Dental Implant Success and Endodontic Condition of Adjacent Teeth: A Systematic Review

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Purpose: Placement of dental implants adjacent to teeth with inflammation, such as periapical lesions, may have implications on the implant prognosis. The aim of this study was to systematically collect the available evidence regarding the influence of endodontic status of adjacent teeth on dental implant prognosis. **Materials and Methods:** A systematic electronic search was conducted using the MEDLINE (PubMed), Embase, EBSCO, CINHAL, COCHRANE, and SCOPUS databases in August 2019. The search was further supplemented with a hand-search citation mining process. All types of studies that addressed the endodontic condition of the adjacent tooth and evaluated dental implant success or survival were analyzed and evaluated according to the PRISMA and NOS guidelines. **Results:** Overall, seven human studies were included in the final analysis. Those included a total of 1,914 implants placed adjacent to teeth with periapical lesions or root canal treatments. Four studies included implants placed adjacent to teeth with periapical lesions (1,634 implants), and three studies included implants placed adjacent to teeth with root canal treatments (280 implants). Lower success rates of dental implants placed adjacent to teeth with periapical lesions or to endodontically treated teeth were reported; however, the results were inconsistent. **Conclusion:** There is some evidence to support an association between the endodontic condition of the adjacent tooth and the success of dental implants, but it is not enough to support a causative relationship. Nevertheless, clinicians should treat any active sources of infection and inflammation in adjacent teeth prior to insertion of dental implants. *Int J Oral Maxillofac Implants 2020;35:e91–e97. doi: 10.11607/jomi.8311*

Keywords: bacteria, bone loss, complications, inflammation, prognosis, survival

Placement of a dental implant adjacent to a tooth with inflammation, in the form of a periapical lesion, brings up several future considerations. First, if the periapical lesion in the adjacent tooth increases in size, the bone support of the adjacent implant might be compromised due to their physical proximity. Second, a potential future surgical intervention (in cases of persistent periapical lesions that do not heal after an ortho-grade endodontic treatment) may also reduce the bone supporting the implant. Finally, and maybe most important, a question arises regarding the potential influence of the infection and inflammation originating in the adjacent tooth on the prognosis of the implant, as seen in periodontal diseases.[1]

Periodontal inflammation was reported to be a significant risk factor for implant failures.[1] In a systematic review, it was reported that adjacent inflammation from other sources, such as periodontal disease, lowers the success rate of dental implants.[2] Several other systematic reviews investigated immediate implantation into extraction sites with periapical lesions, and the relationship seems controversial.[3–10] However, to the authors' best knowledge, none addressed systematically the influence of periapical lesions in adjacent teeth on the prognosis of dental implants. The results of such a systematic review can be used by dental care providers in the process of decision-making regarding implant placement in areas with periapical lesion proximity.

Therefore, the aim of the present study was to systematically collect, critically review, analyze, and evaluate the quality of the available evidence regarding the association between the prognosis of dental implants and the endodontic status of the adjacent teeth.

MATERIALS AND METHODS

Eligibility

The participants, (interventions) exposures, comparisons, outcomes, and study designs (PICOS) were predetermined in order to specifically address and achieve the aforementioned aims and objectives,[11–13] as shown in Table 1. The following PICOS question was formulated: "Is there an association between success/survival of dental implants and the endodontic condition of the adjacent teeth?"

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Table 1 PICOS: Inclusion and Exclusion Criteria

PICOS criteria	Definition
Population	Human with dental implants, without age restriction.
(Intervention)/ Exposure	Subjects diagnosed with a radiolucent periapical lesion in a tooth adjacent to the dental implant. Radiographic diagnosis of a periapical lesion included periapical radiographs, panoramic radiographs, or computed tomography. Only studies addressing endodontic pathology in an adjacent tooth to an implant were included, and studies that did not mention the endodontic status of the adjacent teeth to an implant were excluded. *Studies assessing the presence of apical periodontitis based on the presence of a root canal treatment were included.
Comparison	Subjects with no periapical lesions and no root canal treatment in the teeth adjacent to implants.
Outcome	Implant success Implant survival

Databases

An electronic search using the MEDLINE (PubMed), Embase, EBSCO, CINHAL, COCHRANE, and SCOPUS was performed. This search was further supplemented with a hand-search citation mining process.

