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Review article

Dental Assessment Prior to Orthopedic Surgery: A Systematic Review

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Abstract

Background:

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To reduce the risk of infection after orthopedic surgery, patients are asked to undergo preoperative assessments in various medical domains. However, to our knowledge, there has been no systematic review to evaluate the performance of a preoperative dental assessment before orthopedic surgery. We focus on two questions as follows: 1) is there a link between the presence of preoperative dental assessment and orthopedic infections; 2) is the probability of an orthopedic infection increased in the presence of dental risk factors and co-morbidities?

Patients and Methods:

Databases including PubMed, the Cochrane Library databases and Google Scholar were searched for English-language articles until November 2018. Inclusion criteria were descriptions of infections of joint prostheses and dental infections, and potential dental origins of pathogenic infections. Studies dealing with oral assessments performed before orthopedic surgery were included.

Results:

Based on eligibility criteria, 12 case series, 4 case-control studies and 12 cohort studies were included. In case-controls, prosthesis infection was presumably associated with a dental abscess in 6/224 of cases (2.9%). In cohort studies, exposure was defined as "any dental assessment or dental treatment performed before surgery". Even if only 4 cohort studies provide this information exposure, it would seem that the presence of an infectious complication is less frequent if the preoperative examination has been performed. Dental treatment given before surgery was mainly for scaling–polishing in 78/205 (38%), extraction in 49/205 of cases (24%) and restorative work in 37/205 (18%).

Discussion:

The literature review was made complex by the substantial heterogeneity among included studies. Although there is no formal evidence for or against preoperative dental assessment, it

is advisable to perform this with the aim of maintaining favorable oral hygiene and thus reduce the risk factors.

Level of evidence: Level III, systematic review

Keywords: dental infections; periprosthetic joint infections; preoperative dental assessment.

1. Introduction

Periprosthetic joint infection (PJI) is the most devastating burden for patients after total joint replacement [1]. The incidence of PJI varies from 0.8 to 1.9% after a primary total-knee replacement [2-4] and from 0.3 to 1.7% after total hip replacements [4-8]. Several risk factors for PJI are reported in the literature. Patient-related factors include previous revision arthroplasty or previous infection associated with a prosthetic joint at the same site, tobacco abuse, obesity, rheumatoid arthritis, neoplasm, immunosuppression and diabetes mellitus [9-12]. Postoperative risk factors include wound-healing complications (e.g., superficial infection, hematoma delayed healing, wound necrosis and dehiscence), atrial fibrillation, myocardial infarction, urinary-tract infection, prolonged hospital stay and *Staphylococcus aureus* bacteremia [2-5, 9-19]. With the aim of reducing the risk of infection after orthopedic surgery, patients are asked to undergo preoperative assessments in various medical domains. A search for infections at remote sites is also recommended as bacteremia associated with acute oral, skin, respiratory, gastrointestinal and urogenital infections are known to cause implant infections [20–22].

Focal infections of oral origin may be defined as infections occurring in various tissues or organs of the body and being caused by microorganisms (or their products) present in the oral cavity [23]. The incidence of focal infections of dental origin is reported to be in the range of 0.03 to 0.04% [24,25]. Bacteremia is the best-known type of focal infection and may occur spontaneously (from tooth brushing, mastication) or be caused by dental treatment (e.g. scaling, endodontic treatment, extraction) [26,27], which raises the question of whether or not to prescribe antibioprophylaxis before dental treatment [28-30]. Currently, antibiotic prophylaxis in oro-dental surgery is advised against [29-31]. Indeed, the associated costs and risks are disproportional to efficacy [29]. However, in the preoperative period, the orthopedic surgeon usually asks the dentist for a certificate declaring that all the patient's potential dental

infection sites have been checked and cleared. The question of how dental care should be managed for candidates for joint replacement remains unclear.

We aimed to systematically review and synthesize all the literature regarding the performance of a preoperative dental assessment before orthopedic surgery is undertaken. The aim of this literature review was to answer the following two questions: 1) Is there a link between the presence of preoperative dental assessment and orthopedic infections? 2) Is the probability of an orthopedic infection increased in the presence of dental risk factors and co-morbidities?

2. Search Strategy and Criteria

2.1 Data sources and searches

We followed the PRISMA guidelines to plan and conduct this systematic review [32]. Ethical approval for this study was deemed unnecessary because it was a systematic review the existing literature and did not involve the handling of any individual patient data.

Literature searches for English-language articles until November 2018 were carried out using PubMed, the Cochrane Library databases and Google Scholar. No limits were placed on publication dates. The search strategy was as follows: [“odontology” OR “dental infection” OR “sites of infection” OR “dental assessment”] AND [“infection of joint prosthesis” OR “hematogenous infection” OR “dental focal infection” OR “joint prosthesis”]. For each of the keywords, we also used MeSH descriptors. A manual search completed the search of electronic databases and was intended to find any additional studies from the bibliographic references in each relevant article.

