Review Article

IMPLANT SURVIVAL RATE AFTER IMMEDIATE IMPLANTATION IN INFECTED SOCKETS: A SYSTEMATIC LITERATURE REVIEW

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ABSTRACT

This systematic study was conducted to evaluate the survival rate of immediate implants in sites displaying chronic periapical lesions after using different disinfection methods. A systematic literature search was conducted according to PRISMA guidelines. Clinical trials published in English between the years 2012 and 2023 were selected. Randomized clinical trials (RCT) and cohort human clinical trials evaluating the survival rate of implants placed in infected sockets with a control group and a follow-up period ≥3 months were included. All in vitro, animal, and pilot studies, case reports, and case series were excluded. Cohort studies were evaluated using the Newcastle-Ottowa scale. Cochrane Risk of bias assessment tool version 2 (RoB 2) was used for the selected RCT. Seven studies were included. Five of them were Cohort studies, and 2 of them were RCT. None of the studies met the requirements for quantitative meta-analysis due to their heterogeneity of data. Two hundred and fifty-nine patients and 663 implants were evaluated. The survival rate of implants in reviewed studies ranged from 94.4% to 100%. All studies used curettage in test groups as primary debridement in infected sockets. There were no statistically significant differences ($p<0.05$) in implant survival rates when additional disinfection techniques were used: rinsing with chlorhexidine, and sequestrectomy using Er, Cr: YSGG laser. Analysis of the studies shows that a variety of measures can be used to increase the possibility of implant integration, but without careful curettage of the alveolus, additional disinfection measures are ineffective.

Key words: Immediate implantation, Infected sockets, Survival rate, Decontamination.

Introduction

According to Brånemark's customary approach, a dental implant should not be inserted until the alveolar bone has fully healed [1]. The sockets take up to twelve months to heal completely after extraction [2]. Unfortunately, the resorption of the alveolar ridge following full tooth removal can significantly reduce the remaining bone volume and limit the ability to place an implant in a way that will result in the best restoration [3]. That is why an immediate implant placement protocol was established to achieve better overall results [4].

Over the past eleven years, immediate dental implant placement has gained a lot of interest. Immediate implant placement is defined as a surgical technique during which the implant is placed in the place of an extracted compromised tooth on the same day [5]. The biggest advantages of immediate implant placement are the ability to load the site immediately, reduced number of surgical steps, less resorption of the alveolar bone, and the ability to place an implant in an ideal axial position [6]. When there are patient-centered benefits, such as lower morbidity, a positive psychological impact, and a significantly reduced time required for dental restoration - immediate implant placement should be taken into consideration [7]. Numerous clinical reports and experimental research using animals showed that dental implants placed right away in recently extracted sockets, , had a satisfactory outcome [8-10]. However, the results of immediate implantation could be negatively impacted by an active infection at the extraction site, due to the possibility of an infection spreading to the tissues around an implant, which could cause retrograde peri-implantitis or implant failure [11].

To avoid bacterial contamination and implant failure due to bacterial strains, preventive antibiotics (PAs) are prescribed [12, 13]. The American Heart Association (AHA) recommended antibiotic treatment prior to complicated surgical procedures, such as immediate implantation. Antibiotics like amoxicillin are suggested by the AHA because of their greater absorption and sustained serum levels [14]. Consequently, the use of prophylactic antibacterial medication during dental implant surgeries is currently debatable [15]. According to European Association for Osseointegration, a positive effect of PAs cannot be ruled out in difficult instances, such as immediate implant insertion. But there aren't any defined guidelines for how to administer them in such procedures at the moment [16]. It is clear that successful immediate implant placement also requires comprehensive debridement and disinfection in diseased sockets [17]. In 1995, Novaes Jr. and Novaes

reported the first successful case of immediate implantation in an infected socket. The authors' advised technique includes meticulous socket removal and debridement (removal of a small layer of the bone from the area of the periapical lesion) followed by extensive saline irrigation, guided bone regrowth, primary closure, and a course of systemic antibiotics [18].