Search Strategy

The search strategy was developed and conducted with an experienced reference librarian at the University of Alberta. Medical Subject Headings (MeSH) were included in the PubMed strategy. A search was conducted to identify all types of studies, from earliest available date until August 12, 2019, that reported on the relationship between the endodontic condition of the adjacent teeth and prognosis of dental implants with no language limit applied. The search strategy was assembled from synonyms for apical pathosis and dental implant successes/survival and conducted to identify all the available literature.

The search strategy in Ovid MEDLINE is presented as an example:

1. exp Periapical Diseases/
2. ((((tooth or teeth) adj3 (root* or apex* or apices)) or apical* or periapical* or peri-apical* or radicular* or periradicular or peri-radicular) adj3 (disease* or periodontitis or abscess* or granuloma* or lesion* or cyst* or infect* or inflamm* or patholog* or pathosis*)).mp.
3. 1 or 2
4. Dental Implants/
5. exp Dental Implantation/
6. ((dent* or oral* or tooth or teeth) and Implant*).mp.
7. Dental Prosthesis, Implant-Supported/
8. 4 or 5 or 6 or 7
9. 3 and 8

Titles and abstracts of the studies selected in the preliminary analysis were scanned, and potentially qualifying studies were identified by two independent examiners (Y.B.B., L.L.). These studies received full-text assessment with respect to the inclusion and exclusion criteria (Table 1). Next, for the qualitative assessment part of this review, the studies were systematically selected according to strict criteria, using the PICOS inquiries, as detailed in Table 1.

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) standard for reporting systematic reviews was followed.[11] Any disagreement between the examiners was resolved by discussion until agreement was reached.

Data Management

RefWorks reference manager (ProQuest, RefWorks, LLC) was used for record and data management throughout the review. Duplicates were identified and discarded.

Data Collection

The relevant studies were subjected to a comprehensive text evaluation, including data extraction and methodologic quality analysis. The following information was collected for each included study: names of the authors, year of publication, study design, total number of implants adjacent to teeth with periapical lesions or root canal treatments, follow-up period, definition of pathology/failure/success, control for confounders, evaluation methods, main results (survival rate, success rate, failure rate), and study limitations. To evaluate the association between the prognosis of dental implants and the endodontic status of adjacent teeth, the success/failure rates of the implants were defined as the "outcome."

Quality Assessment and Level of Evidence

The quality of each study was rated independently, based on established criteria according to the Newcastle-Ottawa Scale (NOS) for "assessing the quality of nonrandomized studies in meta-analysis,"[14] and a consensus was reached.

RESULTS

Search Results

Figure 1 depicts the PRISMA flowchart of the search results.[11–13] Overall, there were seven studies, which fulfilled the predetermined inclusion criteria; all were retrospective cohort studies in human subjects.[15–21]

Results of Individual Studies

The included individual studies are described in Table 2. Four out of the seven studies addressed implants placed adjacent to teeth with periapical lesions and included a total of 1,634 implants.[18–21] The other three studies addressed implants placed adjacent to teeth with root canal treatments (regardless of the periapical status or presence of periapical lesions) and included 280 implants.[15–17]

Adjacent Teeth with Periapical Lesions

Only one of the four included studies performed statistical analysis to evaluate the strength of a potential association between success/failure of implants and presence of a periapical lesion in an adjacent tooth.[19] Lefever et al found that 25% of the implants that were placed adjacent to a tooth with a periapical lesion presented apical peri-implantitis (OR = 8, P = .01). This study addressed only a specific type of implant failure, apical peri-implantitis.[19]

