■ ANNOTATION

Antibiotic prophylaxis before invasive dental procedures in patients with arthroplasties of the hip and knee

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More than a million hip replacements are carried out each year worldwide, and the number of other artificial joints inserted is also rising, so that infections associated with arthroplasties have become more common. However, there is a paucity of literature on infections due to haematogenous seeding following dental procedures. We reviewed the published literature to establish the current knowledge on this problem and to determine the evidence for routine antibiotic prophylaxis prior to a dental procedure.

We found that antimicrobial prophylaxis before dental interventions in patients with artificial joints lacks evidence-based information and thus cannot be universally recommended.

Joint prostheses are one of the remarkable advances of modern medicine. In 1936, the first joint replacement, a total hip replacement, was performed.¹ Over 70 years later, more than a million hip replacements are carried out annually worldwide. Apart from loosening of the components or dislocation, infection is the most common complication. Although the overall risk has been reduced to < 1% for hip and < 2% for knee replacements,² infection is observed quite often owing to the sheer volume of patients who undergo joint replacement.³ In the United States, at least 400 000 total hip and knee replacements are carried out each year,³⁻⁵ and approximately 70 000 in the United Kingdom.⁶ However, in managing infection of the prosthesis, the costs of treatment are five to seven times higher than the initial operation and the morbidity is considerable.⁷

Orthopaedic surgeons have considered prophylactic antibiotics to be necessary for patients with joint replacements who undergo any dental procedures, so as to avoid bacteraemia and consequent haematogenous seeding of the implant. We reviewed the scientific literature on the epidemiology, microbiology, pathogenesis and prophylaxis of infections of total hip and knee replacements following dental treatment to ascertain whether this opinion is justified on the basis of the evidence available.

Materials and Methods

We conducted a PubMed search of the literature to identify English-, French- and German-language publications before 1 July 2007 using

the following terms 'dental', 'joint replacement', 'bacteraemia', 'infection', 'prosthesis', 'arthroplasty', 'dentist' and 'prophylaxis', and paired in a second step with the terms 'recommendations' and 'guidelines'. Bibliographies of relevant articles were hand searched to retrieve further papers. Case reports and references to abstracts of conference presentations were also included. Animal studies and *in vitro* experiments were excluded.

Results

Of 144 articles retrieved, 24 were case reports, seven described series involving at least three cases,⁸ 34 were review articles, and 48 were retrieved from publications concerning dentistry or maxillofacial surgery, 20 from orthopaedic journals and 11 from literature concerning infectious diseases; 123 were published before 2002 and 21 within the last five years. Of these articles, 23 prospectively investigated the rate of asymptomatic bacteraemia after dental work. No publication concerning the risk of infection was based on randomised or comparative trials.⁹ There were 27 publications (18.8%) in favour of systemic antibiotic prophylaxis before dental procedures for special circumstances, but 11 (7.6%) did not perceive any benefit. The remaining 106 papers (73.6%) took no clear position on the subject. The delay between intra-oral intervention and symptomatic infection ranged between 24 hours¹⁰ and nine months.¹¹ The delay between implantation of the arthroplasty and dental work ranged between 11¹² and 95 months.¹³

Most patients were immunocompetent, and only a few were immunocompromised.¹³⁻¹⁵

Discussion and review of the literature

Prosthetic joint infections can be classified according to the time of onset as early (less than three months after surgery), delayed (3 to 24 months), or late (more than 24 months after operation).¹⁶ Most early and delayed infections are presumed to be acquired in the operating theatre,^{17,18} whereas late infections^{1,16} are often attributed to haematogenous seeding. Transient bacteraemia of oral origin may harbour risks for infection of implants, but this occurs rarely as anaerobic bacteria or streptococci of the oral cavity are seldom encountered in infections of arthroplasties where cutaneous Gram-positive organisms such as staphylococci predominate.^{2,16,19,20}

A computer simulation model indicated a low incidence of late-stage artificial joint infections associated with dental treatment with 29 to 68 cases per 10⁶ dental visits (0.04%),²¹ whereas retrospective studies showed an incidence of 0.2% for total knee¹³ and 0.1% for total hip replacements.⁸ Some clinicians have attributed up to 6%²² or 11%¹³ of all late infections to a dental source.

In most reports, infection developed within two weeks of a dental procedure.^{9,12,14,15,22-35} However, opinion about an oral origin is often an assumption underlined by microbiological results compatible with oral flora because of the lack of a valid alternative explanation. Occasional cases of pre-existing dental or periodontal infections have been described that may have been the source of joint infection rather than a direct dental procedure.¹² Some papers indicated skin commensals, such as *Staphylococcus epidermidis*, as causative pathogens,²⁵ thereby casting doubt on an oral origin.

