Review Article

Implant periapical lesion — literature review

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The etiologies and mechanisms of implant failure are multifactorial. Implant periapical lesion (IPL) is one possible cause of implant failure. IPL is an infectious-inflammatory alterations surrounding an implant apex. The diagnosis is based on the clinical manifestations and radiological findings, where a radiolucent lesion can be seen in the periapical area. It is apparent that IPL has a multifactorial background, mainly caused by the presence of a preexisting microbial pathology or surgical trauma during implant surgery. To date, there are no clinical protocols for managing IPL. However, while the etiologies of IPL are still not clearly known, successful treatment is available. The low incidence of pathosis may be due to selective placement of edentulous arches in earlier years. As implants become standard for dentate arches, more of these lesions may be expected. Additional data are certainly necessary for a more-comprehensive understanding of the etiopathologic and clinical problems related to IPL. *(J Dent Sci, 2(4) : 179-192, 2007)*

Key words: implant periapical lesion, retrograde peri-implantitis, periapical implant pathology.

The etiologies and mechanisms of implant failure are multifactorial[1]. Mellonig et al. divided implant failures into infectious failure (peri-implantitis) and traumatic failure (retrograde peri-implantitis)[2]. Implant periapical lesion (IPL), which is less often reported, is one possible cause of implant failure[3-7]. Implant periapical lesion was first described in 1992, McAllister reported 2 implant cases in which a periapical radiolucency developed, with a sinus tract, while the implants were still submerged[8].

IPL is an infectious-inflammatory alterations surrounding an implant apex[9]. The diagnosis is based on the clinical manifestations and radiological findings, where a radiolucency can be seen at the periapical level[9]. Implant periapical lesions[12] have also been referred to as periapical implant pathology[10], endodontic-implant pathology[11], periapical implant lesion[1], retrograde peri-implant infection[5], apical peri-implantitis[4], and retrograde peri-implantitis[6], but there are some differences among the definitions of those terms. An implant periapical lesion is an infection located at the apex of an implant[12]. A periapical implant lesion is a rapid infective process (implant-associated osteolysis), and the coalescence of adjacent periapical pathology with the apical segment of a dental implant that results in a common lesion[5,10]. Retrograde peri-implantitis is defined as a clinically symptomatic lesion (radiolucency) around the most apical part of an osseointegrated implant (while the coronal portion of the implant has achieved a normal bone-to-implant surface), which exhibits the capacity of spreading coronally, proximally, and facially[6]. It usually develops within the first few months after insertion due to bacterial contamination during insertion, premature loading, or the presence of preexisting inflammation[6]. Quirynen et al. stated that retrograde peri-implantitis should also be distinguished from non-integration as occurs when the apex of an implant touches an adjacent root and/or when the implant is inserted in an active endodontic lesion of an adjacent tooth[6].

The main differences between IPL and peri-implantitis lie in the microbial composition, rate of

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expansion, and pathway of infection. Microorganisms found in peri-implantitis are more often associated with periodontal pathogens, whereas those found in IPL resemble the composition of endodontic pathogens[5]. The former can be detected more easily clinically via routine probing, whereas the latter rely on patient complaints and a careful radiographic assessment[5].

The most common site of occurrence of IPL is the maxillary premolars[5]. The higher fracture incidence of thin bifid roots, cementoenamel junction constriction, frequent use of posts, and extraction sockets of premolars, which render infection removal even more limited, may explain the greater incidence of residual infection remaining after extraction of maxillary premolars[5] (Tables 1, 2).

The frequency of occurrence of IPL varies. Reiser (1995) observed only 10 infected implant periapical lesions in approximately 3800 placed implants[12]. Peri-implant apical radiolucencies have been reported to have a prevalence of 0.26%[13]. Quirynen's study revealed that the occurrence was 10 of 539 (1.86%), including 7 implants in the upper jaw (1.6%) and 3 in the lower jaw (2.7%)[6]. But, it was higher (9.9%) in Balshi's report[14]. The low incidence of IPL may be due to selective placement into edentulous arches in earlier years. As implants become standard for dentate arches, more of these lesions may be expected[15].

Classification

The classification of IPL can be separated into active and inactive lesions (according to the activity of the infection)[12]. Inactive lesions are likely to be an apical scar, resulting from a residual bone cavity created by placing an implant that was shorter than the prepared drill site. Infected lesions probably occur when an implant apex is placed in proximity to an existing infection or when a contaminated implant is put in place. Bone necrosis caused by overheating during preparation may also be a causative factor[12]. Lesions are also classified according to their evolutive stage as either an acute (non-suppurated and suppurated) or chronic (or periapical abscess)[9] infection.

Quirynen et al. reported that retrograde peri-implantitis is often accompanied by symptoms of pain, tenderness, swelling, and/or the presence of a fistulous tract. It should be distinguished from a clinically asymptomatic, peri-apical radiolucency, which is usually caused by placing implants that are shorter than the drilled cavity or by heat-induced aseptic bone necrosis[6].