2.2 Study selection

A first selection was made on the basis of the titles and abstracts of studies found in our search (Figure 1). The inclusion criteria for selecting articles were:

1) Studies dealing with oral assessments performed before orthopedic surgery;

2) Studies where the pathogens found could have been of dental origin, if reported; and

3) Studies describing infections of joint prostheses and dental infections.

Once the full articles had been retrieved, we excluded all those dealing with the following:

1) Hematogenous infections caused by dental treatment without assessment of joint prostheses. Studies that described bacteremia caused by dental treatment through extractions and periodontal treatment. However, to evaluate the relationship between dental infections and PJI, we focused on only dental infections introduced before orthopedic surgery.

2) Superficial wound infections, since infections that occurred immediately following surgery involved subcutaneous tissue, whereas PJI caused by dental infections were hematogenous.

3) Editorials and recommendations.

4) Studies where the follow-up was not continued until an infection first appeared (i.e. follow-up ceased as soon as the prosthesis had been placed).

2.3 Data extraction

Two authors independently (SB and JNV) scanned the titles and abstracts of potential articles. The full text was further screened and a final decision on its relevance was made. The following data were extracted from the articles: type of study (i.e. clinical trial, case series, case-control, cohort or cross-sectional), number of participants, age and gender ratio, type of prosthesis placed, whether a preoperative dental assessment was performed, pathogens involved (if provided), site of suspected oral infection, associated comorbidities.

2.4. Quality assessment

We performed a quality assessment of each study, using the Newcastle-Ottawa scale (NOS) for cohort and case-control studies [33].

3. Results

3.1 Search results

A total of 84 articles were selected from the databases, 28 of which were eligible for this review (Figure 1). Twelve articles were case series, four were case-control studies, and 12 were cohort studies. None of the clinical trials included focused on specific dental assessment or treatment on the occurrence of PJI.

3.2 Preoperative dental assessment

In case series articles, only one had provided preoperative dental assessment. For all, the remote sites implicated were cases of periodontitis in 8/29 (27%), periapical lesions or dental abscesses in 8/29 (27%), dental treatment in 6/29 (20%), tooth decay in 3/29 (10%), whereas 4/29 (10%) were unknown and 2/29 (7%) were not documented. It was not known if dental-infection sites had been identified preoperatively in any of the cases, nor was it known how long the patients had periodontitis or periapical lesions (Table 1). Infections found were hematogenous, with a mean delay of 32.9 months between insertion of the prosthesis and the first appearance of signs of infection (range, 3 to 111 months). In case-control studies, cases were defined as patients with clinical evidence of PJI and controls were patients without evidence of PJI (Table 2). Only 1 case-control study reported preoperative dental assessment. For all case-control studies, infection of the prosthesis was associated with a dental abscess in 6/224 of cases (2.9%). In cohort studies, we considered that exposure had to be defined as "any dental assessment or dental treatment performed before surgery" (Table 3). Dental assessments mainly concerned periodontitis and dental abscesses. Only 4 cohort studies had provided the information exposure, According to the data from the 12 cohort studies, dental treatment given before surgery was for extraction in 49/205 of cases (24%), scaling–polishing in 78/205 (38%), restorative work in 37/205 (18%), crowns in 6/205 (2.9%), and scaling and root planning for apical periodontitis or endodontic treatment in 2/205 (0.9%).

3.3 Presence of dental risk factors and co-morbidities

In case series articles, patients having at least one associated comorbidity made up 17/29 (59%) of our series (Table 1). In case-control studies, the risk factors associated with joint-prosthesis infections were immunodeficiency, malnutrition, obesity, diabetes, tobacco and alcohol, renal insufficiency, presence of remote infections, and previous surgical intervention at the site. Regarding the surgical procedure, the duration of surgery was considered a risk factor. For joint pathologies, more cases of rheumatoid arthritis were found in infected patients. In cohort studies, risk factors most often retrieved were a previous intervention at the surgical site, rheumatoid arthritis, diabetes, alcohol, obesity and the presence of associated comorbidities.

3.4 Quality Assessment

Tables 4 and 5 show the results of the study quality assessment. Quality assessment was performed according to the objective of the systematic review, and does not reflect the internal validity of each specific study. Overall quality of the studies was poor. Among the studies included, one was NOS score 5, four were NOS score 4, ten were NOS score 3 and one was NOS score 2. No study was found for which the main purpose was to assess the association between a pre-operative dental encounter and the occurrence of PJI.

