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Peri-implantitis: The Good, the Bad and the Ugly

Introduction

Presently, over one million implants are being placed annually worldwide (1,2). Articles report implant survival rates as high as 99 to 100 per cent in periodontally healthy patients (3,4). This does make it appealing to consider implant therapy in our offices.

Yet, it is now also reported that as many as 45 per cent of patients who have implants could experience peri-implantitis (PI), with 14.5 per cent experiencing moderate to severe PI (5). There is cause for concern because many patients do not perceive that there could be a problem once implants are placed. PI is a growing concern in dentistry, and one that patients should be aware of. If left untreated, PI may lead to the loss of implants and existing lesions can lead to more aggressive expression of disease than that of periodontitis (2,6).

This article will explore factors associated with the development of PI and their management under the cumulative interceptive supportive therapy (CIST) protocol. Cases are presented and provide detailed examples of what can go wrong, risk factors at play and treatment outcomes. The article will also review extreme situations where implant removal is required. Cause and effect relationships are elaborated in the hopes of increasing awareness of this condition in the dental practice. The "Achilles heel" of the implant system and biological vulnerabilities are also highlighted.

Similarities with periodontitis

Many similarities exist between PI and periodontitis (PD), including: inflammatory process and response; composition of microbiota; clinical features; shared risk factors (smoking, systemic disease, soft tissue defects, genetic influences, alcohol consumption, poor oral hygiene and irregular maintenance visits); and incidence. It has been shown that periodontal disease affects 46 per cent of people by the age of 30, and 8.9 per cent have severe periodontitis (7). It seems that bacteria do not discriminate between teeth or implants when it comes to propagation of infection.

Also, additional risk factors are associated with disease development around implants and include: bacterial leakage due to configuration and position of the implant-abutment micro-gap; localized inflammation at the implant-abutment interface; micro-movement of prosthetic components; overloading of the implant; poor bone quality at the implant area; residual cement; implants shorter than 10 mm; extraction technique; location in aesthetic zone; platform shift; emergence profile; and restoration anatomy (2).

It is obvious that many factors can contribute to development of PI. Of note, generalized aggressive periodontitis patients have five times greater risk of implant failure and three times greater risk of mucositis and 14 times greater risk of PI (4). Smoking is also a large contributor for limited treatment success (8).

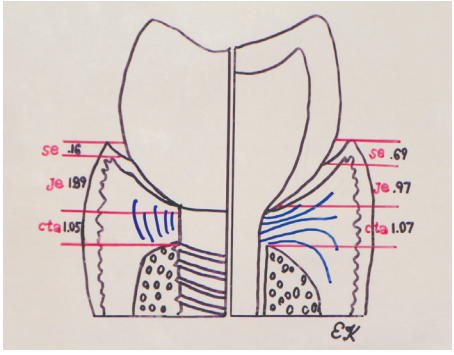

Figure 1.
Implant versus tooth, cross-sectional comparative anatomy. SE — sulcular epithelium; JE — junctional epithelium; CTA — connective tissue attachment. Please refer to Table 1 for clarification. Peri-implant anatomy is more vulnerable when compared to the natural tooth system.

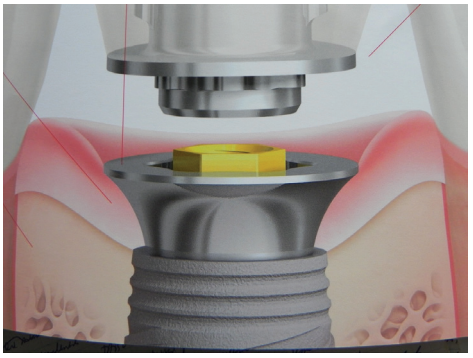

Figure 2.
Nobel Biocare On-1 concept. One of many implant design strategies to try to strengthen the gingival seal ("O-ring" effect around implants). (Reprinted with permission)

Table 1. Tooth and Implant Histological Comparison*

	Tooth	Implant
Connection	cementum, bone, periodontal ligament (flexible)	osseointegration, functional ankylosis (direct contact with bone/rigid)
Junctional Epithelium	hemidesmosomes and basal lamina (lamina lucida, lamina densa zones)	hemidesmosomes and basal lamina (lamina lucida, lamina densa, and sublamina lucida zones)
Connective Tissue	horizontal, oblique, vertical and perpendicular fibres (more collagen with better adhesion and stronger seal)	parallel fibres (seal around implant is weak)
Probing Depth	≤ 3 mm in health	2.5-4.0 mm (dependent upon soft tissue depth)
Bleeding on Probing	more reliable	less reliable

* Adapted from Ikeda et al. (9)

Implant-tooth interface (vulnerability revealed)

In the absence of periodontal health, both locally and systemically, implants are much more vulnerable and therefore more prone to develop PI (9). The peri-implant mucosa consists of weak circular connective tissue fibres oriented in a "loose" parallel arrangement (an "O-ring" effect), compared to the tooth system where collagen fibres are directed perpendicularly to the tooth with direct anchorage to the tooth via cementum attachment ("zipper effect"). Once infected, the "O-ring" protective seal "releases," allowing for the development of circumferential bony defects and a "cratering effect" around the implant. Refer to Figure 1 and Table 1 describing the anatomic and histological differences in the periodontal support around teeth and implants, illustrating the vulnerability faced by implants.