Asymptomatic bacteraemia after dental procedures. Dental work that may provoke bacteraemia does not need to be invasive or surgical. It can be caused by periodontal probing,^{36,37} ultrasonic scaling,³⁷⁻³⁹ tooth brushing,^{37,39} orthodontic appliances,⁴⁰ or occur spontaneously due to simple gingivitis.^{5,41,42} Whether chewing, debanding (removal of fixed orthodontic appliances) or gold chain adjustment (fitting a gold orthodontic appliance) may also cause bacteraemia remains a subject of debate. Some reports are affirmative,^{39,43} while others deny such a link.^{44,45} Upper alginate impression or adjustment of arch wires were not found to increase the rates of bacteraemia.⁴⁶

Routine dental operations can produce ten to 240 colony-forming units of pathogens per millilitre of blood.⁴⁷⁻⁴⁹ Durack⁵⁰ estimated the incidence of asymptomatic transient bacteraemia to be 60% after tooth extraction, 88% after periodontal surgery, 40% after tooth brushing and 35% after tonsillectomy. The cumulative risk of 'spontaneous' bacteraemia from periodontitis, oral hygiene and chewing can be considerably higher than from dental interventions.^{51,52} Transient bacteraemia might occur spontaneously up to 12 times each day.⁵³ After tooth extraction,

90% of positive blood cultures are identified within 30 seconds.^{42,54-57} Most episodes last less than 30 minutes,^{13,42,49,56,58,59} with a mean duration of approximately 11 minutes⁴⁹ and up to 180 minutes at most.⁶⁰ Under normal conditions, the bacteria are rapidly eliminated from the reticuloendothelial system.⁴²

The duration of the dental intervention plays a role. In a prospective trial, the incidence of positive blood cultures was significantly higher when the procedure lasted less than three minutes, compared with more than six minutes.⁶¹ In other studies with orally-induced artificial joint infections, the mean duration of dental procedures was 115 minutes (75 to 205)¹³ or 65 minutes (45 to 90).⁸

Microbiology and regimes for prophylaxis. Among 578 patients with infected joint replacements seen at the Mayo Clinic, Rochester, Illinois, 53% were due to staphylococci, 9% to streptococci, 6% to Gram-negative pathogens and 4% to anaerobes.⁶² In contrast to this variety of bacteria isolated from infected arthroplasties, those found in blood cultures after dental work were streptococci, mostly of the *viridans* group,^{8,12-15,25,36,40,42,46,47,49,52,55-57,61,63} *Gemella*,^{15,37,49,56,57} *Peptostreptococcus*,^{8,13,32,42,49,56,57} *Neisseria*,^{42,56} *Actinomyces*,^{31,39,40,49,56} *Prevotella*,^{15,22,36,39,42,57,63} and other anaerobic bacteria^{37,39,42,47,49,56} or Gram-negative organisms.^{13,23,30,37,40,49,56} In up to a quarter of the patients the bacteraemia was polymicrobial.^{13,37,42,61}

In the 1980s and early 1990s penicillins,⁶⁴ cephalosporins^{21,25,53} and erythromycin^{9,65} were advocated as the antibiotics of choice, despite reports of infection by erythromycin-resistant pathogens.¹⁴ Currently, amoxicillin/ampicillin (2 g), a first- or second-generation cephalosporin, or clindamycin in a dose of 600 mg in cases of intolerance to β -lactam antibiotics, are considered adequate.^{5,6,20,66} The effectiveness of clindamycin has been questioned,^{55,67} partly because of the increasing resistance of streptococci to lincosamide antibiotics. Prophylactic antibiotics are preferably given orally one hour before the dental procedure.^{5,6,68} A second dose is seldom recommended.⁶⁹

Analogy to infective endocarditis. Although endocarditis and an infected joint replacement are different clinical entities,^{5,69,70} their management as regards to dental care have similarities. The measures used in endocarditis have been established in experimental data and animal studies.⁷¹ No randomised trial has ever shown that antibiotic prophylaxis for endocarditis would be effective.⁵⁰ The majority of episodes do not occur after dental procedures. Asymptomatic bacteraemia is much more likely to occur during daily activities than after a dental procedure, and a high percentage of patients develop endocarditis despite correctly administered antibiotic prophylaxis. As a consequence, in April 2007 the recommendations of the American Heart Association were modified in light of the current evidence.⁷² Now, for a procedure that involves the manipulation of gingival tissue, teeth in the periapical region, perforation of the oral mucosa, procedures on the respiratory track or in infected skin and musculoskeletal tissues, antibiotic prophylaxis is restricted to patients with prosthetic cardiac valves, a history of prior