4. Discussion

The literature was reviewed to evaluate the relevance of a dental checkup before orthopedic surgery. However, as this preoperative dental examination is still performed, we think it is important to show this difficulty in highlighting scientific arguments. To our knowledge, the present study is the first review of this subject.

As far as the limitations of this work are concerned, they stemmed from the fact that we did not find any studies initially designed to answer the question “Is there a proven link between orthopaedic infections and the presence of preoperative dental pathologies?”. In fact,

most of studies included dealt with related questions (“Do the bacteria responsible for orthopedic infections originate in the mouth?”, “Is there an association between orthopedic infections and oral health before or after the orthopedic surgery?” or “What is the delay between an oral problem being found and an orthopedic infection occurring?” The literature review was made complex by the substantial heterogeneity among included studies. Initial results did not make it possible to draw definite conclusions on the relationship between preoperative dental assessment and joint infections. For all studies, preoperative dental assessment is generally not documented and, if it was present, mainly concerned periodontitis and dental abscesses. Although the cohort studies revealed a slightly smaller proportion of joint infections in patients where the preoperative oral assessment was carried out, this result is difficult to confirm as very few works stated whether assessment was performed or not. Considering the heterogeneity of the studies, the small number of patients in the studies and the lack of information on conducting a preoperative dental assessment, we can’t affirm that a preoperative dental examination is necessary or not. To answer the question of the necessity for preoperative assessment, more demographic data are required that may be used to compare patients for whom surgery is planned in advance and preoperative assessment is performed, and patients that receive emergency treatment where assessment cannot take place. Lampley et al. [54] reported a good example and suggested that preoperative dental assessment should be reassessed. A study of the economic impact of systematically performing a dental checkup would also be of interest.

This review reports that patients who presented with more than one associated comorbidity were at greater risk of developing an infection in an orthopedic prosthesis [60]. Tokarski et al. [61] reported that preoperative assessment was more likely to reveal dental infections that precluded joint-replacement surgery in patients who had risk factors than in those with no risk factors. However, this study lacked the advantage of hindsight on the

incidence of infections, as the follow-up period ended immediately after placement of the prosthesis. Interestingly, the authors showed a relationship between quality of oral health and quality of life. Thus, it is important to reduce the number of risk factors, a requirement that includes the need to have a healthy mouth [61]. Numerous studies have suggested links between diabetes and periodontal diseases, or between poor dental hygiene and cardiovascular diseases [62]. It is important to re-establish a good-quality oral environment in order to improve quality of life and, thus, to reduce the risk factors for developing a periprosthetic joint infection. Although there is no formal evidence for or against preoperative dental assessment, it is advisable to perform this with the aim of maintaining favorable oral hygiene and thus reduce the risk factors.

In order to guide dental surgery and to carry out a preoperative dental check-up, we could develop the recommendations for preventing heart disease. Most recent recommendations advocate for more restorative treatments, depending on a patient's risk factors and the period between dental assessment and surgery [63]. For urgent surgery (within 1 week), the elimination of active infectious sites is recommended. However, for elective surgery, recommendations have evolved and dental surgeons now have a preventive role. Active infectious sites should be eliminated but we also need to consider alternative treatments, like periodontitis management with non-surgical therapy, restorative dentistry and endodontic therapy for teeth with non-symptomatic apical periodontitis, pulpitis or pulp necrosis, or even treatment of deep caries on molars [63]. The most important aspect is that these recommendations strongly suggest close collaboration between odontologists, cardiologists and cardiac surgeons to evaluate dental health, to determine follow-up protocols and the treatments needed for patients with cardiac disease. While waiting for further studies on preoperative dental assessments, dental surgeons can implement the recommendations for cardiac disease [63,64].

5. Conclusion

Despite the lack of direct evidence of the link between dental infection and joint infection, it is nevertheless useful to maintain good oral health in the general population and to reduce the presence of risk factors that may reduce quality of life. An interesting perspective would be to study the incidence of periprosthetic infections in a group where preoperative assessment was carried out and details were recorded on the number of remaining teeth, their value, and the time between this assessment and the placement of prosthesis.

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Conflict of Interest: Dr. Reina reports personal fees from BBraun, personal fees from Stryker, personal fees from Zimmer, outside the submitted work and Dr. Vergnes reports personal fees from BBraun, personal fees from Sanofi Aventis France, Lilly France SAS and Pfizer SAS, outside the submitted work. The other authors declare that they have no competing interest.