New developments in the field of implantology are inventing systems to strengthen the "O-ring" effect by "narrowing" the neck of the implant with platform shifting technology. Nevertheless, more complications arise around the rigid implant system compared to the more flexible environment of natural teeth. It is therefore important to prepare a properly worded informed consent for treatment form, for patients accepting implant therapy. This way, mutual obligations can be met and understood to avoid future dissatisfaction.

Treatment considerations

Once a proper diagnosis is made, all the risk factors identified (medical and dental), prognosis and treatment plan established, occlusal and implant particulars accounted for, periodontal treatment can commence including attempts at habit modification (including smoking cessation and oral hygiene influences). The hallmark of successful treatment of PI depends on thorough and meticulous surface decontamination of the implant surface. Mechanical choices include powdered abrasive mixtures of sodium bicarbonate and water, curettes made of plastics, carbon graphite and titanium and occasional implantoplasty. Chemical agents that have been studied include cetylpyridimium chloride, citric acid, tetracycline, hydrogen peroxide and ethylenediaminetetraacetic acid (EDTA). Unfortunately, chlorhexidine (CHX) is not as effective for the treatment of PI, as it is for PD lesions. After mechanical debridement, CHX was found to be no more effective than placebo (10). It was also found that CHX may compromise the biocompatibility of titanium surfaces (alters titanium physical properties) and is not recommended to detoxify implants (11).

It has also been reported that mechanical and chemical treatment proved to be the most effective for disinfection of the anodized implant surface than laser therapy (12). A systemic review and meta-analysis indicated that "any superiority of laser treatment in comparison to conventional treatment of PI could not be identified" (13, p. 1). Lasers can be used in addition to conventional treatment, however.

Treatment protocol

The CIST protocol (Table 2) was developed to help simplify the treatment of PI (14). Factors of plaque index, bleeding indices, suppuration, pocket depth and radiographic bone loss are incorporated to provide a guideline towards treatment direction. Conservative therapy involves CIST A (mechanical cleansing), CIST B (antiseptic therapy) and CIST C (antibiotic therapy), much like that utilized for the treatment of periodontitis lesions. This is essentially the "simple before complicated" agenda. Figures 3 and 4 demonstrate successful conservative treatment. A surgical approach is reflected in CIST D, including surgical resective therapy and regenerative therapy. Figures 5 to 8 offer examples of the response of the periodontium to surgical therapy. Ultimately, habit control is essential for successful

Table 2. Cumulative Interceptive Supportive Therapy (CIST)*

Clinical Parameters						
Plaque Index (PII)	Bleeding on Probing (BOP)	Suppuration	Probing Depths (PD) (mm)	Radiographic (Rx) Defect	Maintenance Classification	CIST
±	–	–	<4	–	O	(A)
+	+	–	<4	–	I	A
+	+	±	4-5	+	II	A+B
+	+	±	>5	+ +	III	A+B+C
+	+	±	>5	+ + +	IV	A+B+C+D
+	+	±	>5	+ + + +	V	E

CIST modalities

A. Mechanical cleansing using rubber cups and polishing paste, acrylic scalers for chipping-off calculus. Instruction for more effective oral hygiene practices.
B. Antiseptic therapy. Rinses with 0.1 to 0.2 per cent chlorhexidine digluconate for 30 seconds using approximately 10 ml, for three to four weeks supplemented by irrigating locally with chlorhexidine (preferably 0.2 to 0.5 per cent) using a Leur syringe or local chlorhexidine gel application.
C. Antibiotic Therapy. 1) Systemic ornidazol (2 x 500 mg/die) or metronidazole (2 x 250 mg/die) for 10 days or combination of metronidazole (500 mg/die) plus amoxicillin (375 mg/die) for 10 days. 2) Local: Application of slow release devices for 10 days (25 per cent tetracycline fibres).
D. Surgical Approach. 1) Regenerative surgery using abundant saline rinses at the defect, barrier membranes, close flap adaptation and careful post-surgical monitoring for several months. Plaque control is to be assured by applying chlorhexidine gels. 2) Resective surgery. Apically repositioning of the flap following osteoplasty around the defect.
E. Explantation using specially designed instruments.

* Adapted from Lang et al. (14)

management and prevention of PI and includes diligent oral hygiene, regular periodontal maintenance and smoking cessation.

Worst case scenarios (CIST E)

Patients are seldom happy when unexpected difficulty or implant loss occurs. As per our regulator's informed consent protocol, "Inform before you perform." We need to make sure a properly worded and documented informed consent for treatment form is provided, reviewed thoroughly, and that our patients understand the risks and benefits of our treatment plans. Figures 9 to 11 identify scenarios that we wish to avoid and include elements of smoking, predisposing medical conditions, inadequate oral hygiene, inadequate maintenance and loss of attached gingiva risk factors, amongst others.

Significance of keratinized mucosa

Implants do not do well without the protection of keratinized mucosa. Higher plaque accumulation and gingival inflammation and attachment loss are associated with the lack of attached gingiva around endosseous implants (15,16). Figure 11 demonstrates this risk in an elderly smoking individual with deficient attached gingiva in the 36 area. Implant 36 was lost, but implant 35 is doing well. The pre-emptive reconstitution of the attached gingiva of implant 36 may have led to a more favorable clinical outcome for this tooth.