Table I. Incidence of infections in joint replacements due to haematogenous seeding from dental procedures. Review of the literature (> 100 patients) prior to July 2007

Author	Trial	Number of joints	Infections > 6 mths (%)	Due to dental procedure in absence of pre-existing infection (%)	Remarks
Ainscow and Denham ⁷⁸	Prospective	1112	-	0	224 patients with dental/surgical therapy
Jacobson et al ³⁰	Retrospective	2693	30 (1.1)	1 (0.04)	
Ching et al ⁷⁹	Review	110	-	0	Four episodes due to dental infection
Waldman et al ¹³	Retrospective knee prostheses 1982-93	3490	62 (1.8)	7 (0.2)	Six of seven patients with infection due to dental work had no prophylaxis
LaPorte et al ⁸	Retrospective hip prostheses 1982-94	2973	52 (1.7)	3 (0.1)	No patient with infection due to dental work had prophylaxis
Jacobsen and Murray ⁹	Retrospective	1855	33 (1.7)	1 (0.05)	

endocarditis, congenital heart disease, and cardiac transplant recipients who develop valvulopathy.⁷² Some European societies do not yet follow these recommendations⁷³ and prefer to revise existing guidelines in cooperation with others.⁷⁴

Human studies with infection as an outcome. In contrast to antibiotic prophylaxis for surgical site infection in general,^{16,17,75-77} few studies have assessed the epidemiology of infections of artificial joints in a large patient database (Table I). Ainscow and Denham⁷⁸ followed 1000 patients with 1112 total joint replacements for a mean of six years. Patients were not advised to take antibiotics during dental procedures. Invasive dental or surgical treatment was carried out on 224 patients. Only three developed infection in their implants, all of which were associated with skin infections.⁷⁸ Jacobson et al³⁰ investigated 2693 joint replacements where only one patient acquired an infection thought to be associated with dental treatment. Ching et al⁷⁹ attributed four episodes of infection in joint replacements from among 110 patients to dental infection, but none to dental manipulation in the absence of pre-existing infection. In another retrospective analysis of 24 late infections in joint replacements, only three were related to dental treatment. Of these, two had a pre-existing dental or periodontal infection.⁸⁰ Waldman et al¹³ retrospectively analysed 3490 patients with total knee arthroplasties. Late infections were seen in 62 (1.8%), of which only seven (0.2%) were possibly related to dental work. Six had not received antibiotic prophylaxis.¹³ Jacobsen and Murray⁹ investigated 1855 hip replacements and, of the 33 infections (1.7%) that developed, only one (0.05%) could be attributed to dental treatment. LaPorte et al⁸ retrospectively reviewed the records of 2973 patients with total hip replacements carried out between 1982 and 1994. Late infections were seen in 52 (1.7%), but only three (0.1%) were of oral origin and none had received prophylaxis.⁸

Asymptomatic bacteraemia. Brennan et al,⁴¹ in a placebo-controlled trial, demonstrated that amoxicillin given before non-surgical dental procedures reduced the incidence of

asymptomatic bacteraemia from 20% in the placebo group to 6% in those given amoxicillin, indicating that even correct prophylaxis did not guarantee the absence of bacteraemia. Coulter et al⁴⁷ found a reduction in the incidence of bacteraemia from 63% to 35% with antibiotic prophylaxis. Lockhart et al⁵⁶ noted an incidence of bacteraemia of 89% following invasive dental care in a placebo group, compared with 33% in those given amoxicillin ($p < 0.0001$). Similar observations have been published by others.^{55,67}

In a double-blind, randomised placebo-controlled study of 70 adults undergoing single-tooth extraction, the use of a chlorhexidine mouthwash reduced the rate of asymptomatic bacteraemia at one and three minutes after the start of extraction.⁶¹ Similar findings have been observed using an antibiotic mouthwash⁸¹ or a povidone-iodine solution.³⁸

Existing guidelines, expert opinion and cost-effectiveness analyses. In 1992, the Working Party of the British Society for Antimicrobial Chemotherapy emphasised that there was no evidence to support the use of antibiotic prophylaxis before dental work in patients with joint replacements.⁸² Despite this, 78% of British orthopaedic surgeons admitted to using antibiotics for prophylaxis before dental procedures.⁸³ The Australian Orthopaedic Association Arthroplasty Group emphasised that the risk of a joint replacement becoming infected by a bacteraemia of oral origin is exceedingly low, whereas the risk of an adverse reaction to the antibiotic prophylaxis is higher.⁸⁴ If all patients with joint replacements were to receive antibiotic prophylaxis when having dental treatment, more would die from anaphylactic shock than from infection. This assessment was supported by computer simulation models²¹ that did not confirm the cost-effectiveness of routine prophylaxis.^{5,6,76} Only one group has concluded that antibiotic prophylaxis may be marginally cost-effective for patients with joint replacements.⁶⁵ An analysis from The Netherlands concluded that for some patients with joint disease, but not with joint replacements, antibiotic prophylaxis before dental work was likely to be cost-effective.⁸⁵

