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REVIEW ARTICLE

Bone response after immediate placement of implants in the anterior maxilla: a systematic review

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Abstract

Purpose The objective of this systematic review was to assess the three-dimensional changes in bone tissue after immediate installation of a single implant in a fresh extraction socket in the anterior maxilla.

Methods After defining a strategy, an electronic search was carried out using the databases PubMed, Embase, LILACS, Web of Science, Cochrane, and Scopus. In addition, the gray literature was also researched using Google Scholar and ProQuest. Two reviewers independently screened for eligible studies, assessed the methodological quality, and extracted the data. The inclusion criteria were observational studies and experimental studies that assessed bone response after the immediate installation of a single implant in a fresh extraction socket, immediately loaded or not, in the region between the maxillary canines. Studies were included in any language, with no publication date restrictions and with a minimum of 6 months of follow-up after the surgical procedure.

Results From a total of 3272 articles, only 12 studies met the inclusion criteria and were selected for the review. Bone remodeling after immediate installation of a dental implant was assessed using standardized periapical radiographs and cone beam computed tomography (CBCT).

Conclusion It can be concluded that bone remodeling occurs after tooth extraction and immediate implant installation.

Keywords Dental implants · Bone remodeling · Tooth extraction · Maxilla · Esthetic area

Introduction

The replacement of a maxillary anterior tooth with a dental implant is a complex surgical procedure, mainly due to the series of events that follow the extraction [1]. Alveolar resorption is a multifactorial physiological process that cannot be fully prevented, partly due to the loss of blood supply from the periodontal ligament after extraction [2]. The physiological healing after extraction is accompanied by changes in the soft and hard tissues and may compromise the aesthetics of the area. Bone remodeling begins immediately after extraction and may last for up to 24 months [2]. After an extraction in the anterior maxilla, the buccal bone plate is more susceptible to resorption than the lingual plate, due to its thickness [2–4].

Wöhrle [5] first reported the use of an immediate implant and an immediate provisional crown in a single region of the anterior maxilla. Immediate implant placement has been suggested as a way of minimizing alveolar bone resorption and preserving the tissue architecture [6]. The location of the implant installation, the thickness of the buccal bone crest, and the size of the horizontal buccal gap can significantly influence changes in the bone crest after tooth extraction [7].

Aesthetic success in preserving bone and gingival architecture was achieved through immediate implant installation followed by immediate function in the anterior maxilla [5, 8, 9]. In patients with healthy periodontal tissue, the buccal bone volume can be stabilized and aesthetics maintained using bone substitutes and connective tissue grafts combined with immediate implant placement [10].

Thus, the objective of this systematic review was to assess bone changes after tooth extraction and immediate installation of a dental implant in the anterior maxilla.

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Material and methods

This systematic review followed the guidelines of the Preferred Reports Items for Systematic Reviews and Meta-Analysis (PRISMA). The protocol was registered in the international prospective register of systematic reviews (PROSPERO) under number CRD42016037818.

Research strategy

Electronic searches were individualized and carried out according to the database searched: PubMed, Embase, LILACS, Scopus, Web of Science, and Cochrane Library. Additional searches were carried out from the gray literature using Google Scholar and ProQuest Dissertations & Theses. All of the search strategies are shown in Table 1. Studies were manually included by the expert when not found in electronic searches.

EndNote Web software (Thompson Reuters) was used to import, manage, store, and remove duplicate items. All research in the described databases and gray literature was carried out on August 12, 2016.

Study selection

After the electronic search, the selection of eligible papers was carried out in two phases. In phase 1, two reviewers independently read the titles with their abstracts (R1: R.J.D. and R2: A.C.M.M.) and, if the inclusion criteria were met, the papers were selected. The selected studies were compared by reviewers in order to reach a consensus. A third reviewer (R3: R.D.S.) was consulted in the event of disagreement between the titles and abstracts selected by reviewers 1 and 2. In phase 2, all selected papers were fully read and included or excluded according to the eligibility criteria. In this phase, reviewers 1, 2, and 3 had to reach a consensus in order to include eligible papers.

Eligibility criteria

Inclusion criteria Randomized clinical trials and observational studies assessed bone response after the immediate installation of a single implant in a fresh extraction socket, immediately loaded or not, in the region between the maxillary canines. Studies were included in any language, with no publication date restrictions and with a minimum of 6 months of follow-up after the surgical procedure.