Without adequate attached gingiva, PI can be accentuated in a very non-cosmetic fashion (Figure 12). Notice severe implant thread exposure, periodontal inflammation, 40 per cent bone loss and a severe frenum involvement. Mucogingival surgery corrects this difficulty in the form of a free autogenous gingival graft. In this situation, significant "coverage" of the exposed implant threads is not possible. It would be unfortunate to encounter this scenario in a highly cosmetic area where patient unhappiness could be profound.

Loose implant crowns

Sometimes a cemented implant crown dislodges (Figure 6). Occasionally, a surgical procedure is required to help adjust gingival overgrowth and re-secure the crown. Cement "overflow" can be significant and if not removed can initiate PI. In this case, bruxism necessitated fabrication of a nightguard appliance and heavy occlusion was adjusted utilizing "shimstock."

The screw-in-a-screw retained implant crown also can loosen (Figure 5). In this example, the patient neglected follow-ups until a "bad taste" was identified. Fortunately, the crown could be removed, and a healing abutment replaced while CIST ABCD was provided to rehabilitate area 36. If detected early, PI can be successfully managed.

Emphasis on oral hygiene and maintenance

The better our patients do every day with their oral hygiene, the greater success we will mutually achieve to counteract PI potential. No one can do better than a

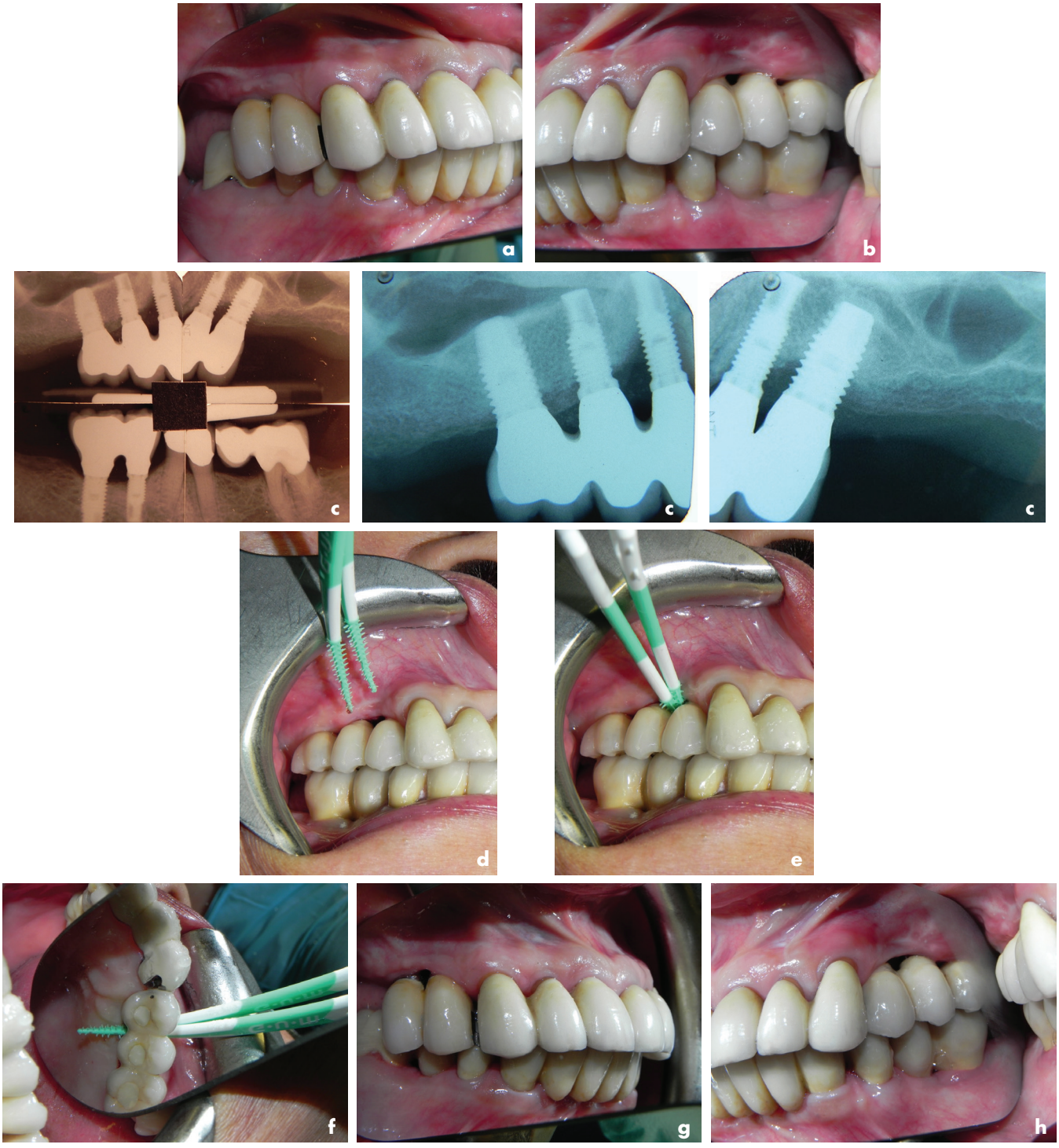

Figure 3.
When treating PI, always consider conservative treatment first. CIST protocol ABC: 76-year old smoking female with history of bilateral sinus lifts and implant placements (two-stage technique) in 2011 provided by another practitioner. Implant 14 infected in October 2015 and surgical debridement was not successful. Patient was referred for management of PI in September 2016. Successful conservative debridement and intense oral hygiene reduced 10 mm pocketing area 14 to 4 mm, and 7 mm pocketing implant 25 to 3 mm. Additional surgery presently not required. In spite of previous extensive surgical management, factors of oral hygiene, smoking and irregular periodontal maintenance contributed to this patient's PI. a/b: Pre-treatment clinical photos of implants 16, 15, 14 and 24, 25 (mirror image). c: Pretreatment radiograph demonstrating significant bone loss implants 14, 25. d/e/f: Intense oral hygiene including "double" thick softpics (and oral B electrical toothbrush) is instrumental for treatment success. g/h: One month post-treatment photos demonstrating periodontal health; decreased pocketing, inflammation is resolved and no bleeding on probing (mirror view).

