Review Article

Is The Periapical lesion a Risk For Periimplantitis? (A review)

Z. Rezaei Esfahrood[1], M. Kadkhodazadeh[2]✉, R. Amid[3], AR. Rokn[4]

[1]Postgraduate student, Department of Periodontics, Dental School, Shahid Beheshti University of Medical Sciences, Tehran, Iran
[2]Associate Professor, Department of Periodontics, Dental School, Shahid Beheshti University of Medical Sciences, Tehran, Iran
[3]Assistant Professor, Department of Periodontics, Dental School, Shahid Beheshti University of Medical Sciences, Tehran, Iran
[4]Dental Implant Research Center, School of Dentistry, Tehran University of Medical Sciences, Tehran, Iran

Abstract

Conventional implant dentistry has been limited to healed edentulous ridges with adequate bone. Predictable success rates resulted in using dental implants in compromised situations such as insertion into old infected sites or near to pathological areas. There is significant data about marginal bone loss and lack of osseointegration around the neck of implants. However, the data about peri apical implant bone loss is really rare.

An electronic search was carried in PubMed regarding articles in the time period from 1980 to 2011. Subsequent manual search was performed included all animal and human case series and clinical trials. Reported success rates and treatment options were calculated in a systematic manner.

There is conflicted data showing a relatively accepted success of implantation immediately after removal of infection directly or indirectly in contact with the apical portion of the implants. However, some complications may happen that must be managed.

The available data about the periapical implant pathologies is relatively inadequate. However, concluded data represents some clinical comments in order to reduce the complexities.

Key Words: Periimplantitis/Retrograde; Implant Failures; Immediate Implantation; Infection

✉ Corresponding author:
M. Kadkhodazadeh, Associate Professor, Department of Periodontics, Dental School, Shahid Beheshti University of Medical Sciences, Tehran, Iran

kadkhodazadehmahdi@yahoo.com

Received: 13 February 2012
Accepted: 30 May 2012

Journal of Dentistry, Tehran University of Medical Sciences, Tehran, Iran (2012; Vol.9, No.2)

INTRODUCTION

The use of implants has developed significantly during the past two decades [1, 2]. Dental implant complications have been classified as follows [3]: compromised successful implant (presence of inflammation and fistula near a successfully osseointegrated implant), failing implant (increasing bone loss in a functional implant) and failed implant (infection around a compromised implant). According to Mellonig et al. [4], implant failures can be placed in two categories; namely, failure due to infection (periimplantitis or retrograde periimplantitis) and failure due to trauma (excessive overloading or implant fracture). Meffert et al. [5] categorized problematic implants into ailing, fail-

ing or failed. Ailing implants demonstrate bone loss with pocket formation which is static at maintenance phases. Failing implants demonstrate bone loss with pocket formation, bleeding upon probing and exudates. Failed implants are clinically mobile. Becker et al. [6] considered excessive heating of the bone and insufficient bone volume as possible causes for implant failure. Many different strategies are described in the literature to treat ailing and failing implants; removal of failed implants must be performed [7].

The etiology and mechanism of implant failure are multifactorial and implant periapical lesion (IPL) has also been documented as one possible etiologic factor for dental implant failures [8- 15]. McAllister et al. [16] first described IPL as corresponding to an occurrence in which the apical part of an implant fails to integrate. Synonyms of IPL are apical periimplantitis or retrograde peri-implantitis [15]. Sussman and Moss [17] introduced the concept of implant periapical pathology, an infectious-inflammatory process in the apical tissues of implant. Reiser and Nevins and Oh et al. [10, 12] categorized implant periapical lesions as inactive (not infected) and infected. Sussman [13] classified the lesions as follows: implant to tooth (type I) when produced during implant insertion and tooth to implant (type II) when IPL occurred due to infection of teeth adjacent to the implant that may contaminated the apical part of the implant.

IPL are infrequent, with a prevalence of approximately 0.26%, according to Reiser and Nevins [10]. A more recent review article reported a 1.86% incidence of such lesions [18]. To date, little is known about the etiology of IPL. It appears to have a multifactorial origin [12, 19-21]. It has been proposed that the most possible etiologic factors of periapical lesions are:

1. pre-existing bone infection, [13]
2. adjacent tooth endodontic lesions, [13, 14, 16, 22]
3. microbial infection from either remnants of extracted teeth or through a seeding mechanism from the remaining teeth, [23-25]
4. excessive heating of the bone during preparation of the osteotomy site, [26, 27]
5. bonemicrofractures caused from overload, [23] and
6. bone fracture inside the hollow implants [29].

Immediate placement of implants into fresh extraction sockets has been demonstrated to be a predictable, successful procedure [30-32].Reduction of treatment time and cost, reduction of surgical procedure, the ability to place the fixture in an ideal angle and an enhanced patient acceptance are major advantages of this technique [32-36]. Various authors [36-41] consider the presence of infection, such as periapicalpathosis, to be a contraindication for immediate placement of an implant, as sites showing pathology have been proposed to compromise osseointegration [35].More recent studies; however, have documented successful outcomes of implant placement into sites with periapical lesion [42, 43].

The aim of this article was to evaluate the effect of an immediately placed implant in an infected site on osseointegration and implant success and to present treatment protocols by review of data from animal studies, human case reports and case series and prospective research.