The success of the procedure mainly depends on the mechanical curettage of contaminated tissues [19]. A variety of decontamination techniques and drug administration protocols have been documented for immediate implantation [20, 21]. Del Fabbro *et al*. used PRGF liquid, which was infused into the implant body to encourage bioactivation of the implant surface [20]. Garcés Villalá *et al.* stated that the key to successful immediate implant placement was that the sockets were cleaned with sterile saline and 3% hydrogen peroxide to eliminate tissue debris from the alveolus, which was essential for the protocol's effectiveness [21].

Information regarding the disinfection of the socket before immediate implantation is essential for a successful outcome [22]. Data on healing dynamics and bone regeneration are needed for each protocol to compare possible options for the best result.

Aim

To evaluate the survival rate of immediate implants in sites displaying chronic periapical lesions after using different disinfection methods.

Materials and Methods

This systematic review was conducted using the Preferred Reporting Item for Systematic Reviews and Meta-Analyses (PRISMA) statement. The protocol for this systematic review was officially registered at PROSPERO (the University of York, Centre for Reviews and Dissemination). The identification number of the study is CRD42023392878.

Focus question

The participant, Intervention, Comparison, Outcome (PICO) principle was used to create a focus question for this study [23]. What is the implant survival rate (O) after immediate implantation (I) in patients with sockets periapical lesions (P) compared to immediate implantation in non-infected sockets (C)?

Inclusion and exclusion criteria

Inclusion criteria

- Articles published in the English language.
- Studies no older than 11 years.
- Cohort or randomized human clinical trials (RCT) evaluating the survival rate of implants placed in infected sockets.
- A follow-up period of ≥3 months
- A clearly defined disinfection protocol.
- Patients in the control group will have to have a healthy periapical area in which implants had been inserted.
- In the test group, immediate implantation had to take place in sites with periapical lesions.
- Report on implant survival rate.

Exclusion criteria

- Systemic diseases.
- Chronic diseases.
- Incompatible medication or condition.
- Smoking > 10 cigarettes a day
- No follow-up
- In vitro, animal, pilot studies, case reports, and case series.

Search strategy and study selection

A systematic literature search was conducted according to PRISMA guidelines. Clinical trials published in English between the years 2012 and 2023 were selected. All authors carried out electronic literature searches independently in MEDLINE (PubMed), and EMBASE (ScienceDirect) databases. The following keywords were used in various combinations to search databases: (Immediate implantation), (Infection), (Infected socket), (Periapical lesion), (Socket decontamination), (Periodontitis), (Survival rate). Following a screening of the titles and abstracts, full-text papers were chosen for rigorous evaluation and analysis per the qualifying requirements. Researchers evaluated search results and discussed differences to come to a conclusion.

Risk of bias tools

Perspective and retrospective cohort studies were assessed using the Newcastle-Ottowa scale. Cochrane Risk of bias assessment tool version 2 (RoB 2) was used for the selected RCT. Using the standardized tool, all possible systematic errors of the included studies were assessed that could have risen due to random sequencing and distribution into groups, deviations from the planned intervention, missing data, evaluation of measurement indicators, selective documentation of results, and other factors.