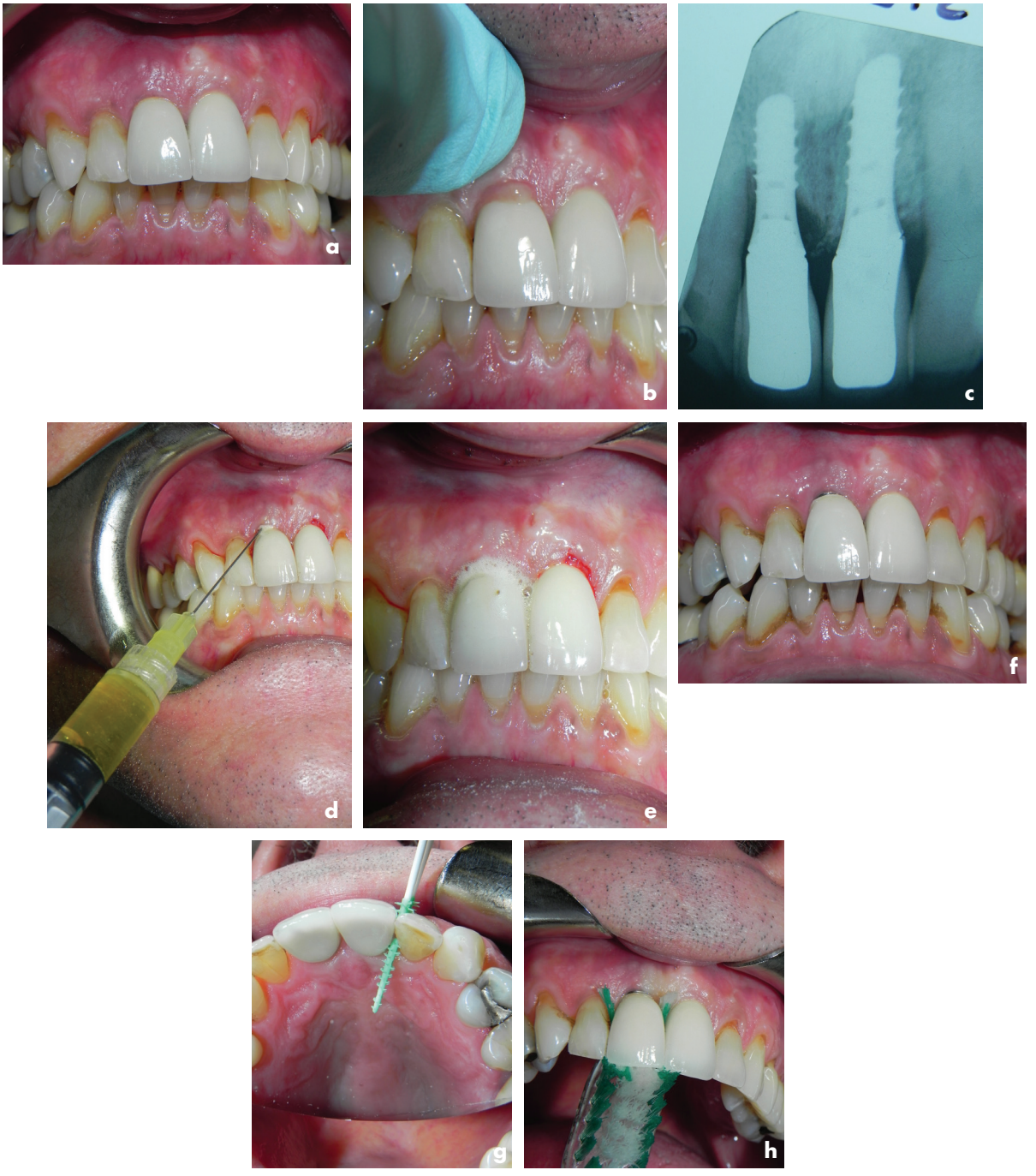

Figure 4.
Unmitigated PI can result in acute peri-implant infections. Even in these cases, conservative management can be effective. CIST protocol ABC: 59-year old smoking retired male seen for treatment of abscessed implant 11. Implants 11 and 21 were placed in 2003 by another practitioner (14 years earlier) and a bone graft was required in area 11 prior to implant placement. Advanced bone loss implant 11 (not 21) and patient was adamant against surgical intervention. He was also unhappy and was not aware that problems could occur around his investment in implants. He said "if he would have known there could be a problem, he would not have accepted this treatment" (and this is 14 years later!). Could be a short memory, but this emphasizes importance of proper documentation in our charts. Conservative CIST ABC succeeded but patient was encouraged to keep seeing his dentist for regular periodontal maintenance and was warned that in the future PI treatment may be re-required including possibility of CIST ABCD regenerative option. Once again, factors of oral hygiene, smoking and irregular periodontal maintenance contributed to this patient's PI. a: Pretreatment photo implant area 11 and 21. b: Purulent exudate with 11 mm pocketing. c: Radiograph demonstrating 40 per cent bone loss around implant 11. d/e: conservative debridement is facilitated by local anesthesia, and narrow-gauge needle irrigation with an antibiotic solution and hydrogen peroxide. f: One month post-operative photo demonstrating healthy gingiva and the gingival "seal" is "tight" around both implants. g: Stability is enhanced with intense stimulation with "double" small softpics. h: Intense brushing concentrating on the gingival margin, as would be also done with the oral-B electrical toothbrush; both oral hygiene devices enhance the "O-ring effect" around implants.