Quirynen et al reported that failed implants, in the maxilla, had five times higher prevalence of a periapical lesion in an adjacent tooth; however, no statistical analysis was applied to determine the significance of this finding.[21]

The study by Bell et al, aiming to compare influence of a periapical lesion in the extraction socket on the prognosis of the dental implants, included a subgroup of implants (n = 51) that were placed adjacent to teeth with a periapical lesion.[18] For this group, a 92% success rate was reported (follow-up periods between 3 and 93 months). Although no statistical analysis was applied, this percentage was lower than the overall success rate in this study, which was between 97.5% and 98.7%. Additionally, implants in that subgroup, placed in sockets with periapical lesions adjacent to retained teeth with periapical lesions, had a significantly lower success rate compared to implants placed in sockets without a periapical lesion adjacent to teeth with periapical lesions (81% vs 100%).[18]

Finally, López-Martínez et al reported on pooled percentage (data on the presence of periapical lesions in an adjacent tooth combined with data on the presence of periapical lesions in the extraction site) and found that 25% of the failed implants presented endodontic failure prior and/or adjacent to the placement of the implant.[20]
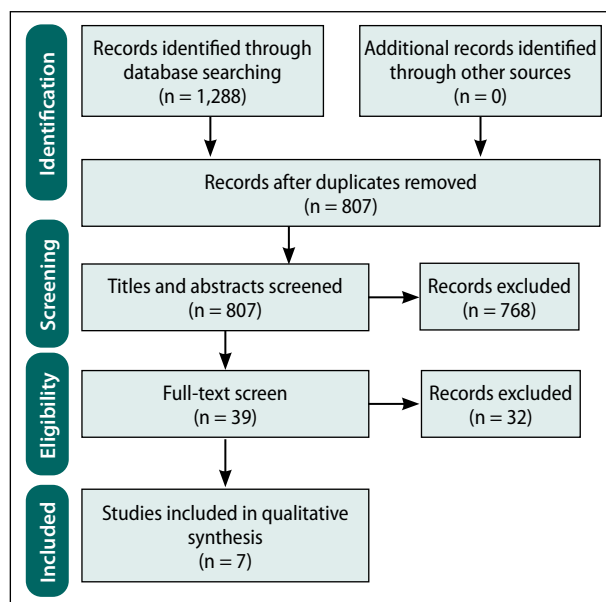

Fig 1 PRISMA flowchart of the search results.

Adjacent Teeth with Root Canal Treatments

As was mentioned earlier, these three studies evaluated the relationship between the presence of root canal treatments (regardless of the periapical status or presence of periapical lesions) in teeth adjacent to the dental implant and prognosis of dental implants. Laird et al found that implants placed adjacent to teeth with a root canal treatment had significantly lower success rates compared to implants placed adjacent to teeth without a root canal treatment (85% vs 98.4%; P = .025), without a difference in the survival rate.[15] However, Doyle et al reported that the presence of adjacent endodontically treated teeth was not associated with the outcomes of implant treatment.[16] Finally, Zhou et al found that 7.8% of the implants placed adjacent to teeth that had a root canal treatment performed at least 1 week before the dental implant was placed had apical peri-implantitis.[17] Also, higher incidence of apical peri-implantitis was found if the root canal treatment was completed within 4 weeks before implant insertion (P < .05). Furthermore, smaller distances (< 2 mm) between the implant and the adjacent root-canalled tooth yielded a significantly higher incidence of apical peri-implantitis. The overall success rate of these implants was 96%. It should be noted that the follow-up period was only 2 to 3 months.[17]

Quantitative Synthesis and Meta-analysis

There was considerable heterogeneity among the included studies in terms of their evaluation methods, apical status of adjacent teeth (detection of periapical lesions, presence of root canal treatments), definition of