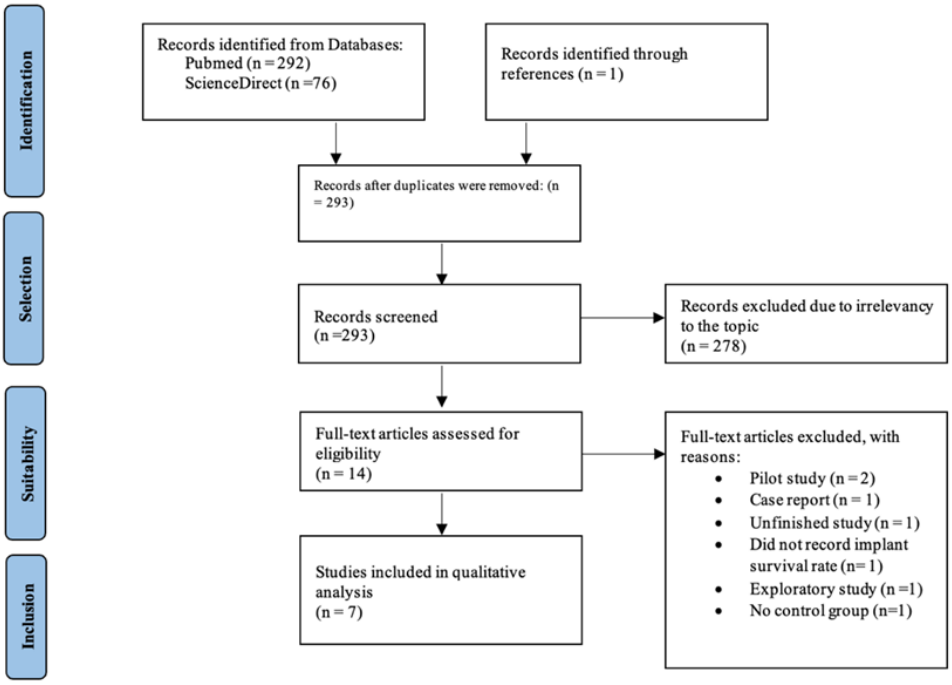

Figure 1. Prisma flow diagram

Results and Discussion

Study selection

Using a PRISMA flow diagram, a review of articles, abstracts, and full-text publications is shown **(Figure 1)**. The various search keyword combinations turned up 368 titles in total. Two hundred and ninety-two records were left after duplicates were eliminated. Fourteen publications were selected for full-text analysis after 278 of them failed to fulfill the inclusion criteria (meta-analysis, systematic reviews, limited data, case reports, animal research, publication date >12 years). 7 studies were included in this review. 5 of the included studies were Cohort studies, and 2 of them were randomized clinical trials. None of the studies met the requirements for quantitative meta-analysis due to their heterogeneity of data.

Patient's data

Patients in the included studies varied in age from 41.9 to 56.3 years old. Seven studies involving a total of 259 patients and 663 implants were inserted and evaluated. All patients in test groups had teeth displaying one of these characteristics: periapical pathology, asymptomatic periodontitis, granulation, or infected tissue in the apical region of the socket after extractions. Control groups in all studies included extracted teeth due to fractures, traumatic causes, or deep caries, but displayed no periapical pathology.

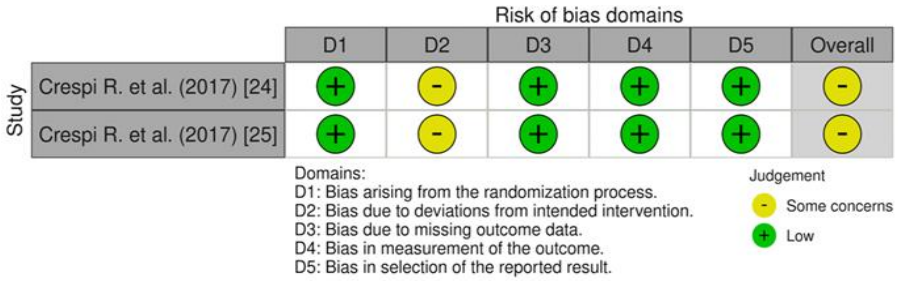

Figure 2. Randomized clinical studies quality evaluation (RoB 2 tool).

Quality evaluation

Figure 2 and **Table 1** below both display the outcomes of the risk of bias evaluation for RCT and cohort trials, respectively. The randomization procedure in both of the RCT [24, 25] papers that we included in our research did not

appear to have a high risk of bias. The five cohort studies [26-30] all exhibit excellent analytical quality.