Animal Studies

Novaes et al. [44] studied the immediate implant placed into periapical lesions which were induced by cutting off the crowns of the third and fourth premolars of four dogs and the contralateral teeth were served as controls. After removing the pulpal tissue, canals were exposed to the oral cavity. After 9 months, test and control teeth were extracted. The animals were premedicated by antibiotics (20,000 IU of penicillin and erythromycin at a dose of 1.0

g/10 kg body weight) 4 days prior to surgery and continued on antibiotics for 4 days post-operatively. The sockets were debrided and rinsed with tetracycline solution before implant placement. All 28 IMZ implants were immediately placed. Twelve weeks later, the animals were sacrificed, all implants were osseointegrated without any sign of inflammation during healing time, but histomorphometric analyses demonstrated a greater bone-to-implant contact (BIC) in the control (38.7%) versus 28.6% in the experimental group. However, the difference was not statistically significant. Shabahang et al. [45] compared implants placed adjacent to teeth with artificially induced periapical lesions, with or without root canal treatment. Forty titanium solid root-form implants were inserted close to premolars in five dogs. After the healing period, the adjacent premolars were treated in one of the following ways: group A, no treatment; group B, induction of a periradicular lesion followed by root canal therapy; group C, induction of a periradicular lesion followed by root canal therapy of the premolar and surgical detoxification of the implant surface; and group D, induction of periradicular lesion and no treatment of the tooth. They found no difference in osseointegration between the four groups after 7.5 months. The results of this study showed that teeth with periradicular lesions do not adversely affect adjacent titanium solid root-form implants. Chang et al. [46] studied the osseointegration of immediate implants placed into infection sites in dogs. A 6-mm defect was created to induce periradicular lesions, followed by teeth extraction and immediate implant placement with (test group 1) or without (test group 2) polytetrafluoroethylene (PTFE) membranes. Implants were placed at healthy extraction sockets, in the control group. Animals were medicated by antibiotic for 5 days, and socket debridement, osteotomy and curettage were performed. Twelve weeks later, the animals were sacrificed. All control and the experimental implants were clinically acceptable. The control group showed significantly greater bone-implant contact (76.03 %) than the test groups 1 (59.55 %) and 2 (48.62 %).

Retrospective Studies

Novaes et al. [47] documented the first case report in which in three cases immediate implants were placed into an infected site. The sites were shown as recurrent endodontic lesion with periapical radiolucency. The treatment after extraction included debridement, a saline rinse guided bone regeneration (GBR) and medication by antibiotics (penicillin V for 10 days beginning 1 day prior to surgery and followed by doxycycline for another 21 days). Implant treatment success for these three patients was 100%. The authors considered that the patient ‘‘must be placed on penicillin V 24 to 48 hours before the procedure and maintained on the medication for 10 days.’’

Sussman [48] reported a case report in which two implants were placed adjacent to endodontically treated teeth. One month after first stage surgery the patient presented with pain. The implant was removed and debridement was done. Five months later, radiographic evaluation indicated resolution of the apical lesion.

Bretz et al. [49] published a case report with a history of failed endodontic treatment, which led to extraction of the involved tooth. Three years later, the implant was placed in this area. At the second stage surgery, a fistula and periapical radiolucency was developed at the apex of the implant.

Treatment consisted of flap elevation through curettage, irrigation with chlorhexidine, GBR with demineralized freeze-dried bone and an absorbable collagen. Amoxicillin (500 mg 4 times a day) and cicladol (β-cyclodextrinepiroxicam) (20mg daily) were administered for 1 week.

Shaffer et al. [24] reported six cases in which the implants were placed close to a tooth with an endodontic lesion (persisting or treated).

The result was extension of that peri-apical lesion and a subsequent failure of the implant.

Ayangco et al. [50] reported three patients with a history of failed endodontic treatment and apicoectomy procedures, which led to extraction of the involved teeth. Implants were placed after healing time (9 weeks-4 months, Brånemark System implants). Despite curettage, socket debridement and the prolonged healing time, implant periapical lesions developed. In the first case, after eighteen months of implant loading, the patient presented with the complaint of swelling. In another patient, nine months after implant loading, the patient was referred due to tenderness upon touching the face, opposite the apical area of the implant. In the last patient, one month after implant placement, the patient presented with pain in the area of the implant. A flap was elevated and granulation tissue curettage was performed around the implant. A tetracycline paste (250 mg mixed with sterile water) was used to detoxify the involved sites. The flap was then repositioned and sutured. Amoxicillin (500 mg 3 times daily for 7 days) was administered for one patient. In the two first patients, periapical radiographs taken 8 months after surgical procedure showed a slight resolution of the peri-implant radiolucency. In the last case, the implant had been stable, loaded and in function for 8 years without any problem. A radiograph taken 8 years after surgical treatment demonstrated complete resolution of the periimplant radiolucency.

Brisman et al. [51] presented four patients in which implant failure was attributed to a periradicular lesion from adjacent asymptomatic endodontically treated teeth with no clinical or radiographic sign of pathology. One involving a mandibular anterior tooth and three involving mandibular posterior teeth. In three patients, implants were removed. The fourth patient was medicated by antibiotic (300 mg of clindamycin four times daily for two days, then 150 mg four times daily for seven days). After two weeks, the infection appeared to be resolved both clinically and radiographically.