Table 2 Characteristics of the Included Studies

Study (year)	Study design	Outcome definition (implants)	Outcome main results (implants)	Other data collected/ confounders mentioned	Study limitation
Quirynen et al (2005)[21]	Retrospective cohort Human N = 539 implants Radiographic method not specified (PA are shown)	Failure (one of): Mobility Radiographic evidence of RL around the implant Complaints of pain	Failed implants characterized > 5 times higher incidence of PALs in the adjacent teeth (only in maxilla). No statistical tests.	Location of implant. Periodontal disease History of diabetes History of smoking	Follow-up period is unknown. Temporality is unknown (when PAL appeared). No statistical tests applied. No consistency of radiographic evaluation method.
Doyle et al (2007)[16]	Retrospective Human N = 32 implants adjacent to tooth with RCT and N = 164 without FU: 12 mo Radiographs (type not specified)	Failure (OR): Removed Planned for removal Survivor (all): Present Success (all): Present Functional No peri-implant radiolucency No implant mobility	The presence of adjacent endodontically treated teeth was not associated with the outcomes of implant treatment (P = .42).	Smoking Diabetes Sex Ages	RCT is not necessarily a PAL. No specification of the radiographic method used.
Laird et al (2008)[15]	Retrospective Human N = 233 implants total N = 20 implants adjacent to RCTs FU: 9–70 mo, average 37 mo Radiographs (type not specified) (PA/panoramic are shown)	Failure (one of): Removed Required surgical intervention Survivor: Functional Success: All remaining	Survival: No adjacent teeth: 92.2% No RCTs in adjacent teeth: 99.2% RCT in adjacent teeth: 95% Nonsignificant difference. Success: No adjacent teeth: 92.2% No RCTs in adjacent teeth: 98.4%* RCT in adjacent teeth-85%*	Location of implant Quality of endodontic obturation Periodontal disease History of diabetes History of smoking	Age and sex are not mentioned. No specification of the radiographic method used. RCT is not necessarily a PAL. Variability in follow-up periods.
Zhou et al (2009)[17]	Retrospective Human N = 128 implants adjacent to RCTs FU: 1 and 3 mo 2D radiographs (PA) Implants inserted adjacent to teeth that had a RCT at least 1 week before	Retrograde peri-implantitis (API) Criteria not given Success: N/A	API: 7.8% Success: 96.1% The multiple logistic regression analysis revealed a higher incidence of API if the RCT was completed within 4 weeks before implant insertion (P < .05). Shorter distances (< 2 mm) yielded a significantly higher incidence of API.	Smoking excluded Bruxism excluded	RCT is not necessarily a PAL. Success/API criteria are not defined. No control group. Only API evaluated (not other failures of implants). Short follow-up time.

2D = two-dimensional; adj = adjacent; API = apical peri-implantitis; FU = follow-up period; mo = months; N = number; N/A = not applicable; OR = odds ratio; PA = periapical; PAI score = periapical index score; PAL = periapical lesion; RCT = root canal treatment; RL = radiolucency; y = years. *Significant difference between the last two groups (P = .025).

implant success/failure, and follow-up periods (Table 2); therefore, quantitative synthesis was not appropriate, and a meta-analysis was not attempted.

Quality Assessment According to the NOS Criteria

The quantitative value of the quality of evidence in the included human studies, based on the NOS, is presented in Table 3. The included studies were awarded between 5 and 7 stars, out of a maximum 9 stars. When a study controlled for periodontal disease and smoking (confounding risk factors for peri-implantitis), it was awarded with one star for each (maximum of two stars) for the comparability criterion. The only two studies that fulfilled this were Quirynen et al and Laird et al.[15,21] The "Outcome" criterion, adequacy of follow-up of cohorts, was not applicable in all of the included studies, since the included cases were based on the availability of good radiographs. This can imply a selection bias.