Exclusion criteria

1. Literature review, letter, personal opinion, book chapter, conference abstract
2. Case report
3. Animal studies
4. Implants installed in healed alveoli
5. Early implants
6. Absence of bone measurements
7. Absence of information about extraction and immediate implant
8. Implants placed in the mandible and/or posterior maxilla
9. Absent adjacent teeth
10. Non adult patients (< 18 years)
11. Not single implant
12. Lack of information about the aesthetic area
13. Defect in the buccal bone plate
14. Paper not found

Data collection

After inclusion of eligible papers, their data were collected by R1 and confirmed by R2. If there was disagreement between the two reviewers, R3 was consulted. The collected data were registered in a table with the main points of interest of each study: the authors of the study, year, country, language of publication, type of study, the total number of patients, mean age, total number of implants with measurements, use of biomaterial, use of soft tissue graft, surgery with or without flap, immediate or non-immediate provisional crown, methodology used to measure the proximal bone remodeling, methodology to measure the buccal plate, survival, duration of follow-up, measurements of proximal bone loss and/or marginal bone loss, measurements of buccal plate loss, and main conclusion.

Bias risk

The methodological quality of the selected studies was assessed using the MAStARI tool (The Joanna Briggs Institute 2014). R1 and R2 replied independently to each question of the tool with "yes," "no," "unclear," and "not applicable". When there were discrepancies and reviewers R1 and R2 did not reach a consensus, R3 was consulted. According to the tool used, when the percentage of "yes" replies for a paper was lower than 50%, the paper was classified as high risk for bias; when the number of "yes" replies was between 50 and 69%, it was classified as moderate risk, and when the "yes" replies were greater than 69%, it was considered as low risk of bias.

Results

In phase 1, according to the search strategy that was carried out, 5034 papers were included from databases and gray literature. Once duplicate studies were removed, 3271 references remained. After reading their titles and abstracts, 151 references were included for full reading. The expert suggested the inclusion of one reference for reading, therefore 152 papers were fully read. Afterwards, the eligible papers were selected according to the inclusion and exclusion criteria. Twelve

Table 1 Search strategies

Base (date of search)	Search
LILACS (August 12, 2016)	English: "immediate dental implant loading" OR "immediate loading" OR "immediate implant" OR "immediate implants" OR "early implant" OR "dental implants, single-tooth" OR "dental implants, single-tooth" OR "dental implants" OR implants OR implant OR "Surgical Dental Prosthesis" OR "Dental Implantation" OR Implantation OR "Implantations" OR "Blade Implantation" AND maxilla OR maxillas OR maxillary OR Maxillae OR "anterior area" OR "maxillary bones" OR "esthetic area" OR "esthetic areas" OR "aesthetic area" OR "Maxillae" OR "esthetics, dental" OR "esthetics" OR "esthetic" OR aesthetics OR esthetic *AND* "Alveolar Bone Loss" OR "Alveolar bone Loss" OR "Alveolar Bone Losses" OR "labial bone" OR "Peri-implant bone" OR "bone effect" OR "bone response" Portuguese: Implante dentário AND maxila OR estética AND remodelação óssea Spanish: Implantación Dental AND Maxilar OR estética AND Remodelación Ósea
PubMed (August 12, 2016)	("immediate dental implant loading"[MeSH Terms] OR "immediate loading" OR "immediate implant" OR "immediate implants" OR "early implant" OR "dental implants, single-tooth"[MeSH Terms] OR "dental implants, single-tooth" OR "dental implants"[MeSH Terms] OR "implants" OR "implant" "OR "Surgical Dental Prosthesis" OR "Dental Implantation"[MeSH Terms] OR "Implantation" OR "Implantations" OR "Blade Implantation"[MeSH Terms]) AND ("maxilla"[MeSH Terms] OR "maxilla" OR "maxillas" OR "maxillary" OR "Maxillae" OR "anterior area" OR "maxillary bones" OR "esthetic area" OR "esthetic areas" OR "aesthetic area" OR "Maxillae" OR "esthetics, dental"[MeSH Terms] OR "esthetics" [MeSH Terms] OR "esthetics" OR "esthetic" OR "aesthetics" OR "esthetic") AND ("Alveolar Bone Loss" [Mesh Terms] OR "Alveolar bone Loss" OR "Alveolar Bone Losses" OR "labial bone" OR "Peri-implant bone" OR "bone effect" OR "bone response")
Cochrane Reviews (August 12, 2016)	("immediate dental implant loading" OR "immediate loading" OR "immediate implant" OR "immediate implants" OR "early implant" OR "dental implants, single-tooth" OR "dental implants, single-tooth" OR "dental implants" OR "implants" OR "implant" "OR "Surgical Dental Prosthesis" OR "Dental Implantation" OR "Implantation" OR "Implantations" OR "Blade Implantation") in title, abstract, keywords and ("maxilla" OR "maxilla" OR "maxillas" OR "maxillary" OR "Maxillae" OR "anterior area" OR "maxillary bones" OR "esthetic area" OR "esthetic areas" OR "aesthetic area" OR "Maxillae" OR "esthetics, dental" OR "esthetics" OR "esthetics" OR "esthetic" OR "aesthetics" OR "esthetic") in title, abstract, keywords and ("Alveolar Bone Loss" OR "Alveolar bone Loss" OR "Alveolar Bone Losses" OR "labial bone" OR "Peri-implant bone" OR "bone effect" OR "bone response")
Scopus (August 12, 2016), Web of Science (August 12, 2016), ProQuest (August 12, 2016)	"immediate dental implant loading" OR "immediate loading" OR "immediate implant" OR "immediate implants" OR "early implant" OR "dental implants, single-tooth" OR "dental implants, single-tooth" OR "dental implants" AND "esthetic area" OR "esthetic areas" OR "aesthetic area" OR "esthetics, dental" OR esthetics OR esthetic OR aesthetics OR esthetic AND "Alveolar Bone Loss" OR "Alveolar bone Loss" OR "Alveolar Bone Losses" OR "labial bone" OR "Peri-implant bone" OR "bone effect" OR "bone response"
Google Scholar (August 12, 2016)	"immediate dental implant loading" OR "immediate implant":"tooth extraction" OR extraction:maxilla OR esthetic OR aesthetic