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Authors' contribution:

S Barrere, N Reina, D Maret: writing, re-reading ; O A Peters, L Rapp, JN Vergnes: re-reading

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Figure legend

Fig 1: Flowchart of literature screening

Table 1: Case Series Articles

Author/ Publication	Number of cases	Age/ gender	Comorbidities/ risk factors	Type and date of prosthesis	Antibioprophylaxis	Preoperative dental assessment	Time to onset	Type of infection	Dental infected site
Sonohata et al. [34]	1	53/ F	Nd Nd	Revision of THA Nd	Cefazolin IV	Nd	18 months	Hematogenous Str mutans gram+	Decay Str parasanguinus (oral flora)
Bengston et al. [35]	2*	56 /F 73 /F	Nd Nd	TKA 1973-1981	Nd	Nd	18 months 111 months	Hematogenous Staph aureus	Unknown
Lindqvist et Slätis [36]	3	67 /M 66 /F 84 /F	Osteoarthrosis Post-traumatic osteoarthritis Bilateral coxarthrosis	THA 1981 1982 1978(l)-1979(r)	erythromycin (-1 d to +3 d) dicloxacillin streptomycin	Nd	3 years 2 years 5years	Hematogenous Str viridans	periodontitis periodontitis periodontitis+ peri-apical lesion
Schurman et al. [37]	1	61 /F	Rheumatoid arthritis	Bilateral knee arthroplasty 1973	Cephalosporin IV (d4)	Nd	2 years	Hematogenous Cocci gram+ Staphaureus	Abscess right lower incisor
Cruess et al. [38]	2*	72 /F 64 /F	NRT Degenerative arthritis	THA 1970	Nd Ampicillin + dimethoxyphenyl penicillin (preop d5)	Nd	2 years 3 months	Hematogenous Staph epidermidis non group A Str	Infected molar Nd
Downes [39]	3*	69/F 54/F 62/M	Osteoarthrosis Nd Osteoarthrosis	THA 1968(l)-1969(r) 1969 1971	Nd	Nd	1-2 years 5 years 3 years	Hematogenous Staph aureus Str β hemolytic	Parotid abscess Nd Periodontitis
Ahlberg et al. [40]	3*	76/F 70/F 39/M	Osteoarthrosis Rheumatoid arthritis Pelvo-spondylitis	THA(x2) TKA 1970 (l)-1971 (r) 1975 1973-74	Cloxacillin Cloxacillin (2w) Nd	Nd	3 years 1 year 3 years	Hematogenous Pneumococcal Str β hemolytic Staph aureus	Unknown sources
Stinchfield et al. [41]	2*	60/M 56/F	Rheumatoid arthritis Osteoarthrosis	THA-TKA 1975 1976	Ampicillin + oxacillin	Full medical exam	5 months 1 year	Hematogenous Str group G Staph aureus	Dental abscess Tooth decay
Bartzokas et al. [21]	4	83/Nd 58/Nd 64/Nd 75/Nd	Osteoarthrosis Osteoarthrosis Osteoarthrosis History of pain after THA	Knee arthroplasty Nd	Nd	Nd	Nd	Hematogenous Str sangunis	Periodontitis + peri-apical infection Increasing periodontal pocket
Bauer et al. [42]	6	Nd	None	THA(x4)-TKA(x2) Nd	Nd	Nd	24 months 84 months 18 months 96 months 4 months 72 months	Hematogenous Str intermedius Str mitis Str adjacent Abiotrophia Str β hemolytic	Extractions Decay Care Abscess Extraction Care
Kaar et al. [43]	1	67/ M	Nd	THA revision Nd	cefazolin	Nd	11months	Hematogenous Str intermedius Str mutans	Supra gingival scaling
Bartz et al. [44]	1	63 /F	Lyme arthritis	THA Nd	Nd	Nd	9 years	Hematogenous Peptostreptococcus micros	Periodontitis Peri apical infection Infected molar

**only cases of dental or unknown sources. Nd: none documented, M: male, F: female, THA: total hip arthroplasty, TKA: total knee arthroplasty, str: streptococcus, staph: Staphylococcus*