Endodontic-implant pathology can be divided into 2 case types according to the main infection pathway: 1) implant to tooth, which occurs during osteotomy preparation either by direct trauma or through indirect damage which causes the adjacent pulp to undergo devitalization and 2) tooth to implant, which occurs shortly after placement of the implant when an adjacent tooth develops a periapical pathology, either by operative damage to the pulp or through reactivation of a prior apical lesion[10]. In both types, the resulting periapical pathology contaminates the fixture and inhibits osseointegration of the implant during stage I healing[10].

Etioloyg

It is apparent that IPL has a multifactorial background, mainly caused by the presence of a preexisting microbial pathology or surgical trauma during implant surgery[7]. It is still not certain whether an implant periapical lesion is composed of healthy tissue, new tissue destruction, or activation of a preexisting condition[16]. There is growing doubt that implants become infected through hematogenous routes and that, instead, late infections are caused by bacteria present at the time of surgery[4]. Occlusally related bone microfractures, buccal plate fenestration, development of osteomyelitis, overheating, implant surface contamination from intraoral sources, and poor bone quality are still controversial etiologies. Microbial contamination appears to be the predominant causative factor[5].

Possible etiologies which induce periapical implant lesions can be divided into 3 parts:

(1) Implant factors: including contamination of the implant surface during production or insertion[12,16], lack of biocompatibility[12,16], and different implant surface designs[16].

The incidence of IPL was significantly higher for TiUnite (micropores) implants than for machined implants[6], but the machined implant surfaces showed a higher treatment failure rate than the TiUnite implants[6]. When coming in contact with a granuloma or endodontic pathology, machined implants are soon completely surrounded by granulation tissue. But, the coronal part of the TiUnite implant still integrates

Table 1. Characteristics of implants with implant periapical lesion in the literature

Study	No. of implants and implant sites	Implant system
1992 McAllister et al.[8]	5; maxillary anterior (4) and maxillary lateral incisor and canine area (1)	Titanium fixtures and HA-coated fixtures
1993 Sussman et al.[11]	1; mandibular central incisor	Screw-Vent (Dentsply)
1995 Reiser[12]	10; maxillary canine (1), premolars (5), mandibular incisors (2), premolars (2)	NA
1995 Piattelli et al.[29]	1; maxillary first premolar	Implant Innovations, West Palm Beach, FL
1997 Bretz et al.[31]	1; maxillary lateral incisor	Sterngold (ImplaMed)
1997 Sussman[19]	1; maxillary first molar	Screw-vent implant (Dentsply)
1998 Sussman[10]	4; maxillary molar, mandibular anterior/ premolar	NA
1998 Piattelli et al.[16]	1; mandible premolar	Bonefit (ITI;Titanium plasma-sprayed)
1998 Piattelli et al.[17]	1; maxillary premolar	Branemark
1998 Shaffer et al.[15]	7; mandibular premolars and molar (3), maxillary premolar (1), mandibular canine (1), and maxillary premolar and canine (2)	Branemark (cases 1 and 2) NA (case 3) Corevent (case 4)
2000 Scarano et al.[18]	1; mandibular premolar	Screw-shaped titanium
2001 Jalbout et al.[3]	4; maxillary first premolar (cases 1 and 4) and maxillary central incisor (cases 2 and 3)	Branemark
2001 Ayangco et al.[32]	3; maxillary premolar (cases 1 and 2), mandibular canine	Branemark
2001 Brisman et al.[22]	4; mandibular incisor, mandibular first molar, mandibular first molar, and mandibular second premolar	NA
2002 Flanagan[4]	1; maxillary premolar	3 *i* Osseotite
2003 Oh et al.[7]	1; mandibular first molar	Branemark
2004 Park et al.[5]	1; maxillary premolar	Branemark Mark III
2005 Tseng et al.[20]	1; mandibular second premolar	ITI
2005 Quirynen et al.[6]	10; maxilla (7; 1,6%) and mandible (3; 2.7%)	Branemark TiUnite vs. machined
2006 Tozum et al.[1]	1; maxillary later incisor	Screw-shaped titanium
2007 Balshi et al.[14]	39; maxilla (9 anterior + 8 posterior) and mandible (11 anterior + 11 posterior)	Branemark
2007 Wang et al.[21]	3; mandibular premolar and molar (#19, #20, and #29)	ITI

Table 2. Characteristics of implant sites with implant periapical lesion in the literature