papers were considered eligible. Figure 1 shows a flowchart of the search process, identification, and inclusion of references.

Characteristics of studies

The studies included in the systematic review were prospective cohort studies (8), retrospective cohort studies (3), and a case-control study (1). Eligible studies were published in China (2), Denmark (5), and the USA (5), between 2003 and 2016, 75% published after 2010. The papers were published in English (10) and Chinese (2). No randomized clinical trial was included after evaluating the exclusion criteria.

One case-control study was eligible; it compared the immediate installation of an implant with a later placement of an implant [11]. The cohort studies assessed 282 immediately placed implants with a minimum follow-up of 6 months and maximum of 10 years; there were 43 implants in the case-control study, totaling data regarding 325 implants.

Data collection

The data collected from the eligible studies are shown in Tables 2 and 3.

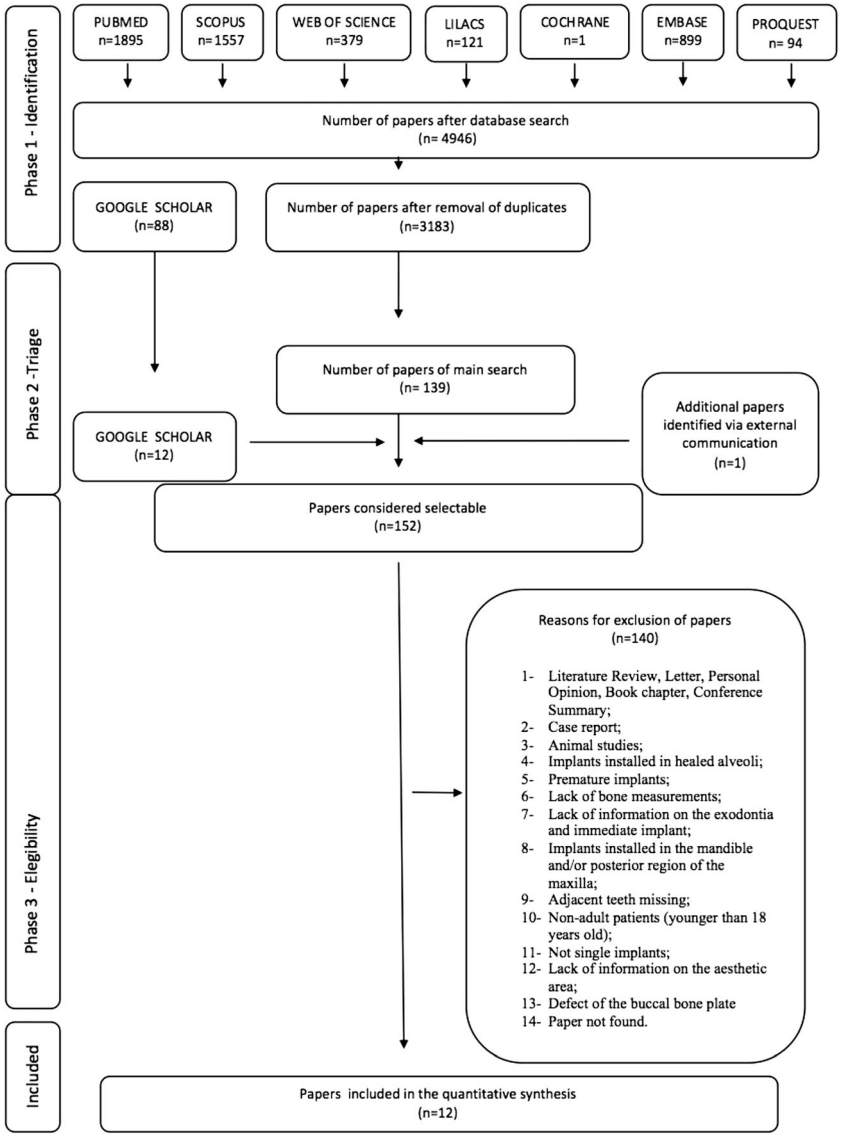

Fig. 1 Flowchart of the search process, identification, and inclusion of references

Bias risk in the studies

The studies were not homogeneous. Only two studies were classified as low bias (16 and 33). Five studies were classified as moderate risk (17, 18, 20, 21, 24). Five studies were classified as high risk of bias (12, 15, 26, 27, 35). The quality of the studies is presented in Tables 4, 5, and 6.

Discussion

This systematic review assessed the bone change after immediate installation of a single implant in the anterior maxilla. Among the 12 eligible studies (prospective cohort, retrospective, and case-control), the survival rate was 100%, ensuring the predictability of the technique success.

A 96.8% survival rate was observed in a systematic review evaluating immediate installation and late installation implants [23]. Esposito et al. [24]observed no early or late failures in their systematic review on immediately placed implants. Also, there was no statistically significant difference in marginal bone level of the implants installed for the three protocol types. Grandi et al. [25] used X-rays