Table II. Summary of national guidelines/recommendations concerning antibiotic prophylaxis before invasive dental procedures in patients with joint replacements

Author	Association	Prophylaxis	Indications
Scott et al ⁸⁴	Australian Orthopaedics	Yes	High-risk dental procedures in immunocompromised patients (immunosuppressive treatment including systemic steroids, insulin-dependent diabetes mellitus, rheumatoid arthritis)
	American Dental Association; American Academy of Orthopedic Surgeons	Yes	For the first two years after joint replacement: all patients for all high-risk dental procedures After 2 years: previous infection of the artificial joint, inflammatory arthritis, type-1 diabetes mellitus, haemophilia, immunosuppression, history of prior or present malignancy, dental extractions, periodontal procedures, dental implantation, root canal work, cleaning if bleeding is anticipated, certain specialised local anaesthetic injections, placement of orthodontic bands
Simmons et al ⁸²	Working Party of British Society for Antimicrobial Chemotherapy	No	No specific mention of higher-risk groups Prophylaxis not recommended
Seymour et al ⁶	British Orthopaedic Association; British Dental Association	Yes	Prophylaxis may be considered only in patients with diabetes mellitus, rheumatoid arthritis, haemophilia, malignancy, overt oral sepsis, or when dental treatment is invasive, complex and of long duration (> 45 minutes)
Rossi et al ⁶⁹	Swiss Society for Infectious Diseases	Yes	Implantation of prosthesis in the last 12 months No general recommendation, even for immunocompromised patients Individual decision

In 1997, the American Dental Association and the American Academy of Orthopedic Surgeons issued an advisory statement^{5,86} which was updated in 2003, together with the provision of an information leaflet for patients.⁶⁸ They stated that antibiotic prophylaxis is not mandatory for routine dental procedures in most patients with joint replacements, but should be considered in those with an increased risk, including joint replacement within the past two years, previous infection of a joint replacement, inflammatory arthritis, type-1 diabetes mellitus, haemophilia, immunosuppression, a history of previous or current malignancy, dental extractions, periodontal procedures, dental implantation, root canal work, descaling if bleeding was anticipated, specialised injections of local anaesthetic, or placement of orthodontic bands.⁶⁸ Arguments for the inclusion of inflammatory arthritis or immunocompromised patients are based on other trials which demonstrated an increased risk of per-operatively acquired infection,⁸⁷ whereas the other recommendations originate from case reports and/or common sense.⁵ Apart from the two-year limit, the recommendations of the American Dental Association were shared by most authors,^{13,25,34,52,69,76,88-94} but sometimes with many restrictions.⁶ The recommendations of the Swiss Society of Infectious Diseases are very similar, except for the use of prophylaxis during dental procedures within one year of joint replacement and the individuals' decision even for immunocompromised patients.⁶⁹ The rationale behind the recommendations of antibiotic prophylaxis in the early period after joint replacement relies mainly on common sense. Local hyperaemia following surgery and the processes of active healing may make the joint

is fully embedded in inactive soft tissue. However, documented clinical evidence for this assumption is lacking. Table II summarises some of the most frequently used guidelines and recommendations.

Conclusions

Infections of total hip or knee replacements due to haematogenous seeding following dental intervention are very rare. The scientific rationale for systemic or local antimicrobial prophylaxis is very weak at best.⁷⁰ No occurrence of genetically identical strains of *Streptococcus* in the mouth and joint has been recorded.⁵² According to the criteria of evidence-based medicine, no supportive data in favour of antimicrobial prophylaxis could be found in our review of the literature, and there was no proof that antibiotic prophylaxis could prevent infection.⁸⁴

However, there have been many cases which have suggested that infection of a joint replacement has had an oral origin.¹¹⁻¹⁴ Because of the heavy financial, medical and social burden associated with infection of a joint replacement, most authors agree that prevention should be recommended for selected individuals. However, this attitude is based more on fear than on science, and the relationship between the individual orthopaedic surgeon and the patient will greatly influence the decision. To avoid this pitfall, Seymour et al⁶ proposed leaving the decision to the dental surgeon. However, the dentists and their patients may seek advice from the orthopaedic surgeon or physician in charge.