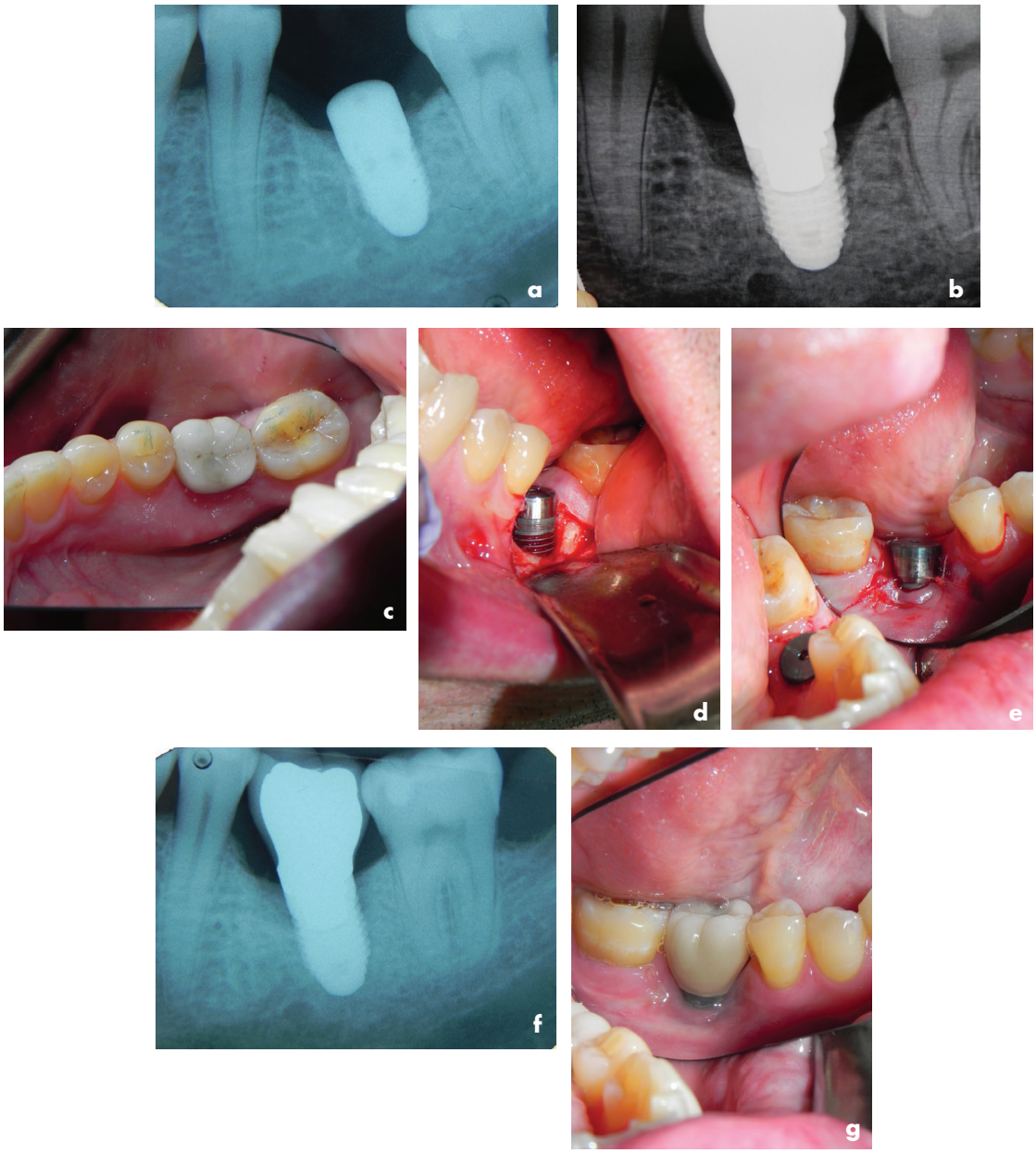

Figure 5.
Example of poor patient compliance. CIST protocol ABCD resective and regenerative: 50-year old non-smoker male had 6 mm x 10 mm Nobel Biocare implant placed February 2015. It was restored by his general dentist four months later but patient did not return for "no cost" oral hygiene and occlusal assessment follow-up. Thirteen months later patient called because "my implant is loose and I have a bad taste in my mouth" (words that immediately catch our attention!). Diagnosis revealed the presence of a loose abutment screw and unfortunately, bone loss circumscribed the implant. Early detection however allowed successful resolution of the difficulty. Factors of patient neglect and irregular follow-up contributed to this scenario. a: 6 x 10 mm implant placed with 3 mm healing abutment; 100 per cent bone stability prior to restorative endeavours four months later. b: Significant bone loss compared to 'a' due to bacterial invasion around loose abutment screw. c: Purulence and gingival inflammation with 6 mm pocketing where loose crown is pinching the gingival margin. d: Periodontal surgery for detoxification of the Implant surface and placement of a 7 mm wide healing abutment allowed for primary closure of the surgical area; it was helpful the crown could be removed for later re-cementation. e: Combination bone regeneration and pocket reduction therapy was provided. f: Three-month post-surgical radiograph demonstrates early bone rehabilitation