Study	Time after extraction	Cause of tooth loss
1992 McAllister et al.[8]	Immediate (case 1) 7 months (case 2)	Periodontitis and periapical lesion (cases 1 and 2)
1993 Sussman et al.[11]	Immediate	Tooth fracture
1995 Reiser[12]	NA	NA
1995 Piattelli et al.[29]	10 months	Caries
1997 Bretz et al.[31]	3 years	Root fracture after endodontic treatment
1997 Sussman[19]	2 months	Endo-periodontal combination
1998 Sussman[10]	NA	NA
1998 Piattelli et al.[16]	NA	No preexisting bone pathology
1998 Piattelli et al.[17]	2 months	Non-restorable caries
1998 Shaffer et al.[15]	NA	NA (cases 1, 2, and 4) and failed endodontic treatment (case 3)
2000 Scarano et al.[18]	NA	NA
2001 Jalbout et al.[3]	NA (cases 1 and 4), 1 year (case 2), and 8 months (case 3)	Failed fixed partial denture (FPD) (case 1), tooth fracture (case 2), failed FPD (case 3), and NA (case 4)
2001 Ayangco et al.[32]	9 weeks (case 1) and 4 months (case 2)	Failed endodontic and apicoectomy procedures
2001 Brisman et al.[22]	7~8 months 3 months NA 7 months	Periodontitis and periapical pathology Endodontic + hemisection NA Periodontitis and caries (alloplastic bone graft)
2002 Flanagan[4]	3 months	Failed endodontic treatment
2003 Oh et al.[7]	3 months	Distal root fracture of first molar and hemisection
2004 Park et al.[5]	8 years	Caries
2005 Tseng et al.[20]	NA	NA
2005 Quirynen et al.[6]	At least 6 months, even to several years	Maxilla: periodontitis, fracture, an apical lesion, agenesis, and trauma, and mandible: caries and an apical lesion
2006 Tozum et al.[1]	1 year	Trauma
2007 Balshi et al.[14]	Immediate implantation (failed implant)	Periodontitis (failed implant)
2007 Wang et al.[21]	NA	Fractured bridge [spell out] and apical periodontitis (#29)

before the fibrous capsulation can reach this area, which results in a lower treatment failure rate[6].

(2) Patient factors: including the presence of a preexisting or adjacent bone pathology (of endodontic or periodontal origin)[1,16-20], the presence of residual root fragments or foreign bodies in the bone[5,12,16-18], implant placement in an infected maxillary sinus[12,16-18], implant placement in a site with poor bone quality[16-18], patients using long-term oral bisphosphonates[21], and smoking[4].

It was suggested that dental implants do not possess the ability to withstand any bacterial challenge during the first stage of osseointegration[11]. When the characteristics of the recipient sites with an IPL were compared with those of successful implants, it was obvious that the incidences of a periapical lesion on the extracted tooth and endodontic pathology/therapy on both the extracted and adjacent teeth were clearly higher[6]. Whether the direct extension of bacterial endotoxins, inflammatory cells, or bacteria themselves are responsible for the contamination and loss of integration of the implant fixture is uncertain[15]. Any plaque-infected lesion may have the potential to spread in a lateral direction (2.0 mm) by traveling through marrow spaces[11]. More-rapid tracking of infection or inflammation has been proposed to be associated with the larger marrow space and nutrient canals in bone, such as the maxilla [5].

Asymptomatic endodontically treated teeth with a normal periapical radiographic appearance could be the cause of implant failure[22,23], because microorganisms may persist even though the endodontic treatment was considered radiographically successful.[6] Even though radiographs may indicate optimal healing, the apex of an endodontically treated tooth often exhibits histological signs of inflammation or persistent microorganisms[6,24-26]. Remaining pathologies are often not detectable on radiographs, and even on tomograms or computed tomographic (CT) scans, these lesions are difficult to diagnose[6]. Since radiographs are only 2-dimensional views of the root, they may lead the practitioner to leave part of the canal space untouched and, therefore, not properly treated[22]. Radiographic resolution of a periapical lesion might not signify the eradication of a bacterial reservoir clinically or histologically[7]. The inability to consistently identify endodontically treated teeth that have potential microbial contamination has resulted in a new dilemma surrounding implant cases[22].

Endodontic lesions are polymicrobial in natural, and are associated with black-pigmented gramnegative rods, such as *Actinomyces, Propionibacterium, Streptococcus,* and *Staphylococcus*[5]. Pathology reports of IPL revealed coccal and filamentous microbes[8]. Bacterial cultures, which may be from apical lesions of adjacent teeth, revealed *Klebsiella pneumonia,* group D (Enterococcus) *streptococci,* gram-positive cocci, *Corynebacterium species,* and *alpha-hemolytic streptococci*[15].

Root canal treatment cannot eradicate all of the microorganisms, and this may allow colonization of the surrounding periapical tissue[27]. These bacteria probably remain after extraction in small islands that escape the acuity of intraoral radiographs[4]. It would appear that even after thorough debridement / irrigation of the extraction sockets and a short healing time, bacteria (or cysts/granulomas) remain in the bone, and lead to the initiation of retrograde peri-implantitis[6,8,11]. Encapsulation is a bacterial survival mechanism. The bone at the implant site may have contained residual encapsulated bacteria, which were then activated by the implant osteotomy, reinstating the infection at the apex of the implant[4]. *Bacteroides forsythus* has been shown to persist in asymptomatic periradicular endodontic lesions and may persist and survive in bone in an encapsulated form after an extraction and infect a newly placed implant[4].

(3) Dentist factors: including overheating of the bone (traumatic factor)[16-18,28], excessive tightening of the implant with compression of the bone chips[16-18], overloading of the implant[16-18], and accidental implantation of gingival epithelial cells[18].