Table 1. Quality assessment using Newcastle-Ottowa scale scale of included cohort studies in systematic review

Study	Selection				Comparability (**)	Outcomes			Total score out of 9
	Representativeness of the exposed cohort(*)	Selection of the non-exposed cohort (*)	Ascertainment of exposure(*)	Outcome not present at the start of the study (*)		Assessment of outcome (*)	Length of follow-up (*)	Adequacy of follow-up (*)	
Montoya-Salazar V. *et al*. (2014) [26]	*		*	*	*	*	*	*	7
Khan Katyayan M. *et al*. (2018) [27]	*		*	*	*	*	*	*	7
Al Nashar A. *et al*. (2015) [28]	*		*	*	**	*	*	*	8
Fugazzotto P. A. *et al*. (2012) [29]	*		*	*	*	*	*	*	7
Jung R. E. *et al*. (2013) [30]	*		*	*	**	*	*	*	8

Treatment outcomes

The results of the evaluated studies are represented in **Table 2.** The included trials' implant survival rates varied from 94,4% to 100%. Clinical and radiographic examinations were used to assess the absence of infection.

After tooth removal, sockets in the Crespi *et al*. randomized controlled study were divided into two groups at random: the test group (TG) had granulomatous tissue extracted and rinsed with a physiologic solution, whereas the control group (CG) had granulomatous tissue which remained. The surgeon and a dental hygienist made follow-up appointments 2 months after and every 6 months after implant insertion. In 372 of the cases, immediate placement was done after teeth extraction. Two implants in TG and 3 implants in CG were removed after a follow-up of 2 months. All implants had a survival rate of 98.66% (98.92% for TG and 98.39% for CG). The survival rate remained unchanged after 3 years, and there were no statistically significant differences in clinical metrics and marginal alterations in bone level between TG and CG ($p > 0.05$). Furthermore, there were no measurable changes in intragroup assessments over time ($p > 0.05$).

Regarding other outcomes, three patients in the CG group reported pain, and 2 had edema at the implant site the in the first 3 months. No statistically significant differences between TG and CG be values were disclosed for bleeding index ($p>0.05$; $p = 0.37$ at 36 months) and plaque accumulation ($p > 0.05$); $p = 0.54$ at 36 months).

Montoya-Salazar V. and others also included a laser treatment in their disinfection protocol. Thirty-six implants were placed in non-infected sockets (control group; CG; n = 18) and infected alveoli (test group; TG; n = 18) that had already been debrided, mechanically cleaned, and rinsed with 90% hydrogen peroxide, irradiated with yttrium-scandium-gallium- garnet (Er, Cr: YSGG) laser, and washed out with a sterile solution. Three months after the operation, all of the prostheses had osseointegrated. In comparison to CG, TG had a 3-year mortality percentage of 100% versus 94.44%.

In the test group, 64 implants were placed after debridement by Fugazzotto P. A. and others. Sixty-four implants were put immediately placed after the removal of a maxillary incisor in the control group that didn't have any periapical pathology. Using Molt and Gracey curettes, the remaining soft tissue and the periapical tumor were both excised. For implants put in sites with periapical pathology and implants positioned in sites without periapical pathology, respective survival rates of 98.1% and 98.2% were noted.

Four studies: Crespi R. and others, Khan Katyayan M. and others, Al Nashar A. and others, and Jung R. E. and others noted a 100% implant survival rate for both control and test groups.