and implant stability with re-insertion of original crown (a new abutment screw was placed however). g: Clinical photo of healed implant 36 area; some implant surface showing, however, area is "healthy" and patient also had renewed interest in regular maintenance with his general dentist and his oral hygiene methodologies.

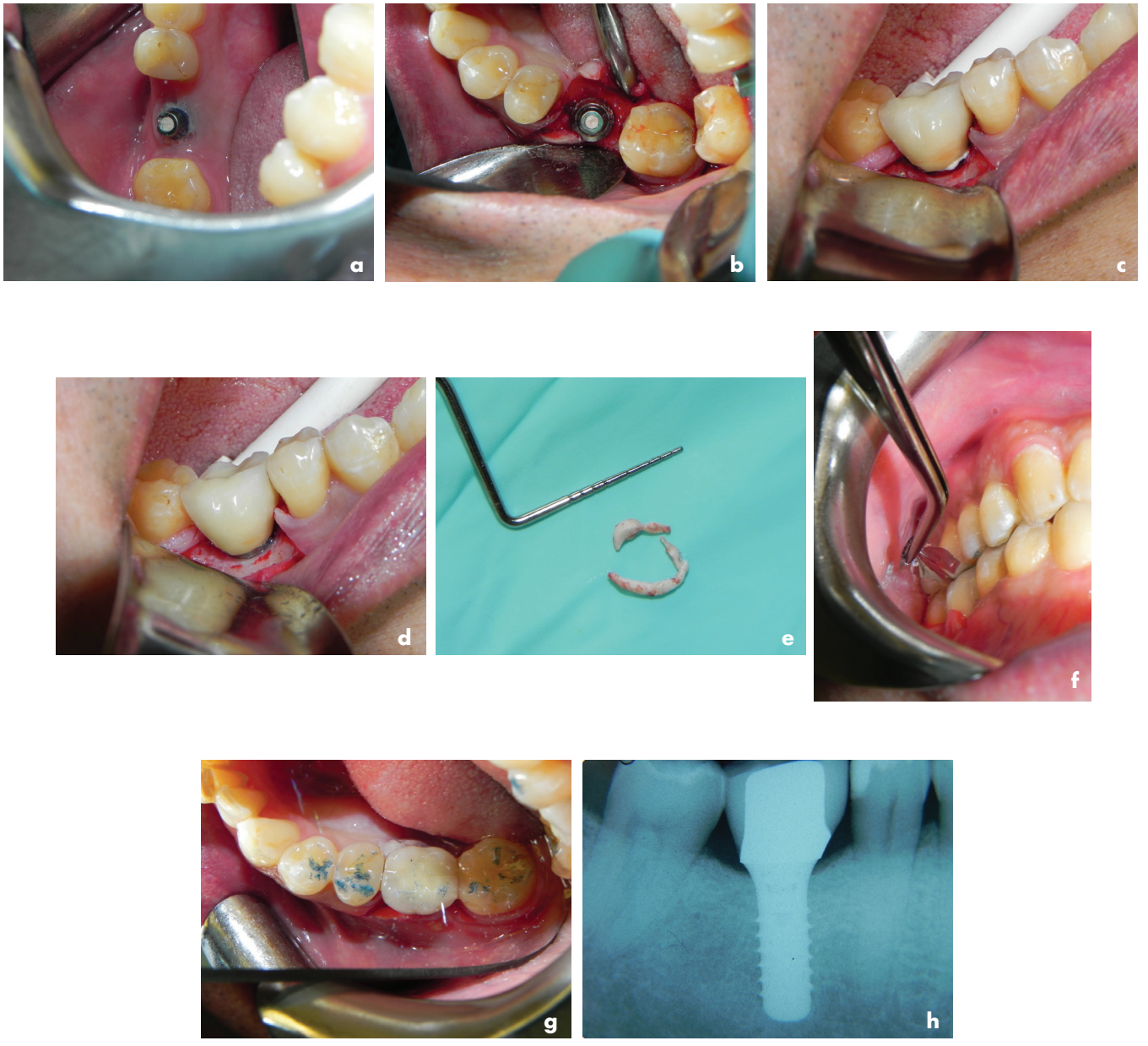

Figure 6.
Example of bruxism and occlusal overload. CIST protocol ABCD resective: Cemented implant crowns can debond for a variety of reasons. Unfortunately, gingival rebound can occur and can significantly cover the margin of the implant abutment not allowing for quick crown re-cementation. Contributing factors in this case included bruxism and heavy occlusion. a: Cemented implant crown dislodged and peri-implant gingiva rebounded 3 mm in the coronal direction making it impossible to re-cement the crown. b: Surgical exposure (with a crown lengthening technique) reveals actual circumference of the 46 implant abutment. c: Implant crown was recemented (notice excess flash at the crown margin). d: Circumferential flash was removed to avoid future PI difficulty. e: An example of excess cement use; this is a known cause of PI. f: The occlusion was tested with Shimstock and heavy occlusal contact was adjusted. g: Articulating paper also helps to verify occlusal contacts. h: Radiograph demonstrates a secure implant crown, fully seated; bone around the implant is still at 100 per cent and patient is being fitted for a bruxism appliance.