IPL is often associated with implants that may have been inserted traumatically[7]. In placing the implant fixture close to an adjacent tooth, the blood supply may be compromised, not only from the periosteum (flap elevation), but also from the osteotomy itself[11]. Excessive bone heat during placement and premature loading may also be involved in the etiology[8]. Overheating can result from insufficient cooling of drills and/or the implant, as well as the use of excessive drilling speed and exertion of excessive force when instrumenting dense bone[12]. Frictional heat generated during site preparation can result in necrosis of local progenitor cells and represents a primary cause for failed implant integration. The relative infrequency of the occurrence of infected implant periapical lesions led to the hypothesis that it most likely occurs when there is

bacterial contamination present, or it is carried to a planned implant with concurrent bone necrosis as a result of overheating[12].

Histologic examinations of IPL showed necrotic bone and inflammatory infiltrate inside the apical hollow portion of the implant[14,16-18,29]. This may be related to fracture and vascular impairment of the bone inside the implant during insertion, bone overheating associated with excessive tightening of the implant and compression of the bone chips inside the apical hole, or contamination of the apical portion of the implant, which subsequently produces necrosis[16-18].

Macromovement as a result of premature loading of the provisional prosthesis results in failure of the implant to osseointegrate. But, micromovement in immediately loaded implants and single-stage implants has never been reported to cause periapical lesions[3] (Table 3).

Diagnosis

A radiographic periapical radiolucency is sometimes asymptomatic[3]. It is necessary to distinguish lesions that are inactive from those that are obviously infected. Distinguishing an infected from an inactive form of IPL cannot readily be done unless clinical symptoms such as suppuration or fistula formation develop[18]. Active or infective lesions tend to increase in size, be symptomatic, and result in fistula formation[18]. Treatments of IPL vary according to the type of lesion. Inactive lesions, which are observed and monitored, do not need further treatment unless their size increases[6,12]. After an infected implant periapical lesion is discovered, it should be treated aggressively[12]. Understanding the time of onset and recognizing early signs and symptoms of IPL are crucial to limit the associated damage[5].

Clinically, patients may complain of swelling, a facial fistula, sometimes associated with tenderness, and a deep periodontal pocket usually accompanies the appearance of infected implant periapical lesions, which are demonstrated by a periapical radiograph[1,3,12]. Formation of a sinus tract is the most common clinical manifestation, but severe pain is an uncommon finding and pocketing is rare[5].

During phase I healing, radiographs are a valuable aid in the early detection of these lesions, perhaps even prior to sinus tract formation. Immediate postoperative radiographs are essential for evaluating implant placement and for use as a baseline in cases with bony changes[8]. Periapical radiographs in the third month of first-stage healing should be routinely taken as a guideline for chronic IPL[5]. But, the lesion might not be evident on periapical radiographs of the mandible, it should be clearly evident with a CT study or occlusal radiograph[1,12,30]. It can be confirmed by extraoral fistulation or a swelling in the floor of the mouth[12] (Table 4).

Management

Treatment varies according to the type of lesion[6,9,12]. The primary goal of periapical lesion treatment is the elimination of infection; the second objective is implant survival[5]. The treatment guidelines are based on 4 phases: 1) recognition of early signs and symptoms, 2) identification of the causes, 3) removal of the infection sources, and 4) reconstruction of the lost host tissue for immediate or future implant placement[5].

Therapies for IPL are similar to those for peri-implantitis: 1) non-surgical treatment with systemic antibiotics; 2) resective treatments including debridement along with detoxification of the implant surface and an intraoral apicoectomy (implant apex) procedure; 3) regenerative treatments including debridement, detoxification of the implant surface, an intraoral apicoectomy (implant apex) procedure, and guided bone regeneration; and 4) removal of the infected implant[1,3-8,10-12,14-22,29,31,32] (Tables 5, 6).

(1) Nonsurgical treatments

Monotherapy via systemic antibiotics cannot achieve complete resolution of IPL[5]. At best, systemic antibiotic therapy results in partial resolution of the clinical symptoms associated with the periapical lesion, while in another instance, even temporary sinus tract healing was not revealed[3,29]. Antibiotic administration alone is unlikely to be successful because of the difficulties in eradicating bacterial colonies from IPL[15]. Antibiotics can be used as an adjutant to reduce the level of infection prior to surgery rather than to induce resolution of the lesion[3,5].

The criteria for selecting antibiotics differ, and include the etiology, the presence or absence of pain and an abscess, the time of onset, and whether the endodontic lesion is open or closed[5]. Penicillin, clindamycin, and erythromycin are first-line an-