Oh et al. [12] published a case report with an endodontically treated tooth which was subjected to distal root resection. Three months after root resection, two root-form implants were placed in the distal site of the tooth. No systemic antibiotics were administered. At the time of implant uncovery surgery (3 months after implant placement), a fistula with radiolucency was found in the area of the implant adjacent to the tooth. The failed implant (mobile) was surgically removed followed by debridement of the site. In addition, apicoectomy procedures were performed on the remaining root. After three months, a root-form endosseous was again inserted in the area of the previously failed implant. At this time, the patient was medicated by antibiotics (amoxicillin 500 mg, three times a day for 10 days) to prevent postsurgical infection. No recurrence of periimplant infection or IPL has been noted over the years. Quirynen et al. [18] in a retrospective study, evaluated predisposing factors for periapical lesions and different treatment options. All implants (426 in the upper and 113 in the lower jaw, Branemark system) were placed. Eventual predisposing factors such as patient characteristics (age, medical history), recipient site (local bone quality and quantity and cause of tooth loss), periodontal and endodontic conditions of the neighboring teeth, implant characteristics (length and surface characteristics) and surgical aspects (guided bone regeneration and osseous fenestration or dehiscence) were considered. Moreover, implants with retrograde periimplantitis were followed to identify their treatment outcome. Seven implants in the upper (1.6%) and three in the lower jaw (2.7%) showed retrograde periimplantitis. Such periapical pathologies occurred at sites with a history of tooth endodontic pathology. A curettage of the periapical lesions and the use of a bone substitute material prevented further progression of such lesions

in the upper jaw. Generally, treatment in the lower jaw was less successful. These results indicated that retrograde periimplantitis is provoked by the remaining scar or granulomatous tissue at the recipient site: endodontic pathology of extracted tooth (scar tissue impacted tooth) or possible endodontic pathology from a neighboring tooth.

Ataullah et al. [52] presented a case with a history of failed endodontic treatment, which led to extraction of the involved tooth. The patient was premedicated by antibiotic (2g of penicillin 1 hour preoperatively and amoxicillin 500 mg 3 times daily for 1 week postoperatively). After flap elevation, debridement of the infected site and GBR with particulate autogenous bone graft mixed with anorganic hydroxyapatite was performed. The implant was placed after six months. Two months after implant placement, the patient presented with a painless swelling. The condition was found as retrograde periimplantitis. The treatment procedure included flap elevation, removal of all remaining tissue tags, saline and cholorhexidine rinse and GBR with Bio-Oss covered with a Bio-Gide membrane. Amoxicillin 500 mg three times daily for 1 week was administered. After 3 months, a periapical radiograph also showed good bone-filling of the periapical lesion. Tözüm et al. [53] presented a patient with large periapical radiolucency involving both the apical regions of the central incisor tooth and the adjacent implant. The treatment procedure included root canal treatment of the tooth followed by surgical procedure including flap elevation, tissue debridement, sterile saline solution, root-end filling of glass ionomer material and GBR with resorbable grafting material (calcium sulfate) and a resorbable membrane. Antibiotics (amoxicillin 500 mg, four times daily) were prescribed for the patient for 10 days. Six months after the surgical procedure, there were no symptoms of pain, inflammation or discomfort. Radiological evaluation demonstrated an uneventful healing. Doyle et al. (54) in a retrospective study, compared 32 single-tooth implants when placed adjacent to teeth with endodontic treatment to 164 implants that were not adjacent to teeth with endodontic therapy. The result demonstrated implant failure rates of 3.1% versus 6.7% for each group, respectively.

Laird et al. [55] evaluated the success and survival rates for implants adjacent to teeth with endodontic treatment and documented the prevalence of endodontic implantitis (E-I) (endodontic involvement in adjacent teeth causing implant failure) and implant endodontitis (I-E) (implant placement causing endodontic failure). Two hundred thirty three single-tooth implants were placed in 116 patients by postgraduate periodontal students and radiographs were taken 9 months after implant insertion. The implants were categorized as follows: group A, 90 implants with no adjacent teeth; group B, 123 implants adjacent to teeth without endodontic treatment; and group C, 20 implants adjacent to teeth with endodontic treatment. The success and survival rates for implants were 92.2% in group A, 98.4% and 99.2% in group B, and 85% and 95% in group C. There were no E-I or I-E in group B, one (5%) of the implants in group C had E-I and two (10%) of the adjacent teeth may have had I-E which suggests that endodontically treated teeth adjacent to single-tooth implants were usually successful and should be maintained.

Steiner [56] published a case report in which a necrotic pulp in a maxillary lateral incisor caused adjacent implant failure. Periradicular lesion was initially interpreted as a failing implant. Subsequent nonsurgical endodontic treatment that combined Ca(OH)2 for interim treatment and mineral trioxide aggregate for final obturation resolved the lesion without surgical intervention and successfully retained both the implant and the resorbed lateral incisor after fourteen months.

Naves et al. [42] documented a case report of three implants immediately placed into sites

with chronic periapical lesions and endodontic treatment failure. Patients started antibiotic coverage that was started 1 hour before surgery and was continued for 7 days. Treatment after extraction consisted of an apical access flap for debridement and GBR with a xenograft and bioabsorbable barrier. After a 3-year follow-up, the implants were successful without any signs of pathology.