Recommendations and future perspectives

Prophylactic antibiotics are not required before a dental intervention in patients with artificial joints and without

cardiac risk factors.⁷² However, a pre-existing dental infection requires antibiotic treatment and prophylaxis. The guidelines listed in Table II may be helpful. A one-year delay between surgery and the dental procedure should be sufficient.⁶⁷ With a surgical site infection, a single pre-operative dose of antibiotic is as effective as prolonged therapy⁷⁶ and a one- to two-hour 'window' before the initial incision has the lowest rate of infection.⁷⁷ We consider that similar timing should be used if it is decided to use prophylactic cover for dental work.

Three important aspects should be borne in mind. First, according to experimental trials, systemic antibiotics could theoretically be replaced by topical antibiotic or oral anti-septic agents.^{6,38,61,81,95} However, further controlled trials, including careful monitoring of adverse events and cost-effective evaluation, are needed before any definitive conclusion can be reached. Second, infected foci elsewhere in the body⁶⁹ must be treated first.^{5,6,8,13,20,24,33,66,80,84,85,94} Finally, all patients should be advised to establish and maintain good oral health.

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References

- Colonna PC. An arthroplastic operation for congenital dislocation of the hip: a two stage procedure. *Surg Gynecol Obstet* 1936;63:777-81.
- Zimmerli W, Trampuz A, Ochsner PE. Prosthetic-joint infections. *N Engl J Med* 2004;351:1645-54.
- Widmer AF. New developments in diagnosis and treatment of infection in orthopaedic implants. *Clin Infect Dis* 2001;33:94-106.
- Darouiche RO. Treatment of infections associated with surgical implants. *N Engl J Med* 2004;350:1422-9.
- American Dental Association, American Academy of Orthopaedic Surgeons. Antibiotic prophylaxis for dental patients with total joint replacements. *J Am Dent Assoc* 1997;128:1004-8.
- Seymour RA, Whitworth JM, Martin M. Antibiotic prophylaxis for patients with joint prostheses: still a dilemma for dental practitioners. *Br Dent J* 2003;194:649-53.
- Bengtson S. Prosthetic osteomyelitis with special reference to the knee: risks, treatment and costs. *Ann Med* 1993;25:523-9.
- LaPorte DM, Waldman BJ, Mont MA, Hungerford DS. Infections associated with dental procedures in total hip arthroplasty. *J Bone Joint Surg [Br]* 1999;81-B:56-9.
- Jacobsen PL, Murray W. Prophylactic coverage of dental patients with artificial joints: a retrospective analysis of thirty-three infections in hip prostheses. *Oral Med Oral Pathol* 1980;50:130-3.
- Downes EM. Late infection after total hip replacement. *J Bone Joint Surg [Br]* 1977;59-B:42-4.
- Rubin R, Salvati EA, Lewis R. Infected total hip replacement after dental procedures. *Oral Surg Oral Med Oral Pathol* 1976;41:18-23.
- Kaar TK, Bogoch ER, Devlin HR. Acute metastatic infection of a revision total hip arthroplasty with oral bacteria after noninvasive dental treatment. *J Arthroplasty* 2000;15:675-8.
- Waldman BJ, Mont MA, Hungerford DS. Total knee arthroplasty infections associated with dental procedures. *Clin Orthop* 1997;343:164-72.
- Skies DJ, Coykendall AL. Prosthetic hip infection related to a dental procedure despite antibiotic prophylaxis. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1995;79:661-3.
- Akintoye SO, Brennan MT, Graber CJ, et al. A retrospective investigation of advanced periodontal disease as a risk factor for septicemia in hematopoietic stem cell and bone marrow transplant recipients. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2002;94:581-8.
- Lew DP, Pittet D, Waldvogel FA. Infections that complicate the insertion of prosthetic devices. In: Mayhall CG, ed. *Hospital epidemiology and infection control*. Third ed. Philadelphia: Lippincott Williams & Wilkins, 2004:1181-205.
- Mangram AJ, Horan TC, Pearson ML, Silver LC, Jarvis WR. Guideline for Prevention of Surgical Site Infection: 1999 Centers for Disease Control and Prevention (CDC) Hospital Infection Control Practices Advisory Committee. *Am J Infect Control* 1999;27:97-132.
- Little JW. Patients with prosthetic joints: are they at risk when receiving invasive dental procedures? *Spec Care Dentist* 1997;17:153-60.