Table 3. Possible etiologies of implant periapical lesion

Study	Etiology
1992 McAllister et al.[8]	Periapically involved tooth, fenestrations and soft tissue involvement at apical region of implants; periapically involved tooth
1993 Sussman et al.[11]	Placement of a fixture into an immediate or potentially infected extraction socket; the distance between the fixture and the adjacent natural teeth; drainage of inflammation via marrow spaces; the health of adjacent teeth; development of an osteomyelitis; loss of bone due to a mucoperiosteal flap procedure; the technique of the particular implant system used
1995 Reiser[12]	Inactive lesion (scar); infective lesion due to contamination and overheating
1995 Piattelli et al.[29]	NA (unknown)
1997 Bretz et al.[31]	Unknown
1997 Sussman[19]	Bacterial contamination from an endodontic lesion of an adjacent tooth (endodontic implant pathology)
1998 Sussman[10]	Implant to tooth -- due to bone overheating, indirect or direct trauma to the tooth root; tooth to implant -- due to periapical pathology leading to contamination of the implant
1998 Piattelli et al.[16]	Bone overheating, fracture of the bone inside the hollow portion with vascular impairment, contamination of implant surface, and poor bone quality
1998 Piattelli et al.[17]	Bone overheating, poor bone quality, and excessive tightening of the implant with compression of the bone chips
1998 Shaffer et al.[15]	Periapical lesion of an adjacent natural tooth
2000 Scarano et al.[18]	Contamination of the implant surface (most probable), bone overheating, and poor quality of the bone site
2001 Jalbout et al.[3]	With no clear etiology (may be microbial involvement and overheating)
2001 Ayangco et al.[32]	Preexisting infection in the bone (failed endodontic treatment)
2001 Brisman et al.[22]	Adjacent endodontically treated tooth (even 12 years previous in case 4)
2002 Flanagan[4]	Residual infection of failed endodontic therapy
2003 Oh et al.[7]	Preexisting endodontic lesion
2004 Park et al.[5]	Retained root tip
2005 Tseng et al.[20]	Periapical lesion of an adjacent natural tooth (radicular cyst) and mandibular first molar with 3 canals
2005 Quirynen et al.[6]	Periapical lesion on extracted and/or adjacent teeth and impacted canine
2006 Tozum et al.[1]	Non-vital central incisor
2007 Balshi et al.[14]	Multifactorial
2007 Wang et al.[21]	Effect of long-term oral bisphosphonates (> 10 years)

Table 4. Symptoms and signs of implant periapical lesion

Study	Onset time	Symptoms and signs
1992 McAllister et al.[8]	Stage I (3 months) Stage II (7 months)	Fistula and apical radiolucency Sinus tract, exudate, and apical radiolucency
1993 Sussman et al.[11]	Stage I (2 weeks) Stage I (3 weeks)	Sensitivity to cold and percussion, apical radiolucency on adjacent later incisor Lateral and apical radiolucency on implant fixture
1995 Reiser[12]	NA	Fistula, tenderness, and apical radiolucency
1995 Piattelli et al.[29]	Stage I (2 months)	Swelling, pain, fistula with purulent discharge, and apical radiolucency
1997 Bretz et al.[31]	Stage II	Fistula and apical radiolucency
1997 Sussman[19]	Stage I(1 month)	Swelling, apical radiolucency (second premolar), and tenderness
1998 Sussman[10]	Stage I	Apical radiolucency
1998 Piattelli et al.[16]	Stage I	Fistula, apical radiolucency, swelling pain, redness, exudate, and no probing depth
1998 Piattelli et al.[17]	Stage I (7 month)	Fistula and apical radiolucency
1998 Shaffer et al.[15]	Stage I (2 months) Stage I (3months) Stage I (4 months) Stage I (2 months - canine) Stage II (11 months, 1st premolar)	Swelling and apical radiolucency Apical swelling Sensitivity and swelling (4 months) → soreness (7 months) Abscess (2 and 5 months) → soreness and swelling (15 months)
2000 Scarano et al.[18]	Stage I (6 months)	Dull, persistent pain, no fistula, and apical radiolucency
2001 Jalbout et al.[3]	Stage I (5 months) Stage II Stage II Post-loading (3 months)	Apical radiolucency (5 months) and sinus tract (post-loading 2 and 14 months) Apical radiolucency (post-stage II 1 month), sinus tract with purulent exudate, and swelling pain (post-loading) Apical radiolucency and palpation pain (post-stage II 4 month) Sinus tract with purulent discharge and apical radiolucency
2001 Ayangco et al.[32]	After loading at 18 months After loading at 9 months Stage I (1 month)	Swelling, fistula, and apical radiolucency Tenderness, no significant probing depth, and stable apical radiolucency Throbbing pain, tenderness, apical radiolucency
2001 Brisman et al.[22]	Stage I (6 weeks) Stage II (4 months) Stage II (4 months) Stage I (2 weeks)	Fistula and apical radiolucency Mobile implant (first time) and fistula (second time) Apical radiolucency Palpation pain, erythema, swelling, and apical radiolucency → severe pain
2002 Flanagan[4]	Stage I (10 weeks)	Apical radiolucency, a loose cover screw, sinus tract, no pocketing, and immobility
2003 Oh et al.[7]	Stage II (3 months)	Fistula, radiolucency (from the apex to the mesial surface), and mobility
2004 Park et al.[5]	Stage I (22 days)	Incision line opening, fluctuant buccal swelling, tenderness, then a fistula, and radiographic osteolysis
2005 Tseng et al.[20]	Post-implantation (6 months)	Gingival recession, pocket depth (9 mm), and apical radiolucency
2005 Quirynen et al.[6]	Stage I (7) Stage II (3)	Fistula, obvious pus, pain, swelling
2006 Tozum et al.[1]	Post-loading (5 years)	7-mm probing depth with pus formation, fistula, and periapical radiolucency
2007 Balshi et al.[14]	Average of 1.64 years (31/39: within first 2 years; 8/39: 2~11 years)	Periapical radiolucency; 66.7% with swelling, suppuration, and fistula
2007 Wang et al.[21]	Stage I (6 weeks: #19 and #20) Stage I (7 weeks: #29)	Fluctuant swelling (suppuration) and periapical radiolucency (#19 and #20) Radiolucency (#29)