Table 2: Case Control Studies

Author/ publication	Number of cases and controls		Age/ gender	Articular pathology	Comorbidities	Preoperative dental assessment	Type of infection	Time to onset	Dental infected site
Peersman et al. [3]	Cases	116 prostheses (3 excluded) (114 patients : 1 excluded)	Nd 1 case for 2 controls	62% : osteoarthrosis 20% : Rheumatoid arthritis 11% : osteoarthrosis post-traumatic 7% other	96% ≥6 comorbidities Comorbidities increasing the risk of infection: Prior open surgical procedure Immunosuppressive therapy Hypokalemia Poor nutrition Diverticulosis Infection elsewhere Diabetes mellitus Obesity Smoking Renal failure Hypothyroidism Alcohol abuse Operative time	OK	14%SSI 86% deep infection } 34,5% hematogenous (=56.5% late deep infection) 35% Staph aureus 15% Staph epidermidis 6% Str group B 4% Escherichia coli, Staph aureus Mr 12% others 9% poly microbial 19% unknown	<3 months 29% <3months 71%>3months	2.6% dental abscesses
	Controls	236 patients	Nd	Nd	80% ≥0 comorbidities Significant difference on the number of comorbidities	OK			
Kessler et al. [45]	Cases	26 patients	~ 61.4 yr 39% M 61% F	31% osteoarthrosis, 8% rheumatoid arthritis 54% osteoarthrosis traumatism 15% revision	Mean BMI 26,7 kg/m² 7.7% diabetes mellitus 11.5% corticosteroid use 3.8% chronic renal failure 3.8% chronic heart failure 3.8% chronic skin disease 3.8% polyneuropathy 3.8% peripheral arterial occlusive disease 19% smoking	Nd	85% exogenous 15% hematogenous 35% Staph aureus (1episode cause by Mr) 31% Staph. coagulase - 15% Enterococcus 12% Enterobacter 8% Klebsiella pneumoniae. Propionibacterium acnes 4% Str milleri, Pseudomonas aeruginosa, Achromobacter spp 15% poly microbial	Mean 193d (10-3762d) 23% <90d 62% 90d-2yr 15%>2yr	3.8% dental abscess (1case)
	controls	52 patients	~ 64 yr 39% M 61% F	31% osteoarthrosis 6% rheumatoid arthritis 64% osteoarthrosis traumatic	Mean BMI 26,5 kg/m² 1.9% diabetes mellitus 5.7% malignant tumor 5.7% corticosteroid use 5.7% chronic heart failure 1.9% chronic skin disease 1.9% polyneuropathy 10% smoking	Nd			
		52 patients	~ 64.6 y 56% M 34%F	48% osteoarthrosis 2% rheumatoid arthritis 50% osteoarthrosis traumatic 2% revision	Mean BMI 27..5 kg/m² 9.6% diabetes mellitus 5.7% chronic heart failure 3.8% peripheral arterial occlusive disease 21% smoking	Nd			
Kaandorp et al. [46]	Cases	37 patients	~ 65 yr 38% M 62% F	67% rheumatoid arthritis 5% osteoarthrosis of an other site 3% ankylosing spondylitis 14% JCA, lupus erythematosus 19% osteoarthrosis hip or knee	5% malignancy 11% diabetes 3% liver disease 32% immunosuppressive therapy 86% infection (skin respiratory-urinary tract)	Nd	41% infection at surgical site 59% hematogenous 40% Staph aureus	Nd	Nd

	Controls	4870 patients	5% >80yr 31%M 69%F	27% rheumatoid arthritis 18% osteoarthrosis hip or knee 8% ankylosing spondylitis 7% JCA, lupus erythematosus 40% osteoarthrosis of an other site 11% traumatic	1% malignancy 4% diabetes mellitus 1% renal disease 1% liver disease 13% immunosuppressive therapy 55% infection (skin, respiratory-urinary tract) 10% invasive dental procedure	Nd			
Cordero-Ampuero et de Dios [47]	Cases	47 patients	~ 81 yr 96% F 4% M	4% rheumatoid arthritis	9% previous surgery 9% obesity 26% diabetes mellitus 4% liver disease 13% corticosteroid use. 4% immunosuppressive therapy 4% thalassemia infection (skin-urinary-respiratory-abdominal)	Nd	Late infection	> 3months	Nd
			~ 67 yr 58% F 42% M	17% post traumatic 63% osteoarthrosis 8% rheumatoid arthritis 4% other inflammatory diseases	60% previous surgery 33% obesity 25% diabetes mellitus 21% liver disease infection (skin-urinary-abdominal-respiratory-dental) 13% alcohol abuse 8% past parenteral drug abuse 13% corticosteroid use 8% immunosuppressive therapy	Nd	Late infection Infection Nd	> 3months	Nd
	Controls	200 patients	~ 84 yr 77% F 23% M	1% rheumatoid arthritis	1% obesity 18% diabetes mellitus 5% liver disease 2% corticosteroid use 4% tuberculosis 3% thalassemia infection (skin-urinary-abdominal-respiratory-dental)	Nd			
			~ 64 yr 55% F 45% M	3% post traumatic 79% osteoarthrosis 2% rheumatoid arthritis 1% other inflammatory diseases	6% previous surgery 19% obesity 11% diabetes mellitus 2% liver disease 3% immunosuppressive therapy 11% tuberculosis 1% thalassemia infection (urinary-abdominal-respiratory)				

Nd: none documented; M: male, F: female, str: streptococcus, staph: Staphylococcus, Mr: methicillin resistant, BMI: body mass index