Table 2 Characteristics of the Included Studies *(continued)*

Study (year)	Study design	Outcome definition (implants)	Outcome main results (implants)	Other data collected/ confounders mentioned	Study limitation
Bell et al (2011)[18]	Retrospective Human N = 51 implants FU: 3–93 mo, average 19.75 mo 2D or 3D radiographs (panoramic/CT)	Success: Successful osseointegration Successful restoration Absence of bone loss Absence of peri-implantitis	Success: 92% (4 failures out of 51) Implants placed in sockets with PALs adjacent to retained teeth with PALs had a significantly higher failure rate (19% vs 0%) compared with implants placed in sockets without a PAL, adjacent to teeth with PALS.	Age Sex Smoking Diabetes Bisphosphonate PAL of adjacent teeth Implant stability at the time of placement	No consistency of radiographic evaluation method. All implants were placed adjacent to a tooth with a PAL. However, some were placed into sites with (n = 20)/without (n = 30) PALs. Variable follow-up periods.
Lefever et al (2013)[19]	Retrospective Human N = 244 implants FU: > 6 mo For teeth: 2D radiographs (PA/panoramic) For implants: 2D (PA)	Apical peri-implantitis/(API): Apical radiolucency on an intraoral radiograph	The influence of the adjacent teeth, in case the extracted tooth showed neither a pathology nor an endodontic treatment: No RCT/no PAL in adjacent tooth: 1.2% RCT/no PAL in adjacent tooth: 0% PAL in adjacent tooth: 25% (API (OR 8.0, P = .01)	N/A	No consistency of radiographic evaluation method for PALs. No control for confounders mentioned. Variability in follow-up periods. Only percentage of API is given, no information about other failures of implants.
López-Martínez (2015)[20]	Retrospective Human N = 800 implants FU: ≥ 5 y For teeth: 2D or 3D radiographs (PA/panoramic/CT) For implants: 2D radiographs (PA)	Failure: Removed Not counted: Implant that has not failed but thas not been possible to evaluate for some reason Survivor: All the remaining implants Success: N/A	No data are provided regarding success rate of implants placed adjacent to teeth with PAL. Failure: Out of 800 implants, 200 (25%) were removed due to a prior PAL in the extraction socket or on adjacent tooth. Survival: 75%	N/A	No information about adjacent teeth separately. No consistency with the radiographic evaluation method. No control for confounders is mentioned. No consistency of radiographic evaluation method for PALs

2D = two-dimensional; adj = adjacent; API = apical peri-implantitis; FU = follow-up period; mo = months; N = number; N/A = not applicable; OR = odds ratio; PA = periapical; PAI score = periapical index score; PAL = periapical lesion; RCT = root canal treatment; RL = radiolucency; y = years. *Significant difference between the last two groups (P = .025).

DISCUSSION

This systematic review aimed to address the relationship between the success and survival of dental implants and the endodontic status of the adjacent teeth. Overall, there is some evidence for lower success and survival rates of implants placed adjacent to endodontically treated teeth or teeth with periapical lesions; however, the results are inconsistent. Currently, there is not enough evidence for a causative association between prognosis of dental implants and the endodontic status of the adjacent teeth based on the criteria of strength of association, consistency, specificity, temporality, and biologic gradient, as described next.[22]

Strength of Association

Only one study presented OR and found a significantly higher prevalence of apical peri-implantitis when implants were placed adjacent to a tooth with a periapical lesion (OR = 8, P = .01).[19]

Consistency

There is some evidence for lower success/failure of implants placed adjacent to endodontically treated teeth or teeth with periapical lesions; however, the results are inconsistent. Some studies found significant differences in the success rate of the dental implants,[15,19] and others either did not find significant differences[16,23] or statistical tests were not applied.[17,18,21] Looking at

Table 3 Methodologic Quality Assessment of Human Cohort Studies According to NOS Criteria[14] (N = 7)