to compare single immediate implants with implants that were installed in healed alveoli of the anterior maxillary region and found no difference between the two techniques in terms of bone change, after 12 months follow-up. All the papers that compared these placement techniques did not consider the thickness or bone height before the tooth extraction for late implants, but only after alveolar healing. Therefore, there was a misinterpretation of the results.

In all of the selected studies, the bone underwent resorption; however, this did not compromise the aesthetics of the

Table 2 Summary of the descriptive characteristics of included studies

Authors, year, country, language	Study type	Number of patients	Age (years)	Installed implants	Diameter (mm)	Length (mm)	Graft material	Flapless	Connective tissue graft	Immediate provisional crown	Late provisional crown
Calvo Guirado et al. 2007 USA English	Prospective cohort	10	37 ± 8	10	4/5/6	13/15	–	–	–	Yes	No
Joudzbalays and Wang 2007 Denmark English	Prospective cohort	12	34 ± 21	14	4.3/5	13/16	Bio-Oss Bio-Gide Resor Pin	Yes	Yes	No	No
Kan et al. 2003 USA English	Prospective cohort	35	41.5 ± 33.23	35	Minimum 3.5	Minimum 13	No	Yes	No	Yes	No
Kan et al. 2011 USA English	Retrospective cohort	35	41.5 ± 33.23	35	–	–	No	Yes	No	Yes	No
Kuckler et al. 2016 Denmark English	Retrospective cohort	20	64 ± 29.69	–	4.1 (cervical portion 4.8 and 1.8 mm polished band)	–	Bio-Oss Bio-Guide	No	No	No	Yes
Lemes et al. 2015 Denmark English	Prospective cohort	12	45.5 ± 27.57	–	3.5 or 4.3	13	No	Yes	No	Yes	No
Malchiodi et al. 2013 USA English	Prospective cohort	58	48.5 ± 41.71	64	3.25 up to 4.9 mm	10 to 16	Autogenous (some cases)	Yes	Not informed	Yes	No
Moriomoto et al. 2015 Denmark English	Prospective cohort	12	41 ± 29.69	12	3.5/4.3 (1.5 mm polished cervical portion)	13 or 16	Synthetic hydroxyapatite	Yes	Not informed	Yes	No
Paul and Held 2013 Denmark English	Retrospective cohort	26	51 ± 46.66	31	Festooned cervical portion	_	Bio-Oss (GAP ≥ 2 mm)	Yes	Yes (GAP ≥ 2 mm)	Yes	No
Quaranta et al. 2016 USA English	Prospective cohort	35	35 ± 21.21	29	3.75 or 4 mm (2 mm polished cervical portion)	12 to 16 mm	No	Yes	No	Yes	No