Bell et al. [57] in a retrospective chart review, analyzed the success of immediately placed implants into extraction sockets demonstrating chronic periapical infection. The charts of 655 patients who had immediately placed implants were evaluated for the presence or absence of periapicalradiolucencies. A total of 922 implants were included. Of the 922 implants, 285 were immediately placed into sites with chronic periapical pathology. The remaining 637 implants, without periapical infection, were served as the control group. The success rate of implants placed in the experimental group was 97.5%; whereas, the success rate of the control group was 98.7%. The difference was not statistically significant. The mean follow-up time period was 19.75 months. A statistically higher failure rate was found for implants placed adjacent to teeth with periapical infection. Fugazzotto [58] in a retrospective study, evaluated immediately placed implants into sockets with and without periapical pathology in 64 patients. The implants placed in the maxillary incisor regions were followed for up to 117-120 months in function, with a mean time in function of 62-64 months. Results from this study showed survival rates of 98.1% and 98.2% for implants placed in sites with or without periapical pathology, respectively.

Prospective studies

Lindeboom et al. [59] published the first prospective controlled study evaluating clinical success when implants are placed immediately into chronic periapical infected sites. Fifty patients were randomized into two groups, 25 implants were immediately placed after extraction and 25 implants were placed after a healing period of 3 months (Frialit-2 Synchro). Thirty-two implants were placed in the anterior maxilla and 18 implants were placed in the premolar region. Patients were premedicated with clindamycin 1 hour preoperatively. Treatment after extraction consisted of the sockets debridement, GBR with autogenous bone and a collagen membrane. The implants were allowed to heal for 6 months. The results demonstrated survival rates of 92% versus 100% for immediate and delayed implants. Mean implant stability quotient, gingival aesthetics, radiographic bone resorption and periapical cultures were not significantly different. Villa et al. [60] studied the survival rate of early-loaded implants immediately placed into sockets with endodontic and periodontal lesions in the mandible. Twenty patients were selected. In each patient, four to six implants were placed in or close to the fresh extraction sockets showing a sign of infection and fixed provisional prostheses were placed within 3 days. Patients received definitive prostheses after 3 to 12 months. A high level of implant survival (100%) was achieved after 15 to 44 months follow-up. The same authors, [61] analyzed the survival rate of immediate and early-loaded implants (n=76) immediately placed after extraction of the teeth with endodontic and periodontal lesions or root fracture in the maxilla. Thirty-three patients were selected. One to six implants were placed in each patient after tooth extraction. Treatment consisted of socket debridement, bone curettage, antibiotic irrigation with rifamycin, GBR with autogenous or anorganic bovine bone with a collagen barrier and a cortisone injection into the soft tissue after suturing. A provisional prosthesis was inserted immediately or within 36 hours. Premedication by antibiotic (amoxicillin starting 1 day before the surgery and continued for 5 days postoperatively). The patients received final prostheses after 6 to 12

months. A high level of implant survival was observed for immediately placed and immediately/early-loaded implants in the maxilla after 1 year, despite the presence of infection.

Seigenthaler et al. [62] evaluated whether immediate implant placed into infected sites leads to more biological complications,compared with sites without periapical pathology. In 17 patients, immediately placed implant into sites with periapical lesion leaded to pain, periapical radiolucency, fistula, suppuration or a combination of these findings. In another 17 patients, immediate implants were placed into sites without periapical lesion. All patients were premedicated with amoxicillin 1 hour preoperatively and was continued for 5 days. After extraction, treatment included of granulation tissue removal, saline rinse and GBR with deproteinized bovine mineral and a collagen barrier. Implants were loaded after a healing time of 3 months. After 12 months, clinical and radiographical outcomes showed no significant differences compared with baseline and in comparison of the test and control groups. Casap et al. [63] placed a total of 30 implants into infected sites in 20 patients. The infections at the sockets varied and consisted of a periodontal cyst, subacute periodontal, perio-endo, chronic periodontal and chronic periapical lesions. Treatment after extraction consisted of socket debridement, peripheral intrasocketostectomy, sterile solution irrigation and GBR with anorganic bovine bone and a titanium-reinforced expanded PTFE membrane. Premedication with antibiotic was performed (amoxicillin or clindamycin, 4 days preoperatively and maintained for 10 days postoperatively). After 12 to 72 months follow-up all implants but one were osseointegrated. Del Fabbro et al. [64] in a Cohort study analyzed the clinical outcome of immediate implant placements into sockets with chronic periapical lesion in combination with plasma rich in growth factor (PRGF). A total of 30 patients were selected and 61 implants were placed. Antibiotics (amoxicillin and clavulanic acid 1 hour before procedure) were administered. After extraction, the sockets were thoroughly debrided and the implant surface was coated in liquid PRGF. All implants were loaded after 3 to 4 months. Of the 61 implants, one failure was observed in a smoker 2 months after placement because of infection. The overall implant success and survival rate was 98.4% at a mean follow-up of 18.5 months. All prostheses were successful. All patients reported full satisfaction for mastication function, phonetics and esthetics. Crespi et al. [65] analyzed the immediate implants placed into sites with or without chronic periapical pathologies in a monoradicular or premolar tooth. Thirty patients were included and placed in two categories: 15 patients as the control group (without periapical lesions) and 15 patients as the test group (with periapical lesions, periapicalradiolucencies and no signs of pain, fistulas or suppuration). All implants were immediately placed after extraction and were loaded after 3 months. Authors reported a survival rate of 100% after a 24-month follow-up. Implants placed immediately in extraction sites with periapical lesions had equally favorable soft and hard tissue integration in comparison to the control group over time.