Table 3: Cohort studies

Author/ Publication	Number of cases	Mean age and gender	Type of prosthesis and articular pathologies	Comorbidities and risk factors	Dental assessment	Dental treatment before orthopedic surgery	Incidence/ Type of infection	Time to onset	Dental infected site
Andrews et al. [48]	64 THA (65 infected patients : 4 died)	Nd 81.5% F 18.5% M	THA 1.8% osteoarthrosis 10.5% rheumatoid arthritis 7.2% Revision 7.7% ankylosing spondylitis 20% traumatism	Previous surgery RA anticoagulant SSI	Nd	Nd	Incidence 3.9% Early infection Late infection 17.6% hematogenous infection 32% Staph aureus 15% Staph. albus 15% Str 11% Escherichia coli 8% Proteus spp 9% Klebsiella/Enterobacter/Serratia 1% Salmonella 7% Pseudomonas 4% anaerobic	54% < 4monts 18% < 1yr 28% < 10yr	Nd
Aomori et al. [49]	105 patients (113 prostheses)	7yr (43-87 yr) 77.1% F 22.8% M	38% THA 58.4% TKA 2.6% TEA 0.9% TSA 82.3% osteoarthrosis 17.7% rheumatoid arthritis	Nd	Dental panoramic 10-48 d (mean 30 d) before prosthetic insertion 74.3% periodontitis 17% toothless	22.1% extractions 0.9% scaling periodontal pocket 73.4% root plaining 4.4% decay treatments	Incidence 1.9% Staph epidermidis	0.9% 1week 0.9% 10months-1yr	Periodontitis P_3 Extraction (2months before surgery) no active outbreak after surgery periodontitis (no active outbreak after surgery)
Barrington et Barrington [50]	100	64 yr 54% F 46% M	75% primary arthroplasty (31% THA, 44% TKA) 25% revision (15% T HA, 10% TKA) Nd	Nd	OK 23% decay of which 1% was periodontitis	32 decay treatments 26 extractions (abscess) 6 crowns 1 root treatment 1 scaling / root planning	0% of infection No infection found	<90d	None
Grogan et al. [51]	12* (13 prostheses)	Nd 41.6% M 58.3% F	TKA 84.6% primary 15.4% revision 41.6% rheumatoid arthritis 50% osteoarthrosis 8.3% lupus	Prosthesis revision Type of prosthesis	Nd	Nd	Incidence 1.71% 50% unknown 7.1%SSI 42.8% hematogenous 21.4% Staph aureus, Str micrococcus 7.1%Escherichia coli, Proteus mirabilis, P maroxella, Str viridans, Enterobacter aerogenes, Staph epidermidis, Str group A, listeria	2 weeks-40 months (mean 8.3 months) hematogenous infection. 3.5-40 months (mean 16.4 months)	No previous oral infections

			erythematosus						
Hamilton et Jamieson [52]	1993 operations	Nd	THA 84% primary 16% revision	Blood transfusion type of anesthesia malignant tumor radio/ chemo immunosuppressive rheumatoid arthritis diabetes mellitus alcohol abuse	Nd	Nd	2% infection 31% Staph aureus 21% Staph epidermidis	Nd	Nd
Jacobsen et Murray [53][9]	33 (infected prostheses)	Nd	Nd	Nd	Nd	Nd	Incidence : 1.8% early infection late infection 43% Staph aureus (late infections ++) 17% Staph epidermidis 17% Pseudomonas aeruginosa 6% Str. α and Enterococcus 3% Str.γ and β, Peptostreptococcus, Candida tropicalis.	<6 months mean 34 months (17-48)	3% associated with dental site Peri apical abscess
Lampley et al. [54]	365 (dental exams)	62.4 yr (16-88) 44% M 56% F	47% TKA: -90% primary -9.4% revision -0.6% arthroplasty 53%THA: -89% primary -11% revision Nd	BMI 30.6 Comorbidity index 2	84%OK 8.8% periodontitis 6.0% toothless 1.6% no check	2% no treatment (no surgery) 6.8% treated	Incidence 1.7% 50% Staph aureus 33% Staph coagulase - 16%Pseudomonas aeruginosa 16%Peptostreptococcus magnus 16%Enterococcus faecalis 16%Str group B	< 6 months mean 68.5days (36 –166)	1 patient needed treatment before surgery
	218 (without)	78.7yr (42 - 101) 32% M 68% F	63%THA 37% hemi HA Nd	BMI 24 Comorbidity index 3.7	none	none	Incidence 2.5% Staph coagulase -	< 1 month mean 16 days (9-28)	None
Maderazo et al. [55]	24 (late infections)	56 yr (27-86)	58%THA 46%TKA 46% osteoarthrosis 29% rheumatoid arthritis 21% traumatism 4% vascular necrosis (radiotherapy) 4% rheumatoid arthritis juvenile	Nd	Nd	Nd	Incidence 1.7% 42% hematogenous. 46% SSI propionibacterium Staph. epidermidis Staph aureus	12 months – 6 yr	Periapical abscess Periodontitis (extractions) extractions
Poss et al. [56]	4240 (prostheses)	65 yr (OA) 55 yr (RA) Nd	2012 THA 1957 TKA (metal-plastic) 156 TKA	Prosthesis revision (risk x8) RA (risk x 2.6)	done	Nd	Incidence: 1.3% 49% early 32% late 10% uncertain	Some days-5 yr 4 months- 9 yr	Gingivitis