Table 5. Antibiotics used for treating implant periapical lesion

Study	Antibiotics used
1992 McAllister et al.[8]	Amoxicillin 250 mg TID and metronidazole 250 mg TID prior to surgical treatment
1993 Sussman et al.[11]	Penicillin 500 mg TID for 7 days (implant placement)
1995 Reiser[12]	Antibiotic therapy for 7 days (surgical treatment)
1995 Piattelli et al.[29]	Antibiotic for 10 days (implant placement and IPL)
1997 Bretz et al.[31]	Amoxicillin 500 mg QID + Cicladol 20 mg QD for 7 days (surgical treatment)
1997 Sussman[19]	Penicillin 500 mg TID for 7 days (ridge preservation)
1998 Sussman[10]	NA
1998 Piattelli et al.[16]	Metronidazole + actisite fibers (Alza) prior to removal of implant
1998 Piattelli et al.[17]	Metronidazole prior to removal of implant
1998 Shaffer et al.[15]	Tetracycline (with bone graft for guided bone regeneration in case 2) Cephalosporin 250 mg QID (surgical treatment) → tetracycline (Enterococcus streptococcus in case 4)
2000 Scarano et al.[18]	NA
2001 Jalbout et al.[3]	Amoxicillin 500 mg TID for 7 days prior to surgical treatment (case 1)
2001 Ayangco et al.[32]	Tetracycline paste for detoxification (all 3 cases), amoxicillin 500 mg TID for 7 days (case 2)
2001 Brisman et al.[22]	Amoxicillin 500 mg TID for 7 days (implant placement) (cases 1~3) Clindamycin 300 mg QID for 2 days, then 150 mg QID for 7 days → antibiotic use after surgical treatment (case 4)
2002 Flanagan[4]	Penicillin 500 mg QID for 7 days with 2-g loading dose (endodontic flare-up) → doxycycline 100 mg BID for 10 days (implant placement) → penicillin 500 mg QID for 7 days prior to surgical treatment
2003 Oh et al.[7]	No antibiotic use (first implant placement) → amoxicillin 500 mg TID for 10 days (second implant placement)
2004 Park et al.[5]	Amoxicillin TID for 7 days (implant placement) → amoxicillin TID for 14 days (fluctuant swelling) → azithromycin 500 mg for 3 days (fistula formation) → surgical treatment
2005 Tseng et al.[20]	NA
2005 Quirynen et al.[6]	NA
2006 Tozum et al.[1]	Amoxicillin 500 mg QID for 10 days (surgical treatment)
2007 Balshi et al.[14]	Amoxicillin 500 mg QID (surgical treatment)
2007 Wang et al.[21]	Azithromycin 500 mg every day for 3 days at implant surgery and incision & drainage → cephalexin (Keflex) 500 mg QID for 14 days , then azithromycin 500 mg every day for 3 days (surgical treatment)

Table 6. Different treatments for implant periodontal lesion

Study	Treatment	Outcome
1992 McAllister et al.[8]	Antibiotic → regenerative treatment	All treated successfully
1993 Sussman et al.[11]	Endodontic treatment on adjacent tooth	Removal of implant
1995 Reiser[12]	Inactive lesion: follow-up Infection lesion: surgical treatment	Inactive lesion: survived Infection lesion: various
1995 Piattelli et al.[29]	Antibiotic → regenerative treatment	Removal of implant
1997 Bretz et al.[31]	Regenerative treatment	Survived (bone fill)
1997 Sussman[19]	Endodontic therapy on devitalized tooth	Removal of implant
1998 Sussman[10]	Endodontic treatment of non-vital tooth	Removal of implant
1998 Piattelli et al.[16]	Metronidazole + actsite fibers	Removal of implant
1998 Piattelli et al.[17]	Metronidazole	Removal of implant
1998 Shaffer et al.[15]	Removal of implants and GBR Apical resection of implant and GBR Apical resection of implant Antibiotic and open curettage	3 new implants placed Survived (in function) Survived (in function) Removal of implants
2000 Scarano et al.[18]	Medication	Removal of implant
2001 Jalbout et al.[3]	Antibiotic failed → GBR (cases 1~4)	All 4 cases successful
2001 Ayangco et al.[32]	Debridement and antibiotics	Survived (in function)
2001 Brisman et al.[22]	Removal of implant + an apicoectomy Removal of implant + GBR; no endodontic retreatment Removal of implant Incision & drainage, and antibiotics → debridement	New implant placement New implant with fistula formation within 4 weeks NA Infection resolved
2002 Flanagan[4]	Debridement, $Ca(OH)_2$ in defect	Survived
2003 Oh et al.[7]	Removal of implant, antibiotics, and debridement	New implant successfully replaced (after 3 months)
2004 Park et al.[5]	Antibiotics, debridement, and removal of implant and root tip	GBR and a wide implant placed simultaneously
2005 Tseng et al.[20]	Removal of implant and GBR	New implant (at 6 months)
2005 Quirynen et al.[6]	Maxilla: debridement and bone grafting (4 of 7) Mandible: trepanation and antibiotics	Maxilla: all successful Mandible: 1of 3 failed
2006 Tozum et al.[1]	GBR (NO detoxification)	Successful (bone fill)
2007 Balshi et al.[14]	Debridement, implant apicoectomies, antibiotics; 72% of cases with GBR	38 of 39 successful
2007 Wang et al.[21]	From alendronate to teriparatid antibiotics + I&D; GBR (#19 and #20) Follow-up (#29)	Successful (bone healing on #19, #20, and#29)