Truninger et al. [66] in a prospective, controlled clinical trial analyzed the outcome of immediate implants placed into sites with or without periapical lesion. Twenty-nine patients were selected (16 patients in the test group and 13 patients in the control group). The clinical and radiological outcomes exhibited no statistically significant differences between the test and control groups after 3 years. There was no retrograde periimplantitis in the 13 examined radiographs of implants immediately placed in sockets with periapical lesions after 3 years.

DISCUSSION

Lazzara for the first time reported immediately placed implants into an extraction socket. The

benefits of this process include reduction of surgical procedures and treatment time, decrease of bone resorption and satisfactory esthetics. Many other studies have also demonstrated favorable and predictable results with immediate implant placement [67-72].

Implant failures are categorized as failures due to infection (periimplantitis or retrograde peri-implantitis) or failures due to trauma (excessive overloading or implant fracture) [4]. Retrograde peri-implantitis, an occurrence of an implant periapical lesion, has been described in the literature.

Histological evaluations of endodontically treated teeth in cadavers, animals or humans exhibited the fact that although the teeth appeared normal in radiography, histological signs of inflammation or persisting microorganisms often exist in the apex of endodontically treated teeth [73-75]. Evidence on the effects of immediate placement of implants into sites exhibiting periapical lesions is scarce. The main limitation of this review is the different definitions of infection that varies between articles.

Providing histological evidence is the major advantage of animal studies. However, very low numbers of animals (4 or 5) were used in each study included in this review. According to these studies, the presence of infected sites did not compromise healing and osseointegration of the immediately placed implants. Apart from rare cases, data from human studies in this review demonstrated high levels of implant survival in the presence of periapical infections. Since only four randomized clinical trial studies were published [44-46, 60-65], further research is required to confirm these results.

Treatment options

Different management approaches were indicated in the literature for implant periapical pathology; namely, implant extraction and periapical surgery with or without implant apex resection. Some authors [10, 12] stated that the infected sites require surgical intervention with removal of the infected tissue via extraction or apical resection of the implant depending on the extent of the lesion or the degree of implant mobility. According to Sussman [13], the implant should be extracted immediately to prevent osteomyelitis and irreversible bone loss. Scarano et al. [14] and Piatelli et al. [29, 76] also prefered to extract the implant, resulting in pain elimination. Other authors [49, 50, 77] concluded that complete and thorough curettage of the lesion with irrigation, a combination of systemic and/or local antibiotics and applying tetracycline to the zone would be a successful approach in the treatment of retrograde periimplantitis. However, there is no conclusive evidence to advocate any specific treatment approach [78].

Effective antibiotics on bacteria associated with implant failure are as follows: penicillin G, amoxicillin, combination of amoxicillin and metronidazole, and amoxicillin-clavulanate [79]. It is still controversial to use prophylactic antibiotics during implant placement. Based on Cochrane review, there are insufficient evidences advocating their use [80]. There are some evidences that 2 gram of amoxicillin given orally one hour before surgery significantly reduced early failures of dental implants [81]. However, further research should be directed to confirm the findings.

CONCLUSIONS

Short-term data from published studies suggested that after complete debridement of the extraction socket and removal of all contaminated tissue, immediate placement of implants into sites with periapical pathologies may be a successful and predictable treatment modality.

ACKNOWLEDGMENTS

The study was supported by a grant from the Dental Research Center, Shahid Beheshti University of Medical Sciences.

REFERENCES

1-Dental endosseous implants: an update. ADA Council on Scientific Affairs. J Am Dent Assoc. 1996 Aug;127(8):1238-9.

2- ADA Council on Scientific Affairs. Dental endosseous implants: an update. J Am Dent Assoc. 2004 Jan;135(1):92-7.

3- Newman MG, Flemmig TF. Bacterial-host interaction. In: Worthington P, Brånemark PI, editors. Advanced osseointegration surgery. Berlin: Quintessence; 1992.

4- Mellonig JT, Griffiths G, Mathys E, Spitznagel J Jr. Treatment of the failing implant: Case reports. Int J Periodont Rest Dent. 1995 Aug;15(4):385-95.

5- Meffert RM. How to treat ailing and failing implants. Implant Dent. 1992 Spring;1(1):25-33.

6- Becker W, Becker BE, Newman MG, Nyman S. Clinical and microbiologic findings that may contribute to dental implant failure. Int J Oral Maxillofac Implants. 1990 Spring;5(1):31-8.

7- Meffert RM, Langer B, Fritz ME. Dental implants: A review. J Periodontol. 1992 Nov;63(11):859-70.

8- Ross-Jansaker AM, Renvert S, Egelberg J. Treatment of periimplant infections: a literature review. J ClinPeriodontol. 2003 Jun;30(6):467-85.