Table 2 (continued)

Authors, year, country, language	Study type	Number of patients	Age (years)	Installed implants	Diameter (mm)	Length (mm)	Graft material	Flapless	Connective tissue graft	Immediate provisional crown	Late provisional crown
Wang et al. 2016 China Chinese	Prospective cohort	20	30 ± 14.14	23	3.5 or 4.3	–	Bio-Oss	Yes	Yes	No	–
Wu et al. 2015 China Chinese	Case-control	38 16 immediate implants 22 late implants	42.5 ± 21.92	Total 43 17 immediate implants 26 late implants	–	–	Bio-Oss + Bio-Oss collagen	Yes: immediate implant No: late implant	Not informed	–	–

rehabilitation. In studies with follow-up longer than 12 months, there was a continuous peri-implantar bone loss [12–14] suggesting the need for a longer follow-up. Mean marginal bone changes in the mean follow-up of 4 years were significantly higher than in the first year [12].

In one selected study, it was possible to compare immediate and late implant placement [11]. No significant differences between the two groups were observed in terms of bone loss and tissue stability after 2 years of follow-up.

In the methodology chosen by the selected studies, the measurement of marginal bone loss was assessed using standardized periapical radiographs. The height and thickness of the buccal bone plate were measured using cone beam computed tomography (CBCT). This method of evaluation of the buccal bone should be employed since the buccal bone is not visible in periapical radiographs. The study by Wang et al. [15] was the only one that used CBCT in a standardized way for marginal bone loss measurement without the need for periapical radiographs.

Only studies on single implants with adjacent teeth were included, because the bone-remodeling pattern is considered to be different when between two adjacent implants. The level of the bone adjacent to the tooth implant is the main factor for the stability of the interproximal soft tissue [26]. The preservation of the interproximal alveolar bone is very important from an aesthetic point of view.

Eight of the selected studies assessed installed implants that were immediately loaded with a provisional crown. In three cohort studies, the implants remained submerged during healing [13, 15, 16]. Among the non-functionally loaded implants, biomaterials were used to fill the space between the implant and the remaining bone. Membranes and soft tissue grafts were used to facilitate healing.

It can be seen that the immediate function protocols did not result in any significant difference in the survival rates when compared with immediate implants that were loaded at a later date.

Among the selected papers, 41.6% did not use filler material between the implant and the buccal bone plate. The absence of the biomaterial can contribute to shortening of the gingival margin compromising the aesthetics in immediate implants, especially in aesthetic region [17]. It is suggested that less resorption occurs when the space between the buccal bone plate and the implant is filled with a low resorption biomaterial, such as the deproteinized bovine bone [27].

Surgical trauma and the elevation of the flap in a root extraction and implant installation have also been proposed as influencers in bone remodeling [3].

The preservation of bone thickness after immediate installation of dental implants is extremely important in rehabilitations of the anterior aesthetic zone of the maxilla. Experimental and clinical studies have shown that the buccal