- Baker KA. Antibiotic prophylaxis for selected implants and devices. *J Calif Dent Assoc* 2000;28:620-6.
- Cutando-Soriano A, Galindo Moreno P. Antibiotic prophylaxis in dental patients with body prostheses. *Med Oral* 2002;7:348-59.
- Jacobsen JJ, Schweitzer S, DePorter DJ, Lee JJ. Chemoprophylaxis of dental patients with prosthetic joints: a simulation model. *J Dent Educ* 1988;52:599-604.
- Steingruber I, Bach CM, Czermak B, Nogler M, Wimmer C. Infection of a total hip arthroplasty with *Prevotella loeschii*. *Clin Orthop* 2004;418:222-4.
- Messini M, Skourti I, Markopoulos E, et al. Bacteremia after dental treatment in mentally handicapped people. *J Clin Periodontol* 1999;7:469-73.
- Bartzokas CA, Johnson R, Jane M, et al. Relation between mouth and haematogenous infection in total joint replacement. *BMJ* 1994;309:506-8.
- Thyne GM, Ferguson JW. Antibiotic prophylaxis during dental treatment in patients with prosthetic joints. *J Bone Joint Surg [Br]* 1991;73-B:191-4.
- Brand RA. Late hematogenous infection in total joint replacement. *J Iowa Med Soc* 1975;65:388-90.
- Wilson PD Jr, Salvati EA, Blumenfeld EL. The problem of infection in total prosthetic arthroplasty of the hip. *Surg Clin North Am* 1975;55:1431-7.
- Stinchfield FE, Bigliani LU, Neu HC, Goss TP, Foster CR. Late hematogenous infection of total joint replacement. *J Bone Joint Surg [Am]* 1980;62-A:1345-50.
- Lindqvist C, Slätis P. Dental bacteremia: a neglected cause of arthroplasty infections? *Acta Orthop Scand* 1985;56:506-8.
- Jacobson J, Millard HD, Plezia R, Blankenship JR. Dental treatment and late prosthetic joint infections. *Oral Surg Oral Med Oral Pathol* 1986;61:413-17.
- Strazzeri JC, Anzel S. Infected total hip arthroplasty due to *Actinomyces israelii* after dental extraction: a case report. *Clin Orthop* 1986;210:128-31.
- Sullivan PM, Johnston RC, Kelley SS. Late infection after total hip replacement, caused by an oral organism after dental manipulation: a case report. *J Bone Joint Surg [Am]* 1990;72-A:121-3.
- Cruess RL, Bickel WS, von Kessler KL. Infections in total hips secondary to a primary source elsewhere. *Clin Orthop* 1975;106:99-101.
- Lattimer GL, Keblish PA, Dickson TB Jr, Vernick CG, Finnegan WJ. Hematogenous infection in total joint replacement: recommendations for prophylactic antibiotics. *JAMA* 1979;242:2213-14.
- Cioffi GA, Terezhalmay GT, Taybos GM. Total joint replacement: a consideration for antimicrobial prophylaxis. *Oral Surg Oral Med Oral Pathol* 1988;66:124-9.
- Daly CG, Mitchell DH, Highfield JE, Grossberg DE, Stewart D. Bacteremia due to periodontal probing: a clinical and microbiological investigation. *J Periodontol* 2001;72:210-14.
- Kinane DF, Riggio MP, Walker KF, MacKenzie D, Shearer B. Bacteraemia following periodontal procedures. *J Clin Periodontol* 2005;32:708-13.
- Cherry M, Daly CG, Mitchell D, Highfield J. Effect of rinsing with povidone-iodine on bacteraemia due to scaling: a randomized-controlled trial. *J Clin Periodontol* 2007;34:148-55.
- Forner L, Larsen T, Kilian M, Holmstrup P. Incidence of bacteremia after chewing, tooth brushing and scaling in individuals with periodontal inflammation. *J Clin Periodontol* 2006;33:401-7.
- Burden DJ, Coulter WA, Johnston CD, Mullally B, Stevenson M. The prevalence of bacteraemia on removal of fixed orthodontic appliances. *Eur J Orthod* 2004;26:443-7.
- Brennan MT, Kent ML, Fox PC, Norton HJ, Lockhart PB. The impact of oral disease and nonsurgical treatment on bacteremia in children. *J Am Dent Assoc* 2007;138:80-5.
- Tomás I, Alvarez M, Limeres J, et al. Prevalence, duration and aetiology of bacteraemia following dental extractions. *Oral Dis* 2007;13:56-62.
- Ulualp K, Condon RE. Antibiotic prophylaxis for scheduled operation procedures. *Infect Dis Clin North Am* 1992;6:613-25.
- Murphy AM, Daly CG, Mitchell DH, Stewart D, Curtis BH. Chewing fails to induce oral bacteraemia in patients with periodontal disease. *J Clin Periodontol* 2006;33:730-6.
- Lucas VS, Kyriazidou A, Gelbier M, Roberts GJ. Bacteraemia following debanding and gold chain adjustment. *Eur J Orthod* 2007;29:161-5.
- Lucas VS, Omar J, Vieira A, Roberts GJ. The relationship between odontogenic bacteraemia and orthodontic treatment procedures. *Eur J Orthod* 2002;24:293-301.