Table 2. Evaluated studies and implant survival rate

Name	Khan Katyayan M. *et al.* (2018) [27]	Crespi R. *et al.* (2017) [25]	Montoya-Salazar V. *et al.* (2014) [26]	Crespi R. *et al.* (2017) [24]
Type	Cohort	RCT	Cohort	RCT
Number of patients, males(M) females(F)	15 11M 4F	60 22M 38F	18 -	60 22M 38F
Mean age (years)	41.9	56.3 ± 12.1	-	-
Age range (years)	28-54	32-67	18-50	35-72
Number of implants	20	60	36	372
Follow-Up (months)	12 24	6 12	12 24 36	3 6 12 24 36
Reason for extraction	Chronic periapical lesions Root caries Root fracture	Asymptomatic apical periodontitis	Chronic periapical lesion of endodontic or endoperiodontal origin	Asymptomatic periodontitis
Disinfection protocol in test groups	Curettage Rinsed with 0.2% CHX, PSS	Curettage	Curettage 90% hydrogen peroxide Sequestrectomy (Er,Cr:YSGG laser)	Curettage Rinsed with PSS Sequestrectomy (Er,Cr:YSGG laser)
Survival rate	100%	100%	94.44% for TG 100% for CG	98.66%
Drug therapy	Amoxicillin 1000mg an hour before surgery Amoxicillin 500mg x3 per day for 5 days	Amoxicillin 1000mg an hour before surgery and x2 per day for 7 days	Amoxicillin 1500mg x3 per day for 10 days/ Clindamycin 900mg x3 per day for 10 days (4 days before surgery, 6 days after)	Amoxicillin 1000mg an hour before surgery and x2 per day for 7 days
Post-operative regime	Chlorhexidine 0.2% mouthwash x2 per day for 15 days	-	Chlorhexidine 0.12% mouthwash x2 per day for 14 days	Chlorhexidine mouthwash x 2 per day for 15 days

Fugazzotto P. A. *et al.* (2012) [30]	Jung R. E. *et al.* (2013) [29]	Al Nashar A. *et al.* (2015) [28]
Cohort	Cohort	Cohort
64	27	15
23M	-	7M
41F		8F
46.0	53.0 test group 60.0 control group	-
21-71	28-87	30-55
148	27	30
3	12	3
7	60	6
		12
Periapical pathology Granulation tissue in the apical area of the tooth	Periapical pathologies periapical Radiolucencies > 1 mm Suppuration	Chronic periodontitis
Curettage	Curettage	Curettage
98.1% TG 98.2% CG	100%	100%
Amoxicillin 500mg x 3 per day for 10 days/Clindamycin 300mg x 2 per day for 10 days Etodolac 400 mg x 3 per day for 5 days Oxycodone/ acetaminophen 1 tab every 4-6 h. according to the need	Amoxicillin 750mg x3 per day for 5 days	Clindamycin 600mg hour before surgery Clindamycin 300mg x4 per day for 5 days Ibuprofen 600mg x2 per day for 7-10 days
-	Chlorhexidine 0.2% mouthwash	Extraoral ice packs for 2 h; Warm chlorhexidine 0.2% HCl mouthwash x2 per day for 7 days; Soft brush

In a double-blind, randomized clinical study, Crespi *et al.* divided subjects into two groups: group A, which included 30 teeth, received soft tissue debridement prior to implant placement; group B, which also included 30 teeth, received soft tissue debridement but with reactive soft tissue left in the apical lesion. Even though there were no statistically significant changes between basal bone levels and between groups, all fresh sockets in both groups showed buccal-palatal bone loss after one year [31]. A survival rate of 100% with a mean implant stability quotient of 65 and no statistically significant variations between groups ($p > 0.05$) were observed in group B. Three individuals in Group B provided edema and three noted discomfort at the implant location. There were no complaints of soreness or other discomforts in group A.

Khan Katyayan *et al*., disinfection protocol included 0.2% chlorhexidine rinsing, debridement of infected sockets using curettage, and rinsing with the physiologic solution. No pain, mobility, flap dehiscences, suppuration, or radiolucency around the implant was reported during follow-ups.

Every patient in the research by Al Nashar *et al*. got two implants near their lateral mandibular incisors. PRGFs were

used to treat one of the two implants (group I), leaving the other untreated and acting as a placebo. (group II). Every cohort received 15 immediate inserts. After meticulously removing any granulation or fibrous tissue from both groups' extraction sites, the areas were irrigated with sterile saline. Only at the test locations were the prepped PRGFs slowly and gently injected into the drill holes just prior to implant insertion. In addition, PRGFs were applied to the device before sitting.

Before insertion, all granulation tissues were removed by Jung R. E. and others. Fifteen of the 27 patients belonged to the control group, which had no periapical diseases, and 12 patients belonged to the test group, which had periapical pathologies. All patients underwent guided bone regeneration (GBR).