Table 3 Summary of the descriptive characteristics of included studies

Authors, year, country, language	Study type	Number of patients	Age (years)	Installed implants	Diameter (mm)	Length (mm)	Graft material	Flapless	Connective tissue graft	Immediate provisional crown	Late provisional crown
Calvo Guirado et al. 2007 USA English	Prospective cohort	10	37 ± 8	10	4/5/6	13/15	–	–	–	Yes	No
Joudzbalays and Wang 2007 Denmark English	Prospective cohort	12	34 ± 21	14	4.3/5	13/16	Bio-Oss Bio-Gide Resor Pin	Yes	Yes	No	No
Kan et al. 2003 USA English	Prospective cohort	35	41.5 ± 33.23	35	Minimum 3.5	Minimum 13	No	Yes	No	Yes	No
Kan et al. 2011 USA English	Retrospective cohort	35	41.5 ± 33.23	35	–	–	No	Yes	No	Yes	No
Kuckler et al. 2016 Denmark English	Retrospective cohort	20	64 ± 29.69	–	4.1 (cervical portion 4.8 and 1.8 mm polished band)	–	Bio-Oss Bio-Guide	No	No	No	Yes
Lemes et al. 2015 Denmark English	Prospective cohort	12	45.5 ± 27.57	–	3.5 or 4.3	13	No	Yes	No	Yes	No
Malchiodi et al. 2013 USA English	Prospective cohort	58	48.5 ± 41.71	64	3.25 up to 4.9 mm	10 to 16	Autogenous (some cases)	Yes	Not informed	Yes	No
Moriomoto et al. 2015 Denmark English	Prospective cohort	12	41 ± 29.69	12	3.5/4.3 (1.5 mm polished cervical portion)	13 or 16	Synthetic hydroxyapatite	Yes	Not informed	Yes	No
Paul & Held 2013 Denmark English	Retrospective cohort	26	51 ± 46.66	31	Festooned cervical portion	–	Bio-Oss (GAP ≥2 mm)	Yes	Yes (GAP ≥2 mm)	Yes	No
Quaranta et al. 2016 USA English	Prospective cohort	35	35 ± 21.21	29	3.75 or 4 mm (2 mm polished cervical portion)	12 to 16 mm	No	Yes	No	Yes	No
Wang et al. 2016 China	Prospective cohort	20	30 ± 14.14	23	3.5 or 4.3	–	Bio-Oss	Yes	Yes	No	–

Table 3 (continued)

Authors, year, country, language	Study type	Number of patients	Age (years)	Installed implants	Diameter (mm)	Length (mm)	Graft material	Flapless	Connective tissue graft	Immediate provisional crown	Late provisional crown
Chinese Wu et al. 2015 China Chinese	Case-control	38 16 immediate implants 22 late implants	42.5 ± 21.92	Total 43 17 immediate implants 26 late implants	–	–	Bio-Oss + Bio-Oss collagen	Yes: immediate implant No: late implant	Not informed	–	–

bone will quickly reabsorb 4 to 8 weeks after extraction with the possibility of a reduction in bone height [2, 18, 28].

The protocol that involves dental element extraction and immediate implant with an immediate provisional crown has high success rates in the anterior region of the maxilla [9, 17]. Primary stability of the implant is a requirement for the adoption of immediate function. Three to five millimeters of implant should be inserted into the remaining bone to provide initial stability of the implant and enable immediate function [29].

Minimal traumatic extraction, flapless lifting, implant installation, and immediate provisional crown combined with biomaterial filling of the gap between the implant and the buccal bone plate have shown to increase the height and thinning of the buccal bone plate and reduce the height of the peri-implant bone crest [19].

The marginal bone loss in studies with 12 months of follow-up showed a mean maximum bone loss of 2.69 mm [14] and gain of 0.02 mm [13]. Despite significant marginal bone loss, immediate implant procedure is considered favorable for the peri-implant bone response and for the aesthetic outcome of immediate implants with provisional crowns in the anterior maxilla region [25].

Among the selected papers, all immediately loaded implants had the centric and eccentric contacts set to a non-functional load [9, 14, 20, 30–33]. Immediate single implants combined with immediate load do not interfere with the osseointegration process when the forces are properly adjusted [34].

The final restorations were installed after 5 months in all studies selected by this systematic review.

Immediate implants may maintain the height of adjacent papillae [5, 9]. The risk of buccal gingival recession is described in one immediate study [12, 21] as well as in one late study [35].

Only three studies measured the thickness of the buccal bone plate around the immediately installed implants [13, 15, 32].

The thickness of the buccal bone plate is crucial for the successful long-term aesthetic outcome of immediately installed implants. A threshold of 2 mm is recommended to minimize vertical bone plate resorption [4]. The width of the horizontal defect was the main factor for the vertical dimension of facial bone [13]. The buccal bone dimension is associated with a reduction in width of keratinized tissue.