47. Coulter WA, Coffey A, Saunders ID, Emmerson AM. Bacteremia in children following dental extraction. *J Dent Res* 1990;69:1691-5.
48. Roberts GJ, Radford P, Holt R. Prophylaxis of dental bacteraemia with oral amoxicillin in children. *Br Dent J* 1987;162:179-82.
49. Roberts GJ, Jaffray EC, Spratt DA, et al. Duration, prevalence and intensity of bacteraemia after dental extractions in children. *Heart* 2006;92:1274-7.
50. Durack DT. Prevention of infective endocarditis. *N Engl J Med* 1995;332:38-44.
51. Pallasch TJ, Wahl MJ. Focal infection: new age or ancient history. *Endodontic Topics* 2003;4:32-45.
52. Trampuz A, Zimmerli W. Antimicrobial agents in orthopaedic surgery: prophylaxis and treatment. *Drugs* 2006;66:1089-5.
53. Sandhu SS, Lowry JC, Morton ME, Reuben SF. Antibiotic prophylaxis, dental treatment and arthroplasty: time to explode a myth. *J Bone Joint Surg [Br]* 1997;79-B:521-2.
54. Roberts GJ, Gardner P, Simmons NA. Optimum sampling time for detection of dental bacteraemia in children. *Int J Cardiol* 1992;35:311-15.
55. Diz Dios P, Tomás Carmona I, Limeros Posse J, et al. Comparative efficacies of amoxicillin, clindamycin, and moxifloxacin in prevention of bacteremia following dental extractions. *Antimicrob Agents Chemother* 2006;50:2996-3002.
56. Lockhart PB, Brennan MT, Kent ML, Norton HJ, Weinrib DA. Impact of amoxicillin prophylaxis on the incidence, nature, and duration of bacteremia in children after intubation and dental procedures. *Circulation* 2004;109:2878-84.
57. Rajasuo A, Perkki K, Nyfors S, Jousimies-Somer H, Meurman JH. Bacteremia following surgical dental extraction with an emphasis on anaerobic strains. *J Dent Res* 2004;83:170-4.
58. Robinson L, Kraus FW, Lazansky JP, et al. Bacteremias of dental origin. II: a study of the factors influencing occurrence and detection. *Oral Surg Oral Med Oral Pathol* 1950;3:923-36.
59. Savarrio L, Mackenzie D, Riggio M, Saunders WP, Bagg J. Detection of bacteraemias during non-surgical root canal treatment. *J Dent* 2005;33:293-303.
60. Guntheroth WG. How important are dental procedures as a cause of infective endocarditis? *Am J Cardiol* 1984;54:797-801.
61. Lockhart PB. An analysis of bacteremias during dental extractions: a double-blind, placebo: controlled study of chlorhexidine. *Arch Intern Med* 1996;156:513-20.
62. Steckelberg JM, Osmon DR. Prosthetic joint infections. In: Bisno AL, Waldvogel FA, eds. *Infections associated with indwelling medical devices*. Third ed. Washington DC: American Society of Microbiology Press, 2000:173-209.
63. Debelian GJ, Olsen I, Tronstad L. Anaerobic bacteremia and fungemia in patients undergoing endodontic therapy: an overview. *Ann Periodontol* 1998;3:281-7.
64. Jaspers MT, Little JW. Prophylactic antibiotic coverage in patients with total arthroplasty: current practice. *J Am Dent Assoc* 1985;111:943-8.
65. Tsevat J, Durand-Zaleski I, Pauker SG. Cost-effectiveness of antibiotic prophylaxis for dental procedures in patients with artificial joints. *Am J Public Health* 1989;79:739-43.
66. Curry S, Phillips H. Joint arthroplasty, dental treatment, and antibiotics: a review. *J Arthroplasty* 2002;17:111-13.
67. Göker K, Güvener O. Antibacterial effects of ofloxacin, clindamycin and sulfamonomethoxime on surgical removal of impacted third molars. *J Marmara Univ Dent Fac* 1992;1:237-49.
68. American Dental Association, American Academy of Orthopaedic Surgeons. Your joint replacement, dental procedures and antibiotics. *J Am Dental Assoc* 2003;134:899.
69. Rossi M, Zimmerli W, Furrer H, et al. Antibiotic prophylaxis for late blood-borne infections of joint prostheses. *Schweiz Ärztezeitung Monatsschr Zahnmed* 2005;115:2085-92.
70. Wahl MJ. Myths of dental-induced prosthetic joint infections. *Clin Infect Dis* 1995;29:1420-5.
71. Moreillon P. Endocarditis prophylaxis revisited: experimental evidence of efficacy and new Swiss recommendations: Swiss Working Group for Endocarditis Prophylaxis. *Schweiz Med Wochenstr* 2000;130:1013-26.
