after	Provisional crown for 6 mo	9 mo after implant placement, cement-retained, PFM crown
Implant-to-bone gap: porcine bone + colleague membrane	Stage-two surgery 4 mo after	NR	4 mo after implant placement, cement-retained, PFM crown
DBBM + resorbable membrane	Stage-two surgery 4 mo after	Cement-retained provisional crown for 4 mo	8 mo after implant placement, cement-retained, PFM crown
DBBM + titanium-reinforced expanded tetrafluoroethylene membrane	RPD, stage-two surgery 3 mo after	Cement-retained provisional crown for 1.5 mo, abutment torque 35 Ncm	4.5 mo after implant placement, cement-retained, PFM crown
Implant-to-bone gap: autogenous bone Fenestration defect: autogenous bone + allograft/ DBBM+ membrane	NR	NR	3–7 mo after implant placement

was deemed as CD, and Type 4A was deemed as CWD. The 4C protocol was found to have the highest level of evidence (SCV) and can be recommended as routine for single tooth replacement in the posterior mandible.

Although the esthetic requirement is commonly cited as a reason for immediate placement or loading, there is a paucity of data on esthetic outcomes with immediate implant treatment. In addition, only a few trials measured the long-term peri-implant tissue health, prosthesis stability, and patient-centered outcome. Therefore, the primary outcome of this systematic review was implant survival, and no further assessment of implant success, esthetic outcome, and patient-centered outcome was performed.

In the present systematic review, all types of clinical study were included to provide as much available evidence as possible. This inevitably led to the limitation that studies with a lack of homogeneity were included. Thus, a validation tool was needed to evaluate the validity and reliability of the results in a scientific perspective, as well as to provide clinical reference for clinical practice. A combination of scientific criteria of study design, sample size, and outcome homogeneity was used. However, other critical factors, such as the risk of bias and follow-up periods of the study, were not able to be included as a factor in this criteria.

CONCLUSIONS

Among the different locations for a single implant, clear differences in the level and quality of scientific evidence for alternative treatment protocols were identified. Types 1C and 4A in the anterior maxilla, Type 1C in the posterior maxilla, and Type 4C in the posterior mandible were scientifically validated with high survival rates. Caution is necessary when understanding outcomes and level of evidence for Types 1A, 2-3C, and 4C in the anterior maxilla; Types 1A, 4A, and 4C in the posterior maxilla; and Types 1C and 4A in the posterior mandible. Several of the possible treatment sites and protocols have no published studies. Selection from the 12 implant treatment protocols for single tooth replacement should be patient-, location-, and site-specific. Esthetic parameters and not only implant survival should be considered when selecting between the appropriate treatment protocols.

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