Among the eligible studies of this review, there was a lack of standardization for the measurement of marginal bone loss and buccal bone plate. Only two papers [13, 15] assessed in the same study the marginal bone loss and buccal bone plate. The remaining ten papers assessed either the marginal bone loss or the bone loss of the buccal bone plate. Among the papers that assessed the marginal bone loss, there was no standardization between the measurements of marginal bone crests. Some papers assessed only the mesial and distal bone crest, and others, only the mean.

Table 4 Summary of the descriptive characteristics of included studies

Autores, Ano, País, Língua	Metodologia mensuração proximal	Metodologia mensuração tábua óssea vestibular	Sobrevivência	Follow-up	Perda óssea mesial (mm)	Perda óssea distal (mm)	Perda óssea marginal média	Perda tábua óssea vestibular (mm)	Conclusão principal
Calvo Guirado et al. 2007 USA English	Periapical Radiograph	–	100%	Surgery 15 days 1 month 2 months 3 months 6 months	IL − 0.7 IC − 0.5	IL − 0.6 IC − 0.7	–	–	Bone loss less than 1 mm in all the implants
Joudzbalays and Wang 2007 Denmark English	Periapical Radiograph	–	100%	6 months 12 months	IL 6–2.76 IC 6–3.06 IL 12–2.42 IC 12–2.7	IL 6–2.98 IC 6–3.45 IL 12–2.82 IC 12–3.24	6–0.57 mm 12–1.72 mm	–	Immediate implant promotes excellent gingival aesthetics
Kan et al. 2003 USA English	Periapical Radiograph	–	100%	0, 3, 6, and 12 months (12 months) 12 to 42 months mean 16.7 months	− 0.26 ± 0.40mm* (12 months)	− 0.22 ± 0.28mm* (12 months)	− 0.93mm* (12 months)	–	Bone architecture preserved
Kan et al. 2011 USA English	Periapical Radiograph	–	100%	T0: pre-surgery T1: surgery T2: 12 months T3: mean of 4 years (2–8.2 years)	− 0.72 ± 0.27* (T3)	− 0.63 ± 0.21* (T3)	–	–	Mean alterations at the level of the mesial and distal bone were significantly greater than those observed at 1 year follow-up
Kuckler et al. The width of the horizontal defect was the main indicator for the vertical dimension of the buccal bone plate 2016 Denmark	– English	CBCT** (2, 4, 6 mm of the cervical portion of the implant (BT) /vertical distance between the cervical portion of the implant and the first contact of the bone crest)	100%	10.5 (min. 10.1 and max. 11.5) years	–	–	+ 0.02 (gain)	BT2: − 0.13 mm BT4: − 0.15mm* BT6: − 0.13 mm*	
Lemes et al. 2015 Denmark English	–	CBCT** – height of the buccal bone crest (central point, 1 mm mesial and 1 mm distal)	–	Pre-surgery (T0) 0 months (T1) 6 months (T2)	–	–	3.31mm*	–	After 6 months there was loss of the height of the buccal bone crest after immediate implants