9- Klinge B, Gustafsson A, Berglundh T. A systematic review of the effect of anti-infective therapy in the treatment of periimplantitis. J ClinPeriodontol. 2002;29Suppl (3):213-25.

10- Reiser GM, Nevins M. The implant periapical lesion: etiology, prevention and treatment. CompendContinEduc Dent. 1995 Aug;16(8):768, 770, 772.

11- Piatelli A, Scarano A, Piatelli M, Podda G. Implant periapical lesion: clinical, histologic and histochemical aspects. Int J Periodont Restorative Dent. 1998 Apr;18(2):181-7.

12- Oh TJ, Yoon J, Wang HL. Management of the implant periapical lesion: a case report. Implant Dent. 2003;12(1):41-6.

13- Sussman HI. Periapical implant pathology. J Oral Implantol. 1998;24(3):133-8.

14- Scarano A, Di Domizio P, Petrone G, Lezzi G, Piattelli A. Implant periapical lesion: a clinical and histologic case report. J Oral Implantol. 2000;26(2):109-13.

15- Flanagan D. Apical (retrograde) periimplantitis: a case report of an active lesion. J Oral Implantol. 2002;28(2):92-6.

16- McAllister BS, Masters D, Meffert RM. Treatment of implants demonstrating periapicalradiolucencies. Pract Periodontics Aesthet Dent. 1992 Nov-Dec;4(9):37-41.

17- Sussman HI, Moss SS. Localized osteomyelitis secondary to endodontic-implant pathosis. A case report. J Periodontol. 1993 Apr;64(4):306-10.

18- Quirynen M, Vogels R, Alsaadi G, Naert I, Jacobs R, van Steenberghe D. Predisposing conditions for retrograde peri-implantitis, and treatment suggestions. Clin Oral Implants Res. 2005 Oct;16(5):599-608.

19- Esposito M, Hirsch JM, Lekholm U, Thomsen P. Biological factors contributing to failures of osseointegrated oral implants. (I). Success criteria and epidemiology. Eur J Oral Sci. 1998 Feb;106(1):527-51.

20- Esposito M, Hirsch JM, Lekholm U, Thomsen P. Biological factors contributing to failures of osseointegrated oral implants. (II). Etiopathogenesis. Eur J Oral Sci. 1998 Jun:106(3):721-64.

21- PeñarrochaDiago M, BoronatLópez A, Lamas Pelayo J. Update in dental implant periapical surgery. Med Oral Patol Oral Cir Bucal. 2006 Aug 1;11(5):E429-32.

22- Tseng CC, Chen YH, Pang IC, Weber HP. Peri-implant pathology caused by periapical lesion of an adjacent natural tooth: a case report. Int J Oral Maxillofac Implants. 2005 Jul-Aug;20(4):632-5.

23- Mombelli A, Buser D, Lang NP. Colonization of osseointegrated titanium implants in edentulous patients. Early results. Oral MicrobiolImmunol. 1988 Sep;3(3):113-20.

24- Shaffer MD, Juruaz DA, Haggerty PC. The effect of peri-radicular endodontic pathosis on the apical region of adjacent implants. Oral Surg Oral Med Oral Pathol Oral RadiolEndod. 1998 Nov;86(5):578-81.

25- Mombelli A. Etiology, diagnosis and treatment considerations in peri-implantitis. CurrOpin-