72. Wilson W, Taubert KA, Gewitz M, et al. Prevention of infective endocarditis: guidelines from the American Heart Association. *Circulation* 2007;116:1736-54.
73. Brunner-La Rocca HP, Zuber M, Jaussi A. Endokarditis-Prophylaxe: erste stellungnahme der SLG zu neuen richtlinien der AHA. *Schweizerische Ärztezeitung* 2007;88:1243 (in German).
74. Horstkotte D, Follath F, Gutschik E, et al. Guidelines on prevention, diagnosis and treatment of infective endocarditis executive summary; the task force on infective endocarditis of the European Society of Cardiology. *Eur Heart J* 2004;25:267-76.
75. Hill C, Flamant R, Mazas F, Evrard J. Prophylactic cefazolin versus placebo in total hip replacement: report of a multicentre double-blind randomised trial. *Lancet* 1981;1:795-6.
76. Norden CW. Antibiotic prophylaxis in orthopaedic surgery. *Rev Infect Dis* 1991;13:842-6.
77. Classen DC, Evans RS, Pestotnik SL, et al. The timing of prophylactic administration of antibiotics and the risk of surgical-wound infection. *N Engl J Med* 1992;326:281-6.
78. Ainscow DA, Denham RA. The risk of haematogenous infection in total joint replacements. *J Bone Joint Surg [Br]* 1984;66-B:580-2.
79. Ching DW, Gould IM, Rennie JA, Gibson PH. Prevention of late haematogenous infection in major prosthetic joints. *J Antimicrob Chemother* 1989;23:676-80.
80. Maderazo EG, Judson S, Pasternak H. Late infections of total joint prostheses: a review and recommendations for prevention. *Clin Orthop* 1988;229:131-42.
81. Vergis EN, Demas PN, Vaccarello SJ, Yu VL. Topical antibiotic prophylaxis for bacteremia after dental extractions. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2001;91:162-5.
82. Simmons NA, Ball AP, Cawson RA, et al. Case against antibiotic prophylaxis for dental treatment of patients with joint prostheses. *Lancet* 1992;339:301.
83. Sandhu SS, Lowry JC, Reuben SF, Morton ME. Who decides on the need for antibiotic prophylaxis in patients with major arthroplasties requiring dental treatment: is it a joint responsibility? *Ann R Coll Surg Engl* 1997;79:143-7.
84. Scott JF, Morgan D, Avent M, Graves S, Goss AN. Patients with artificial joints: do they need antibiotic cover for dental treatment? *Aust Dent J* 2005;50:45-53.
85. Krijnen P, Kaandorp CJ, Steyerberg EW, et al. Antibiotic prophylaxis for haematogenous bacterial arthritis in patients with joint disease: a cost effectiveness analysis. *Ann Rheum Dis* 2001;60:359-66.
86. Barry JM, Ferguson CD. Current dental concepts in antibiotic prophylaxis for total joint replacement patients. *Gen Dent* 2000;48:170-2.
87. Wilson MG, Kelley K, Thornhill TS. Infection as a complication of total knee replacement arthroplasty: risk factors and treatment in sixty-seven cases. *J Bone Joint Surg [Am]* 1990;72-A:878-83.
88. Yagiela JA. Prophylactic antibiotics: cardiac and prosthetic considerations. *J Calif Dent Assoc* 1995;23:29-40.
89. Marculescu CE, Osmon DR. Antibiotic prophylaxis in orthopedic prosthetic surgery. *Infect Dis Clin North Am* 2005;19:931-46.
90. Rose RE. Routine prophylactic antibiotics for arthroplasty patients receiving dental care: is it necessary? *West Indian Med J* 2003;52:317-20.
91. Deacon JM, Pagliaro AJ, Zelicof SB, Horowitz HW. Prophylactic use of antibiotics for procedures after total joint replacement. *J Bone Joint Surg [Am]* 1996;78-A:1755-70.
92. Curran JB, Ogle RG, Waite DE. Infection of abnormal heart valves and total joint prosthesis following dental procedures. *Northwest Dent* 1976;55:192-6.
93. Field EA, Martin MV. Prophylactic antibiotics for patients with artificial joints undergoing oral and dental surgery: necessary or not? *Br J Oral Maxillofac Surg* 1991;29:341-6.
94. McGowan DA, Hendrey ML. Is antibiotic prophylaxis required for dental patients with joint replacements? *Br Dent J* 1985;158:336-8.
95. Tzuket A, Leviner E, Sela M. Prevention of infective endocarditis: not by antibiotics alone: a 7-year follow-up of 90 dental patients. *Oral Surg Oral Med Oral Pathol* 1986;62:385-8.