			(metal-metal) 115 TSA 90% osteoarthrosis + rheumatoid arthritis 10% others				50% Staph aureus 9.6% Staph. epidermidis, Diphtheroids 15% Str group B 1.9% Lactobacillus 5.7% Klebsiella, Pseudomonas 7.6% Escherichia coli		
Schmalzried et al. [57][2]	43 (47 prostheses ÷ in 3 groups according to the surgery)	50yr (perioperative contamination) 49 yr (hematogenous) 47 yr Repeat infection 53% F 47% M	THA 15% osteoarthrosis 13% osteonecrosis 11% rheumatoid arthritis 4% congenital dysplasia of the hip	Systemic disease: 38% surgical contamination 74% hematogenous 38% repeat infection	Nd	Nd	Incidence 1.5% 0.4% perioperative contamination 0.6% hematogenous 0.4% repeat infection 33% Staph aureus 16% Escherichia coli 13% Staph epidermidis, Pseudomonas 6% polymicrobial	mean 20 months (1-60) mean 40 months (1-96) mean 42 months (1-84)	1 patient (Nd)
Uçkay et al. [58]	6101	69.9 yr Nd	66% THA 34% TKA 7% revision 93% primary arthroplasty polymyalgic revision rheumatoid arthritis lupus erythematosus	malignant tumur diabetes mellitus alcohol abuse renal insufficiency BMI ASA 3-4 revision	Nd	Nd	Incidence: 1.2% (1.1%THA / 1.2%TKA) 10% hematogenous 29.6% early 33.8% delayed: 28.6% hematogenous 36.6% late: 71.4% hematogenous 42% Escherichia coli 8.6% Staph aureus, Klebsiella 5% Bacteroides fragilis, Str pneumoniae 3.7% Enterococcus faecalis, Proteus mirabilis, Str bovis 1.2% Str oralis	Mean 33 months (6-67) < 3 months >24 months	Dental abscess (3 cases)
Waldman et al. [59]	9*	65 yr (56-76) 67% F 33% M	TKA 22% rheumatoid arthritis 44% osteoarthrosis	33% diabetes mellitus 22%corticosteroid use	Nd	Nd	Incidence: 2.1% late deep infection 33% Str viridans 22% Peptococcus 11% Staph aureus Mr, Str mutans, Serratia marcescens	mean 72 months (26-95)	Periodontitis Periodontal abscess

*12 infected patients for 604 patients (801 prostheses)
**9 patients had undergone dental treatments with respect to the infection included in the 3490 TKA implanted, of which 74 TKA infected
Nd: none documented, M: male, F: female, THA: total hip arthroplasty, TKA: total knee arthroplasty, TSA: total shoulder arthroplasty, TEA: total elbow arthroplasty str: Streptococcus, staph: Staphylococcus, Mr: Methicillin resistant, BMI: body mass index

Table 4: Study Quality assessment using Newcastle-Ottawa scale for cohort studies.