Periodontol. 1997;4:127-36.
26- Eriksson RA, Adell R. Temperatures during drilling for the placement of implants using the osseointegration technique. J Oral Maxillofac Surg. 1986 Jan;44(1):4-7.
27- Watanabe F, Tawada Y, Komatsu S, Hata Y. Heat distribution in bone during preparation of implant sites: Heat analysis by real-time thermography. Int J Oral Maxillofac Implants. 1992 Summer;7(2):212-9.
28- Meffert RM. Periodontics and peri-implantitis: one and the same. Pract Periodontics Aesthet Dent. 1993 Dec;5(9):79-80, 82.
29- Piattelli A, Scarano A, Balleri P, Favero GA. Clinical and histologic evaluation of an active "implant periapical lesion": A case report. Int J Oral Maxillofac Implants. 1998 Sep-Oct;13(5):713-6.
30- Chen ST, Wilson TG Jr., Hammerle CH. Immediate or early placement of implants following tooth extraction: review of biologic basis, clinical procedures, and outcomes. Int J Oral Maxillofac Implants. 2004;19 Suppl:12-25.
31- Esposito MA, Koukoulopoulou A, Coulthard P, Worthington HV. Interventions for replacing missing teeth: Dental implants in fresh extraction sockets (immediate, immediate-delayed and delayed implants). Cochrane Database Syst Rev. 2006 Oct 18;(4):CD005968.
32- Hammerle CH, Chen ST, Wilson TG Jr. Consensus statements and recommended clinical procedures regarding the placement of implants in extraction sockets. Int J Oral Maxillofac Implants. 2004;19 Suppl:26-8.
33- Werbitt MJ, Goldberg PV. The immediate implant: bone preservation and bone regeneration. Int J Periodontics Restorative Dent. 1992;12(3):206-17.
34- Schwartz-Arad D, Chaushu G. The ways and wherefores of immediate placement of implants into fresh extraction sites: a literature review. J Periodontol. 1997 Oct;68(10):915-23.
35- Mayfield LJA. Immediate, delayed and late submerged and transmucosal implants. Berlin: Quintessence; 1999. p. 520-34.
36- Barzilay I. Immediate implants: their current status. Int J Prosthodont. 1993 Mar-Apr;6(2):169-75.
37- Becker W, Becker BE. Guided tissue regeneration for implants placed into extraction sockets and for implant dehiscences: Surgical techniques and case report. Int J Periodontics Restorative Dent. 1990;10(5): 376-91.
38- Quirynen M, Gijbels F, Jacobs R. An infected jawbone site compromising successful osseointegration. Periodontol 2000. 2003;33:129-44.
39- Lundgren D, Nyman S. Bone regeneration in 2 stages for retention of dental implant. Clin Oral Implants Res. 1991 Oct-Dec;2(4):203-7.
40- Wilson TG Jr. Guided tissue regeneration around dental implants in immediate and recent extraction sockets: Initial observations. Int J Periodontics Restorative Dent. 1992;12(3):185-93.
41- Tolman DE, Keller EE. Endosseous implant placement immediately following dental extraction and alveoloplasty: preliminary report with 6-year follow up. Int J Oral Maxillofac Implants. 1991 Spring;6(10:24-8.
42- Naves Mde M, Horbylon BZ, Gomes Cde F, Menezes HH, Bataglion C, Magalhaes D. Immediate implants placed into infected sockets: A case report with 3-year follow-up. Braz Dent J. 2009;20(3):254-8.
43- Del Fabbro M, Boggian C, Taschieri S. Immediate implant placement into fresh extraction sites with chronic periapical pathologic features combined with plasma rich in growth factors: Preliminary results of single-cohort study. J Oral Maxillofac Surg. 2009 Nov;67(11):2476-84.
44- Novaes AB Jr, Vidigal Junior GM, Novaes AB, Grisi MF, Polloni S, Rosa A. Immediate implants placed into infected sites: A histomorphometric study in dogs. Int J Oral Maxillofac Implants. 1998 May-Jun;13(3):422-7.
45- Shabahang S, Bohsali K, Boyne PJ, Caplanis N, Lozada J, Torabinejad M. Effect of teeth with periradicular lesions on adjacent dental implants Oral Surg Oral Med Oral Pathol Oral RadiolEndod. 2003 Sep;96(3):321-6.
46- Chang SW, Shin SY, Hong JR, Yang SM, Yoo

HM, Park DS et al. Immediate implant placement into infected and noninfected extraction sockets: a pilot study. Oral Surg Oral Med Oral Pathol Oral RadiolEndod. 2009 Feb;107(2):197-203.
47- Novaes AB Jr, Novaes AB. Immediate implants placed into infected sites: A clinical report. Int J Oral Maxillofac Implants. 1995 Sep-Oct;10(5):609-13.
48- Sussman HI. Implant pathology associated with loss of periapical seal of adjacent tooth: clinical report. Implant Dent. 1997 Spring;6(1):33-7.
49- Bretz WA, Matuck AN, de Oliveira G, Moretti AJ, Bretz WA. Treatment of retrograde periimplantitis: clinical report. Implant Dent. 1997 Winter;6(4):287-90.
50- Ayangco L, Sheridan PJ. Development and treatment of retrograde peri-implantitis involving a site with a history of failed endodontic and apicoectomy procedures: a series of reports. Int J Oral Maxillofac Implants. 2001 May-Jun;16(3):412-7.
51- Brisman DL, Brisman AS, Moses MS. Implant failures associated with asymptomatic endodontically treated teeth. J Am Dent Assoc. 2001 Feb;132(2);191-5.
52- Ataullah K, Chee LF, Peng LL, Lung HH. Management of retrograde peri-implantitis: a clinical case report. J Oral Implantol. 2006;32(6):308-12.
53- Tözüm TF, Sençimen M, Ortakoğlu K, Ozdemir A, Aydin OC, Keleş M. Diagnosis and treatment of a large periapical implant lesion associated with adjacent natural tooth: a case report. Oral Surg Oral Med Oral Pathol Oral RadiolEndod. 2006 Jun;101(6):132-8.
54- Doyle SL, Hodges JS, Pesun IJ, Baisden Mk, Bowles WR. Factors affecting outcomes for single-tooth implants and endodontic restorations. J Endod. 2007 Apr;33(4):399-402.
55- Laird BS, Hermsen MS, Gound TG, Al Salleeh F, Byarlay MR, Vogt M et al. Incidence of endodontic implantitis and implant endodontitis occurring with single-tooth implants: a retrospective study. J Endod. 2008 Nov;34(11):1316-24.
56- Steiner DR. The resolution of a periradicular lesion involving an implant. J Endod. 2008 Mar;34(3):330-5.
57- Bell CL, Diehl D, Bell BM, Bell RE. The immediate placement of dental implants into extraction sites with periapical lesions: a retrospective chart review. J Oral Maxillofac Surg. 2011 Jun;69(6):1623-7.
58- Fugazzotto PA. A retrospective analysis of implants immediately placed in sites with and without periapical pathology in 64 patients. J Periodontol 2011;31: [Epub ahead of print].
59- Lindeboom JA, Tjiook Y, Kroon FH. Immediate placement of implants in periapicalinfected sites: A prospective randomized study in 50 patients. Oral Surg Oral Med Oral Pathol Oral RadiolEndod. 2006 Jun;101(6):705-10.
60- Villa R, Rangert B. Early loading of interforaminal implants immediately installed after extraction of teeth presenting endodontic and periodontal lesions. Clin Implant Dent Relat Res. 2005;7 Suppl:S28-35.
61- Villa R, Rangert B. Immediate and early function of implants placed in extraction sockets of maxillary infected teeth: A pilot study. J Prosthet Dent. 2007 Jun;97(6 Suppl):S96-S108.
62- Siegenthaler DW, Jung RE, Holderegger C, Roos M, Hammerle CH. Replacement of teeth exhibiting periapical pathology by immediate implants: A prospective, controlled clinical trial. Clin Oral Implants Res. 2007 Dec;18(6):727-37.
63- Casap N, Zeltser C, Wexler A, Tarazi E, Zeltser R. Immediate placement of dental implants into debrided infected dentoalveolar sockets. J Oral Maxillofac Surg. 2007 Mar;65(3):384-92.
64- Del Fabbro M, Boggian C, Taschieri S. Immediate implant placement into fresh extraction sites with chronic periapical pathologic features combined with plasma rich in growth factors: Preliminary results of single-cohort study. J Oral Maxillofac Surg. 2009 Nov;67(11):2476-84.
65- Crespi R, Capparè P, Gherlone E. Fresh-socket implants in periapical infected sites in humans. J Periodontol. 2010 Mar;81(3):378-83.
66- Truninger TC, Philipp AO, Siegenthaler DW, Roos M, Hämmerle CH, Jung RE. A prospective, controlled clinical trial evaluating the clinical and