tibiotics for dental infections[4]. Bacteria associated with failing implants have been found to be sensitive to the following antibiotics: penicillin G, amoxicillin, a combination of amoxicillin and metronidazole, and amoxicillin-clavulanate[32]. But, it is difficult to obtain a culture from IPL sites[4], and patient compliance can be a problem with antibiotic administration[4]. Therefore, systemic antibiotics should not be used as the sole therapeutic method for treating IPL, and definitive surgical intervention should take place within 1 month of IPL onset to limit the extent of disease progression[5] (Table 5).

(2) Resective treatments

Antibiotics are unsuccessful because the underlying problem and bacterial source are not eliminated[15]. Therefore, when lesions persist, meticulous debridement or removal of the infection sources, including the contaminated apex of the implant and endodontic/periodontal lesions, or the complete removal of an implant if it is not osseointegrated is essential[7,15]. Based on recent knowledge, if the dental implant exhibits stable osseointegration and the periapical lesion does not risk the adjacent region, it is suggested that removing the implant be avoided, and complete debridement of the lesion be performed[1].

Surgical intervention comprises 3 steps: (1) removal of infected tissue via mechanical debridement; (2) decontamination of the implant surface; and (3) thorough rinsing of the infected bony housing to remove detached microorganisms and prevent further colony formation via a nucleation effect[5].

A semilunar flap should be elevated to avoid anatomically vital structures and preserve marginal tissues except when the marginal buccal bone is expected to be involved and removal of the implant is anticipated[3]. Surgical access is also more restricted with IPL, rendering infection removal more unpredictable[5]. For implants involving the mandible, an intraoral transmandibular approach, intraoral periosteal dissection, and an extraoral approach have been proposed[29].

Debridement is accomplished using conventional stainless steel surgical instruments. There is no need to be concerned about scratching or roughening the titanium at the apical portion of the implant[32].

Several chemical techniques using citric acid, chlorhexidine gel, stannous fluoride, tetracycline hydrochloride, polymyxin B, and chloramine T and hydrogen peroxide have been proposed to disinfect implant surfaces[31,32]. Some pathogens can withstand the acid attack of an agent such as chlorhexidine and citric acid. Calcium hydroxide has been shown to be a better inhibitor of growth activity of bacterial species commonly involved in endodontic infections than chlorhexidine[4].

Clinicians should consider preserving the implant apex only if the implant periapical lesion is small and the infection is completely accessible[12]. Quirynen et al. indicated that the removal of all granulation tissue is sufficient to arrest the progression of bone destruction. The removal of the apical part of the implant does not seem mandatory[6].

Treatment of an infection at the apex of an implant can tax the surgical capabilities of a clinician[29]. Retaining the apical aspect of the implant, which is coated with a bacterial-laden biofilm, can obstruct the complete mechanical removal of the granulation tissue and limit the opportunity to eliminate the infection, resulting in failure[12]. Salvaging the implant should be attempted via an implant apicoectomy if (1) sufficient osseointegration remains, (2) the infection is compartmentalized to the apex, (3) the defect and implant surface are completely accessible, and (4) sufficient length remains to allow for removal of the apical portion[12,14]. The implant remains unloaded for a minimum of 6 months to allow for wound healing and bone maturation[12]. The titanium can be cut more cleanly using a carbide bur compared to a diamond bur, which has a tendency to shred the titanium[12].

Once the lesion reaches the portion of the implant that has an internal screw thread, an implant apicoectomy is no longer possible, since a channel would then exist between the oral cavity and the osseous environment for bacterial migration. Other treatment options, such as antibiotics and detoxification, are recommended prior to implant removal[14].

(3) Regenerative treatments

Reconstruction of the lost tissue is the last phase of IPL management. Controversy about the use of membranes and bone substitutes still exists, but the use of occlusive membranes in critical-sizes defect (> 5-mm-diameter defects) seems important for optimal bone formation and maturation[5]. The bone substitute is to prevent membrane collapse, and to localize a high

concentration of antibiotics in the infected site for a longer period[5].

The type of healing achieved appears to include a fibrous band of tissue between the implant and bone graft, and reosseointegration might not be achieved[3]. In one study, reosseointegration failed to occur or was minimal and difficult to achieve on meticulously cleaned implant surfaces that had been exposed to bacterial contamination[5].