The objective of this comprehensive review was to evaluate the effectiveness of different disinfection protocols in assessing the survival rate of an immediate dental implant placement. The goal of immediate implantation surgery is to keep the hard and soft tissues as sturdy and favorable to achieving good stability and accurate three-dimensional placement of the implant as possible. Different surgical protocols are used to achieve this goal. Eini *et al*. claim that there are stringent requirements for instant loading that must be met to prevent non-osseointegration, including the right insertion force to achieve primary implant stability, the right implant length, and the lack of any systemic or local contraindications [32].

According to Crespi *et al*., the endo-periodontal origin of the infection and its association with the anaerobic bacteria typically contained in the infected root canal (Fusobacterium, Prevotella, Porphyromonas, Actinomyces, Streptococcus, and Peptostreptococcus) may both contribute to the high success rates of immediate implants placed in sockets with chronic illnesses [33, 34]. The ensuing changes in the anaerobic environment caused by socket extraction and curettage would result in the elimination of the associated endo-periodontal bacteria [33]. However, similar to the findings of other writers [17, 18, 21], our results suggest that immediate implants may be successfully placed into debrided infected dentoalveolar sockets under regulated circumstances.

According to the findings of this systematic review, the most essential factor for an implant to integrate with an infected site is meticulous curettage.

Some authors use additional measures for possible better disinfection and implantation outcome. Kakar *et al*. used an *in situ* hardening bone graft replacement to deal with peri-implant flaws for all patients. The socket was also prepared and decontaminated using an Er, Cr: YSGG laser unit (Waterlase MD, Biolase Technology, Irvine, CA) with an MZ-4 (14 mm) radial-firing point. The implant survival rate was 95.45%, and only 5 implants were removed and recorded as failures [17]. Chrcanovic *et al*. [35] pointed out that although laser treatment is viable for debriding infected sockets prior to implantation because of the visible reduction in bacteria reported by Kusek [36], the number of patients (n = 10) reported in the literature is small, whereas Kakar *et al*. [17] confirmed the effectiveness of laser treatment after conducting more extensive research (n = 68). Montoya-Salazar *et al*. also used laser as an additional measure. According to the protocol infected sites were irradiated with Er, Cr: YSGG laser in the test group. The survival rates of both groups were not significantly different (p = 0.720). One implant that failed in the treatment group was due to the patient's inadequate cleanliness and lack of cooperation [26]. The capacity of an Er, Cr: YSGG laser with a wavelength of 2780 nm to ablate compromised tissues with minimal thermal side effects and little to no damage to surrounding tissues led to its selection [37, 38]. This laser's high decontamination capability allows for a 98% decrease in dangerous germs, which reduces the wound healing time and the possibility of post-operative infections [39]. Er, Cr: YSGG lasers are the least excruciating because of their water/air mist, which also has a cooling and analgesic impact and lessens the sensation of tissue scorching and charring [40, 41]. The outcome of laser therapy is comparable to the documented success rates for immediate implantation in areas that are not infected [17, 42].

It is important to note that PRGF was only used in one research [28]. To effectively treat extracted sockets and lower the risk of infection, PRGF can be used in combination with immediate implantation. When fused with the bone, PRGF can function as an osteoconductive, autologous bone graft in the space between the implant surface and socket sides [43, 44]. In immediate implantations, platelet-derived growth factors may be used to successfully promote the regeneration of soft tissues and to lessen pain and inflammation [45, 46]. Al Nashar *et al*. study resulted in a 100% survival rate in both groups, where in group I the implants were treated with PRGFs, and in group II – not. Implant osseointegration was achieved in all cases. The results of the implants treated with PRGFs versus those not treated did not vary significantly [28]. However, Pal US *et al*. concluded that immediate implantation in compromised sockets with two doses of PRGF is a successful and superior rehabilitation option [47]. Moreover, Del Fabbro *et al*. investigated the result of immediate implants in fresh extraction sockets of teeth afflicted by periapical lesions utilizing PRGF as an adjuvant and found it to be a safe and effective rehabilitation therapy option [20].