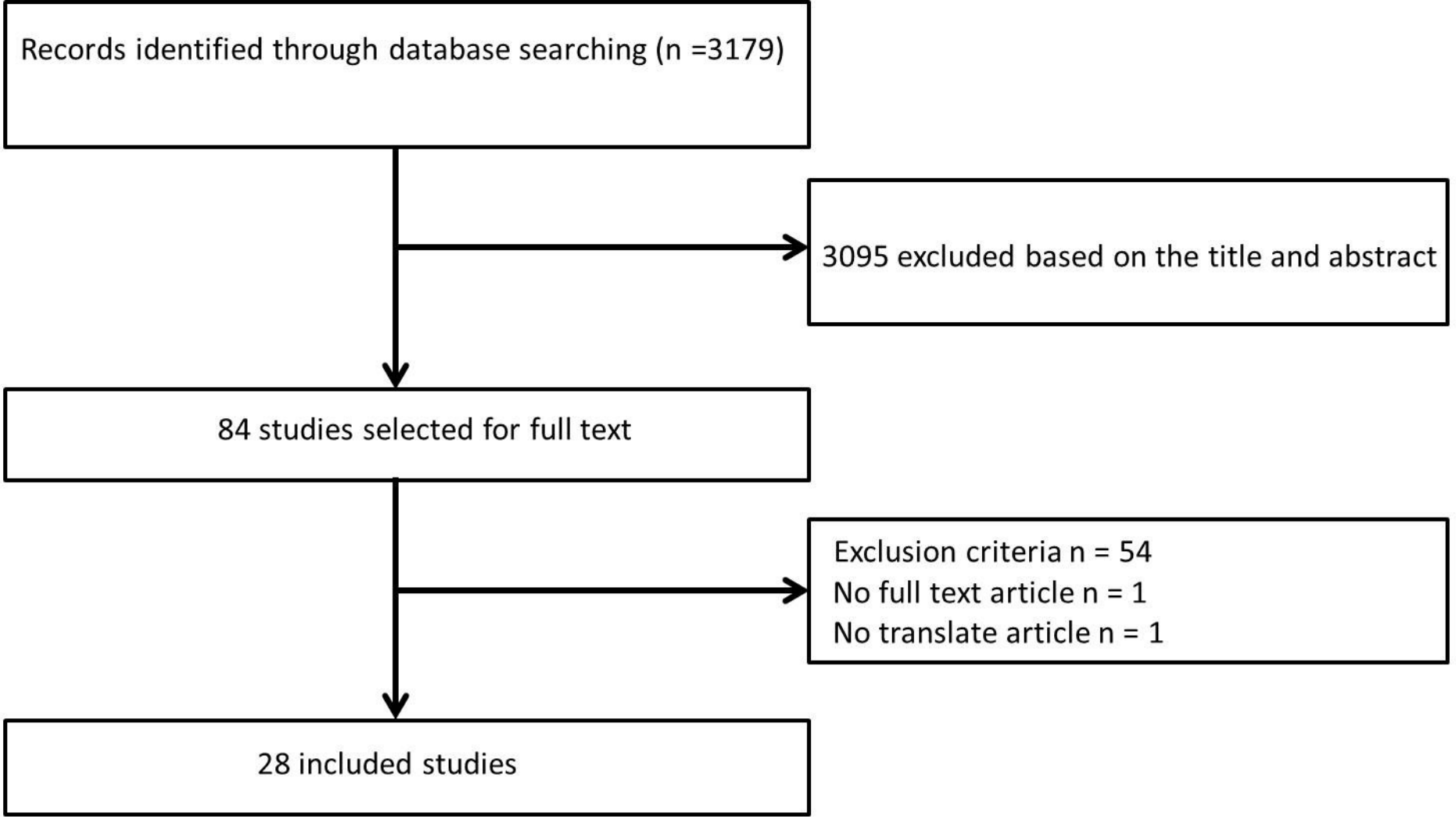
Study, year	Selection				Comparability of cohorts (matched for)	Outcome			Total score
	Representativeness of exposed cohort	Selection of non exposed cohort	Ascertainment of exposure	Outcome not present at baseline		Assessment of outcome	Sufficient follow-up duration	Adequate follow-up	
Andrews [48] 1981	-	-	-	-	-	★	★	★	3
Aomori [49] 2003	-	-	★	★	-	★	★	-	4
Barrington [50] 2011	-	-	★	★	-	★	-	-	3
Grogan [51]1986	-	-	-	★	-	★	★	★	4
Hamilton [52] 2008	-	-	-	★	-	★	★	-	3
Jacobsen [53] 1980	-	-	-	★	-	★	★	-	3
Lampley [54] 2014	-	-	★	★	-	★	★	★	5
Maderazo [55] 1988	-	-	-	★	-	★	★	-	3
Poss [56] 1984	-	-	-	-	-	★	★	★	3
Schmalzried [57] 1992	-	-	-	-	-	★	★	★	3
Uçkay [58] 2009	-	-	-	★	-	★	★	★	4
Waldman [59] 1997	-	-	-	★	-	★	★	★	4

NB: Quality assessment is performed according to the objective of the systematic review, and does not reflect the internal validity of each specific study.

Table 5: Study Quality assessment using Newcastle-Ottawa scale for case-control studies

Study, year	Adequate definition of case	Representativeness of cases	Selection of control	Control for important factor or additional factor	Exposure assessment	Same method of ascertainment for cases and controls	Non response rate	Total score
Peersman [3] 2001	✓	✓	✓	-	-	-	-	3
Kessler [45] 2012	✓	✓	✓	-	-	-	-	3
Kaandorp [46] 1995	-	✓	-	✓	-	-	-	2
Cordero-Ampuero [47] 2010	✓	✓	✓	-	-	-	-	3

NB: Quality assessment is performed according to the objective of the systematic review, and does not reflect the internal validity of each specific study.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3095 excluded based on the title and abstract
84 studies selected for full text
Exclusion criteria n = 54
No full text article n = 1
No translate article n = 1
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