(4) Removal of failed implants

The breakdown around natural teeth is not the same as that around implants. Lindhe et al. reported that the latter lesion is osteomyelitis not periodontitis, so treatment would probably fail. Therefore, the best course of action would be to remove the implant fixture[33].

After removal of failed implants, another controversy seems to be whether bone augmentation should proceed with a staged approach or a simultaneous approach[5,7,24]. The latter method can reduce treatment time, but there is a higher risk associated with potential recurrence of the infection[5].

Treatment of an infection at the apex of an implant can be very difficult[11]. To date, there has been an absence of clinical protocols for managing implant periapical lesions[12]. However, while a clean etiology of IPL is still unknown, successful treatment is available[8].

Prevention

IPL is preventable disease. A combination of careful evaluation of planned implant sites for potential contaminants, careful surgical techniques, and maintaining meticulous sterilization techniques may limit the incidence of infected implant periapical lesions[7,12].

1. Evaluation of implant sites for potential contamination

Proper radiographic assessment and evaluation of the past history of the extracted teeth cannot be overlooked[5]. Pepelassi et al. demonstrated that periapical radiography detected 61.8% of 1234 osseous defects, whereas panoramic radiography detected only 21.0% of them. Neither method, however, is reliable for detecting moderate-sized periapical osseous defects[34]. Periapical radiographs should be taken of the future implant site and adjacent teeth, in addition to any panoramic views[15].

The meticulous removal of granulation tissue, root fragments, foreign bodies, and infection (periodontal or periapical) from the proposed implant site is critical[12]. Note that if there is postextraction residual infection in the medullary bone, the apex of the implant may be contaminated through tracking[10]. It can be speculated that complete removal of etiologic factors by thorough debridement of the socket, in addition to the use of antibiotics, can reduce or eliminate any infection that has resulted from bacterial contamination[5,7,8].

The cortical plate being engaged circumferentially will likely result in fenestration during normal remodeling following wound healing[8]. Soft-tissue involvement is a potential location for microbe penetration as well as soft-tissue encapsulation. Therefore, augmentation of the involved area with bone graft techniques and/or guided tissue regeneration techniques is indicated at the time of implant placement[8].

Immediate implant placement in acutely infected sockets should not be performed[3], and implants should only be placed when bone filling has occurred and radiographic pathology is not detected in the extraction wound[3]. Shabahang et al. reported that eliminating contaminated soft and hard tissues by meticulous debridement and a peripheral alveolar ostectomy, combined with pre- and postoperative antibiotics, should eradicate the infection and establish a favorable basis for bone healing and osseointegration with immediate implantation[35].

The dental practitioner should not only carefully evaluate the surgical area but also examine and follow up the adjacent teeth and/or alveolar bone to achieve successful long-term outcomes[1]. Adjacent teeth that exhibit periodontal disease or periapical infections should be treated or extracted before implant placement[12,15], and an implant should only be placed once the infection of adjacent teeth is stabilized[5]. Prophylactic endodontic therapy of a nearby tooth may be prudent therapy before implant placement[10]. Therefore, a vitality test of adjacent teeth and quality assessment of their endodontic treatment should be part of routine implant treatment planning[5].

Most *streptococci,* common dental infectious agents, are very susceptible to penicillin. *Bacteroides spp*. are inhabitants of tooth periapical lesions[4]. These

bacteria are susceptible to metronidazole, cefoxitin, chloramphenicol, and clindamycin. Therefore, penicillin or higher doses of clindamycin or erythromycin should be considered for routine prophylaxis during implant surgery, especially with failed endodontics, to prevent IPL[4].

2. Maintaining careful, sterile surgical techniques

Anytime an osteotomy is performed, an iatrogenic component can be introduced[11]. This may be due to using improper techniques or to malfunctioning equipment when preparing the implant site[11]. Biologically related early losses were calculated on a sample of 16,935 Branemark implants and found to be 3.6%[13]. Many early failures can probably be explained by improper surgical techniques[18]. Suggested preventive strategies of implant periapical lesions include careful management of contaminants and heat generation during implant surgery[12].

Because increased bone density creates bone coolant problems, additional temperature control can be achieved by cooling the drills and the drill site with water irrigation between drilling steps. Less cooling will take place the deeper the drill site is in the bone, so intermittent drilling (or pumping) allows for better drill cooling[12]. Therefore, whatever system is utilized, the operator should remove the bur from the bone to allow for proper cooling every 15 to 20 seconds[11].

The fixture should be removed from the commercial packing just prior to installation. It should never come in contact with saliva, teeth, oral tissues, or the lips[12].

CONCLUSIONS

Although implant periapical lesion occurs infrequently in the literature, it remains a valid concern to the success and longevity of osseointegrated implants. With careful planning, periapical implant lesion is preventable. There is no conclusive evidence at this time to support a specific approach. Treating the lesion lacks systemic scientific validation and is based mainly on empirical experience and inferences from in vitro findings. Additional data are certainly necessary for a more-comprehensive understanding of the etiopathologic and clinical problems related to implant periapical lesion.

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