NOS criteria	Quirynen et al[21]	Doyle et al[16]	Laird et al[15]	Zhou et al[17]	Bell et al[18]	Lefever et al[19]	López-Martínez et al[20]
Selection							
1) Representativeness of the exposed cohort	★	★	★	★	★	★	★
2) Selection of the non-exposed cohort	★	★	★	X	★	★	★
3) Ascertainment of exposure	★	★	★	★	★	★	★
4) Demonstration that outcome of interest was not present at start of study	★	★	★	★	★	★	★
Comparability							
1) Comparability of cohorts on the basis of the design or analysis[a]	★★	★	★★	★	★	X	X
Outcome							
1) Assessment of outcome	★	★	★	★	★	★	★
2) Was follow-up long enough for outcomes to occur?	X	★	X	X	X	X	★
3) Adequacy of follow-up of cohorts	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Total awarded stars (out of maximum 9)	7	7	7	5	6	5	6

A study can be awarded a maximum of one star for each numbered item within the Selection and Outcome categories. [a]A maximum of two stars can be given for Comparability.

endodontically treated teeth as a group, without addressing the apical status (inflammation vs no inflammation), may explain the conflicting results. Zhou et al found that API was present in 7.8% of the implants that were placed adjacent to endodontically treated teeth.[17] This percentage is higher compared with the previously reported prevalence of API, 0.26% to 2.7%.[21,24]

Specificity

Failure of implants cannot be directly attributed to presence of a periapical lesion in an adjacent tooth since the success of implants depends on multifactorial factors related to the patient, operator, and implant, including smoking, sex, edentulism, implant diameter, and bone augmentations.[25,26] Due to the common risk factors for periapical lesions and peri-implantitis, their independent higher presences in the same subject cannot be ruled out.

Animal studies allow control of multiple confounders that exist in human studies. Shabahang et al, in a prospective controlled study in dogs, found that there was no difference in the success/failure rates between implants placed adjacent to a periapical lesion or adjacent to a healthy tooth in a short-term follow-up.[23]

Therefore, it is highly important to control for common risk factors such as periodontal disease and smoking, which are known to reduce the prognosis of dental implants.[2,26] Control for risk factors was reflected in the quality assessment of the study (Table 3).

Temporality

In the studies included in this review, although periapical lesions were present at the time of implant insertion in the human studies that compared adjacent teeth with periapical lesions to adjacent teeth without periapical lesions,[18–21] the periapical lesion might have been present for different periods of time in each patient, which may potentially have an influence on the prognosis of the dental implant.

Biologic Gradient

No studies addressed the relationship between the amounts of inflammation associated with the adjacent tooth to the prognosis of the dental implant.

The method used for radiographic evaluation of periapical lesions or peri-implantitis may have a critical influence on the study results.[27,28]

The subjects compared in the included human studies were based on the availability of radiographs (preoperative radiograph that shows the periapical area of an adjacent tooth to an implant, as well as a follow-up radiograph that shows the same area). It is important to note that in this method of case selection, some successful implant cases with presence of periapical lesions in adjacent teeth might have been overlooked and not included in the evaluation. This would result in a selection bias toward enlarging the group of failed implants, which are placed next to teeth with periapical lesions.

The major limitation of this review is the fact that a meta-analysis could not be performed due to heterogeneity among the studies. Methods of definition and assessment for the endodontic status of adjacent teeth and for implant success varied among studies. More controlled studies are needed to understand the influence of the endodontic status of adjacent teeth on the prognosis of implants. Future research should be directed toward large cohort studies with long-term follow-up, better control of confounders, addressing dynamics of the endodontic status of the adjacent teeth (healing process vs active disease), and differentiation between early and late implant failure.

Since the cumulative evidence might suggest an association between the endodontic status of the adjacent teeth and the success and survival rates of the dental implant, a comprehensive examination for every implant candidate would be extremely important. This should include a thorough periodontal examination (and treatment if needed) as well as detection of potential apical lesions in the entire dentition.

CONCLUSIONS

There is some evidence for an association between the endodontic status of the adjacent teeth and the success and survival rates of the dental implant; however, the findings are not consistent and might be subjected to bias. Nevertheless, clinicians should treat any active sources of infection and inflammation in adjacent teeth prior to insertion of dental implants.

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