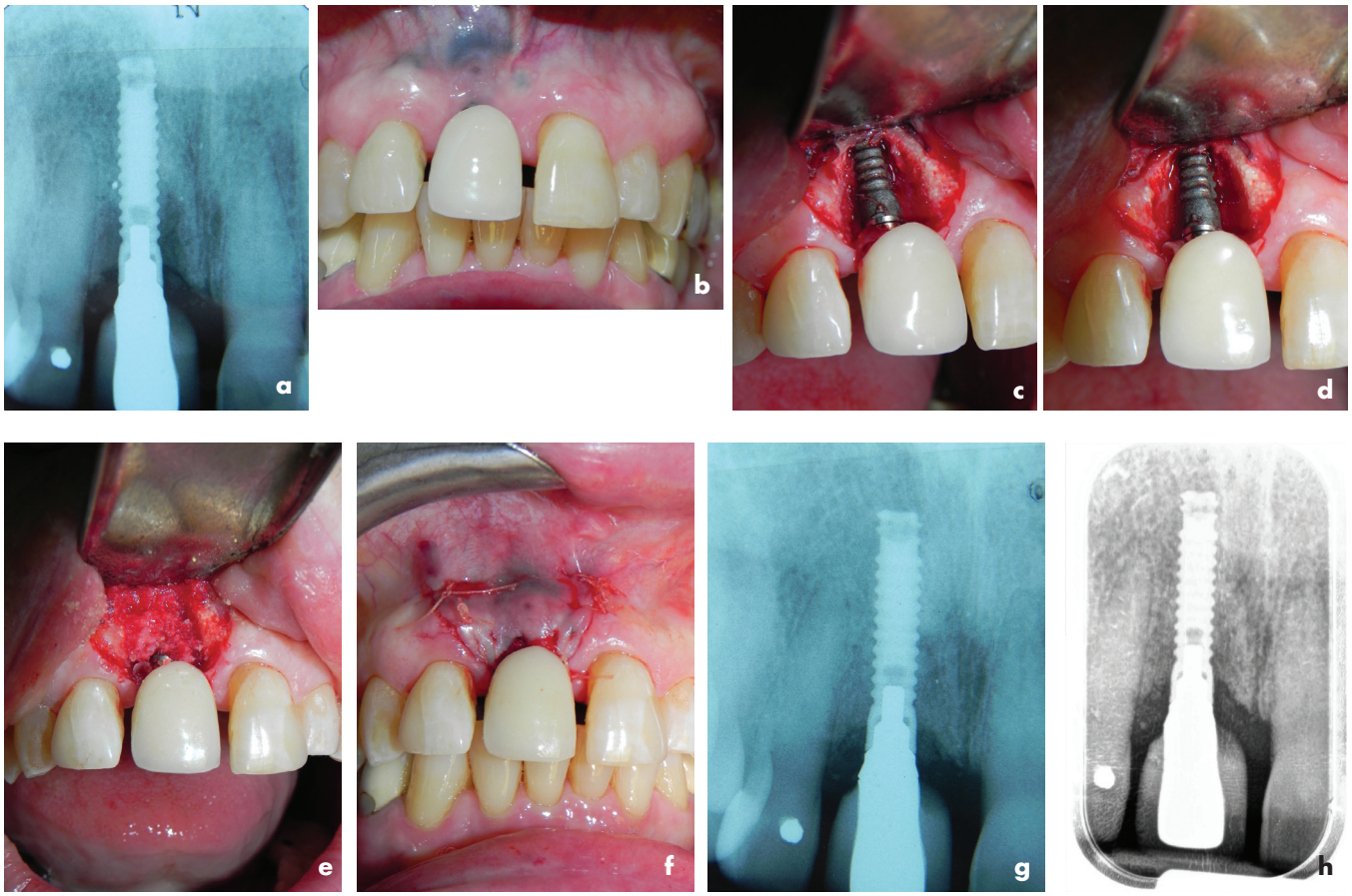

Figure 7.
Example of CIST protocol ABCD regenerative: 68-year old non-smoking female on Fosamax (seven years) had implant 11 placed 12 years earlier by another practitioner. PI associated with 9 mm labial pocketing and 35 per cent bone loss in a highly aesthetic area. Fortunately, regenerative therapy was successful. Bone regeneration can be unpredictable but factors of good oral hygiene, regular periodontal maintenance and non-smoking tendencies cannot be overstated. a: Radiograph demonstrating 35 per cent bone loss with implant 11. b: Clinically, the gingiva is not overly inflamed but it is obvious that area 11 has undergone several interventions including apical endodontic surgery with a retrograde amalgam restoration; one wonders if past trauma to the alveolar bone can contribute to future vulnerability. c: Surgical exposure prior to detoxification of the implant surface. d: Chemical detoxification of the implant surface. e: Bioactive glass bone grafting material placed and packed to fill all voids. f: Labial flap sutured with primary closure. g: Post-operative radiograph demonstrates surgical attempt for 100 per cent bone regeneration. h: Eight-month follow-up from general dentist indicating successful rehabilitation of area 11 radiographically; patient lives "out of town," and as per usual, regular periodontal maintenance visits and oral hygiene protocol were emphasized.