radiological outcome after 3 years of immediately placed implants in sockets exhibiting periapical pathology.Clin Oral Implants Res. 2011 Jan;22(1):20-7.
67- Lazzara RJ. Immediate implant placement into extraction sites: surgical and restorative advantages. Int J Periodontics Restorative Dent. 1989;9(5):332-43.
68- Becker W, Dahlin C, Becker BE, Lekholm U, van Steenberghe D, Higuchi K et al. The use of e-PTFE barrier membranes for bone promotion around titanium implants placed into extraction sockets: a prospective multicenter study. Int J Oral Maxillofac Implants. 1994 Jan-Feb;9(1):31-40.
69- Becker W, Dahlin C, Lekholm U, Bergstrom C, van Steenberghe D, Higuchi K, et al. Five-year evaluation of implants placed at extraction and with dehiscences and fenestration defects augmented with ePTFE membranes: results from a prospective multicenter study. Clin Implant Dent Relat Res. 1999;1(1):27-32.
70- Gelb DA. Immediate implant surgery: three-year retrospective evaluation of 50 consecutive cases. Int J Oral Maxillofac Implants. 1993;8(4):388-99.
71- Grunder U, Polizzi G, Goene R, Hatano N, Henry P, Jackson WJ et al. A 3-year prospective multicenter follow-up report on the immediate and delayed-immediate placement of implants. Int J Oral Maxillofac Implants. 1999 Mar-Apr;14(2):210-6.
72- Rosenquist B, Ahmed M. The immediate replacement of teeth by dental implants using homo logous bone membranes to seal the sockets: clinical and radiographic findings. Clin Oral Implants Res. 2000 Dec;11(6):572-82.
73- Rowe AH, Binnie WH. Correlation between radiological and histological inflammatory changes following root canal treatment. J Br Endod Soc. 1974 Jul;7(2):57-63.
74- Green TL, Walton RE, Taylor JK, Merrell P. Radiographic and histologic periapical findings of root canal treated teeth in cadaver. Oral Surg Oral Med Oral Pathol Oral RadiolEndod. 1997 Jun;83(6):707-11.
75- Seltzer S. Long-term radiographic and histological observations of endodontically treated teeth. J Endod. 1999 Dec;25(12):818-22.
76- Piattelli A, Scarano A, Piattelli M, Podda G. Implant periapical lesions: clinical, histologic, and histochemical aspects. A case report. Int J Periodontics Restorative Dent. 1998 Apr;18(2):181-7.
77- Rodríguez A, Rodríguez F. Proceso periapical implantológico. Rev Esp Odontostomatológico de Implantes 1995;3:159-62.
78- Nevins M, Meffert R, Tarnow D, Cochran D, Cohen R, Iacono V et al (eds). Consensus report. Implant therapy I. Proceedings of the 1996 World Workshop in Periodontics. Ann Periodontol. 1996;1:792-5.
79- Sbordone L, Barone A, Ramaglia L, Ciaglia RN, Iacono VJ. Antimicrobial susceptibility of periodontopathic bacteria associated with failing implants. J Periodontol. 1995 Jan;66(1):69-74.
80- Esposito M, Coulthard P, Oliver R, Thomsen P, Worthington HV. Antibiotics to prevent complications following dental implant treatment. Cochrane Database Syst Rev. 2003;(3):CD004152.
81- Esposito M, Grusovin MG, Talati M, Coulthard P, Oliver R, Worthington HV. Interventions for replacing missing teeth: antibiotics at dental implant placement to prevent complications. Cochrane Database Syst Rev. 2008 Jul 16;(3):CD004152.