Some of the authors used GBR with autologous bone or allograft, which may increase the implant's chances of osteointegration [29, 30]. Al Kudmani *et al*. concluded that hard and soft tissue proportions are preserved by a combination of buccal gap bone grafting and immediate implantation [48]. These advantages lead to the long-lasting durability of the implant. Using resorbable or non-resorbable membranes, Roland E. Jung *et al*. concluded that implants

inserted simultaneously with GBR provide a high survival rate varying from 91.9% to 92.6%, making it a safe and predictable procedure [49]. On the other hand, bone regeneration has a higher impact on lowering the chance of resorption, but has nothing to do with residual bacteria in the post-extraction site, but still may be used in infected sockets. In the posterior maxilla, chronic periapical lesions with a history of endodontic failure may be indicated to replace missing teeth with immediate implant insertion and guided bone regeneration, according to Hosam El Dein Said *et al*. [50].

It is important to note that various medicines used for prophylaxis or treatment after surgery might have a significant effect on the success of implantation. Prophylactic antibiotic therapy was used in 5 out of 7 of the articles included in this study, while post-operative antibiotic treatment was found to be prescribed in all of the articles. None of the included studies indicated the use of local antibiotic therapy during the procedure. In Passarelli *et al*. study, the comprehensive analysis did not show that local/topical antibiotics were better than mechanical debridement, scaling, root planning, or a placebo ointment. To minimize the overestimation of the true efficacy of local/topical antibiotics, only RCTs were included [51]. According to Romandini *et al*.'s meta-analysis, all antibiotic prophylactic regimens had a greater impact on lowering implant failures than a placebo or no antibiotics [52]. However, when used on its own, antibiotic prophylaxis failed to show a statistically significant positive outcome thus data should be interpreted with caution in this meta-analysis.

In individuals without penicillin allergies, amoxicillin was the most frequently recommended antibiotic, though one author used clindamycin [28]. 2-3 g of amoxicillin administered orally one hour before surgery greatly lowers implant failure [53]. Momand *et al*. study noted that in combination with implantation, antibiotic prophylaxis is likely of small benefit [54]. Antibiotic prophylaxis may improve, according to Zhurakivska *et al*., implant success and short-term survival rates [55]. However, a sub-analysis of the major trials reveals that antibiotic prophylaxis had little to no advantage in uncomplicated implantation in healthy patients [56]. Although, analyzed studies that didn't use pre-operative antibiotic treatment still had 98,1-98,2% [30] and 100% [29] success rates. Post-operative antibiotics are useful to prevent postoperative infections following implant placement [57].

In 5 of the 7 studies, chlorhexidine mouthwash 0.12-0.2% was included in postoperative treatment. After a surgical procedure such as immediate implant placement, mechanical means of plaque control are limited, so antimicrobial strategies are often used. CHX has been shown to penetrate biofilms, alter biofilm formation, or have a direct bactericidal effect [58, 59]. Chlorhexidine, however, changes the surface topography of dental implants and causes cell cytotoxicity, which can obstruct re-osseointegration and even result in dental implant failure. As a result, its use during implant insertion is still debatable. [60, 61].

Conclusion

Analysis of the studies shows that a variety of measures can be used to increase the possibility of implant integration, but without careful curettage of the alveolus, additional disinfection methods are ineffective. Both pre and post-operative antibiotic treatment is essential for predictable implant survival rate results in immediate implantations, whereas the use of local antibiotics usage are neither necessary nor effective to improve the implant survival rate. A great alternative would be irradiations with Er, Cr: YSGG laser due to its water/air mist, which effectively removes debris in infected alveoli and has minimal risk of overheating of the bone due to its water/air spray cooling features. PRGF has osteoconductive properties and accelerates the healing of the alveoli and integration of the implant. Therefore it is a great tool to increase the survival rate of immediate implantations in compromised sockets. No trustworthy comparisons between disinfection methods could be made due to a dearth of data and the current variability between studies. To determine the optimal instant insertion procedure in infected sockets, more thorough, uniform clinical studies are required.

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