*Study showed statistically significant difference

***CBCT*, cone beam computed tomography

Table 5

Authors, year, country, language	Methodology proximal measurement	Methodology buccal bone plate measurement	Survival	Follow-up	Mesial bone loss (mm)	Distal bone loss (mm)	Mean marginal bone loss	Buccal bone plate loss (mm)	Main conclusion
Malchiodi et al. 2013 Estados Unidos Inglês	Periapical radiograph	–	100%	0 months 6 months 12 months 3 years	− 0.7 ± 0.5 mm	− 0.9 ± 0.5 mm	− 0.8 ± 0.6 mm	–	Immediate implant is a predictable technique and should be considered as first choice
Moriomoto et al. 2015 Dinamarca Inglês	–	CBCT (0, 2, 4, 6, 8, 10, 12 mm apical of the cervical portion of the implant)	100%	13.3 months	–	–	–	− 0.26 mm (thickness) − 0.25 mm (height)	Immediate implants in the anterior region of the maxilla undergo small bone alterations.
Paul and Held 2013 Dinamarca Inglês	Periapical radiograph	–	100%	0, 6, 12, 36, 60 mean 3.4 years 5 years	–	–	− 0,33 mm (6 months) − 043 mm (12 months) − 0,44 mm (36 months) − 0,52 mm (60 months)	–	After 1.5–5.5 years (mean 3.4 years), implants had satisfactory esthetic success.
Quaranta et al. 2016 Inglês Estados Unidos	Periapical radiograph and CBCT**	–	100%	0 (T0), 6 (T1), 14 (T2), 48 (T3), 60 (T4), 72 (T5), 120 (T6) months (10 years)	–	–	(− 1.43 ± 0.19)* (T1)* (− 2.69 ± 0.42 mm) (T6)	–	Immediate implant after extraction in the anterior region of the maxilla is a predictable technique.
Wang et al. 2016 Chinês China	–	CBCT MP1 0 mm MP2 2 mm MP3 4 mm MP4 6 mm MP5 8 mm Apical line between the implant and the mesial and distal bone ridge	100%	6 months	–	–	(− 0.42 ± 1.24) mm Ankylos (− 0.91 ± 1.96) mm replace	MP1 (− 0.89 ± 2-.06) MP2 (− 0.52 ± 1-.02) MP3 (− 0.5 ± 0.-87) MP4 (− 0.75 ± 1-.28) MP5 (− 0.59 ± 1-.60)	Immediate implant surgery does not stop bone remodeling in the anterior region of the maxilla.
Wu et al. 2015 Chinês China	Periapical radiograph	–	100%	24 months	(0.67 ± 0.35) immediate implant (0.69 ± 0.49) late implant	(0.73 ± 0.31) immediate implant (0.75 ± 0.48) late implant	–	–	After 2-year follow-up, both groups showed tissue stability. Shortening of treatment time is beneficial to immediate implants.

*Statistically significant difference

**_CBCT_, cone beam computed tomography

Table 6 Risk of bias assessed by Meta Analysis of Statistics Assessment and Review Instrument (MAStARI) [1] critical appraisal tools. Risk of bias was categorized as high when the study reaches up to 49% score "yes", moderate when the study reached 50% to 69% score "yes", and low when the study reached more than 70% score "yes"

Question	Answer*											
	Calvo Guirado [5]	Joudzbalays and Wang [12]	Kan et al [13]	Kan et al. [14]	Kuckler et al. [15]	Lemes et al. [16]	Malchiodi et al. [17]	Moriomoto et al. [18]	Paul and Held [19]	Quaranta et al. [20]	Wang et al. et al. [21]	Wu et al. [22]
1. Was the sample representative of patients in the population as a whole?	N	N	N	N	N	N	N	N	N	N	N	N
2. Were the patients at a similar point in the course of their condition/illness?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
3. Had bias been minimized in relation to selection of cases and of controls?	N	Y	Y	Y	Y	Y	U	Y	N	Y	Y	N
4. Were confounding factors identified and strategies to deal with them stated?	N	N	Y	Y	N	N	N	N	NA	N	N	N
5. Were the outcomes assessed using objective criteria?	Y	N	Y	Y	Y	Y	Y	Y	Y	U	Y	Y
6. Was follow-up carried out over a sufficient time period?	N	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y
7. Were the outcomes of people who withdrew described and included in the analysis?	NA	NA	NA	NA	Y	N	Y	NA	N	N	Y	N
8. Were outcomes measured in a reliable way?	N	N	Y	N	N	Y	U	U	U	N	Y	U
9. Was appropriate statistical analysis used?	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
% yes/risk	22.22% high	44.44% high	77.77% low	66.66% moderate	66.66% moderate	55.55% moderate	55.55% moderate	55.55% moderate	44.44% high	44.44% high	77.77% low	44.44% high

*Y, yes; N, no, U, unclear, NA, not applicable

1 Meta Analysis of Statistics Assessment and Review Instrument (MAStARI). Joanna Briggs Institute Reviewers Manual. Australia: The Joanna Briggs Institute, 2014

An alternative for future studies of immediate implants in the anterior maxilla is the standardization of the method. Wang et al. [15] standardized the proximal measurements and measurements of the buccal bone plate exclusively by means of cone beam computed tomography.

Conclusion

The major limitation of this systematic review is the lack of standardization for measurement of marginal bone loss and/or buccal bone plate across the eligible studies. There was an inevitable marginal and buccal bone remodeling that occurred after tooth extraction and immediate implant installation in all studies. Randomized clinical trials are still necessary.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval As it is a systematic review, there is no need for ethical approval.

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