well-informed patient for her or himself, every day, with the right tools on a regular basis. We tend to encourage more aggressive and consistent oral hygiene around implants to help stimulate a healthy "O-ring" effect. This enhances periodontal health around the vulnerable implant-gingival interface. Refer to Figures 3, 4 and 8 describing ideal daily oral hygiene practice to enhance peri-implant gingival health. A healthy "O-ring" around implants significantly reduces incidence of PI. Also, patients on regular periodontal maintenance have significantly lower PI and PD difficulty (2).

Conclusions

Of the many factors that can influence the development of PI, the most significant "Achilles heel" may be the vulnerable implant gingival interface. If we equate PI to a movie, the most appropriate would be *The Good, The Bad and the Ugly*. The "Good" is that, after nine years, over half of people with implants do not have PI. Also, if detected early, PI can be successfully managed. The "Bad" is that, after nine years of implant function, slightly less than half of patients can develop PI, and some will have moderate to severe PI. The "Ugly" part is that some situations of PI continue to deteriorate in spite of our treatment efforts (8). Early detection is really important, as is disclosing the risks through a strong informed consent process.

To end with a quote by Dr. Peter Fritz (periodontist, Fonthill, Ontario): "The patient often asks the question, 'How long do implants last?' The long answer to

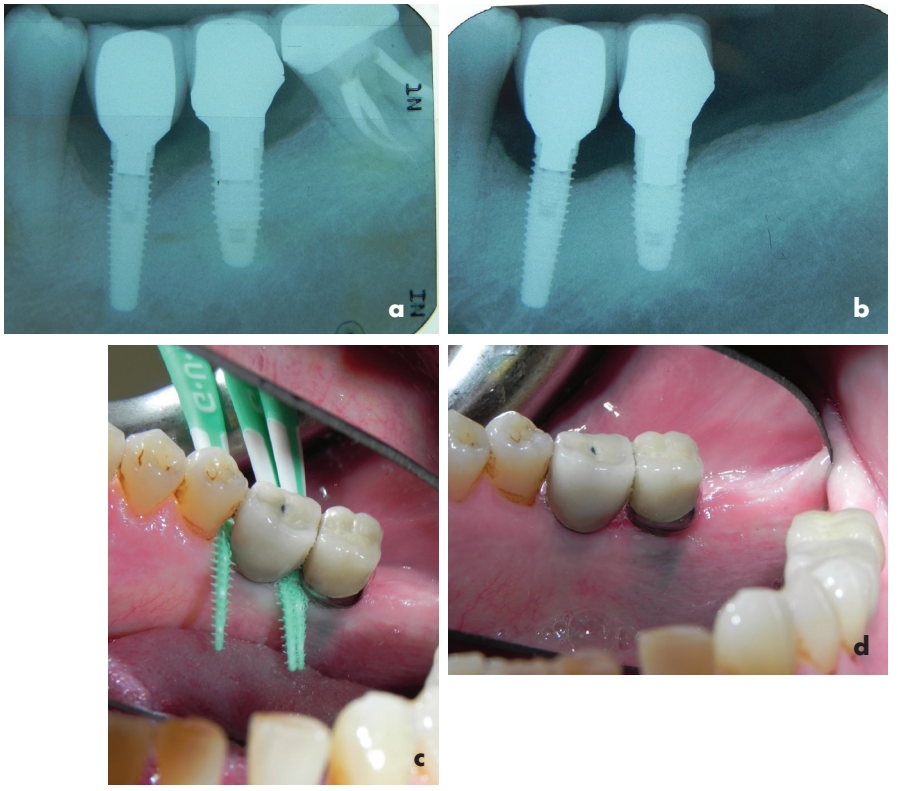

Figure 8.
Treatment of PI can have long-term benefits once all controllable factors are accounted for. CIST Protocol ABCD regenerative: 68-year old non-smoking male, originally had two implants placed by an oral surgeon in 2005, area 36, 37. Implant 36 required replacement in 2006. PI identified area 36, 37 in 2013 with 7 mm pocketing and a "crater" bone defect, especially to implant 36. Bone grafting surgery was provided November 2013 and has maintained benefit four years later. a: Pre-operative radiograph November 2013. b: Post-operative radiograph April 2017 demonstrating excellent bone stability around implant 36, but area 37 has faltered; CIST Protocol ABC re-initiated to help stabilize 5 mm pocketing around implant 37. c: Vigorous interdental oral hygiene allows the gingival tissues to "blanch" if done properly; this is encouraged several times per day. d: Tissue health is obvious in this projection; sometimes people need to be reminded of their daily responsibilities in order to ensure periodontal health, give that treatment success is promoted with excellent oral hygiene, regular periodontal maintenance, patient awareness and absence of smoking.

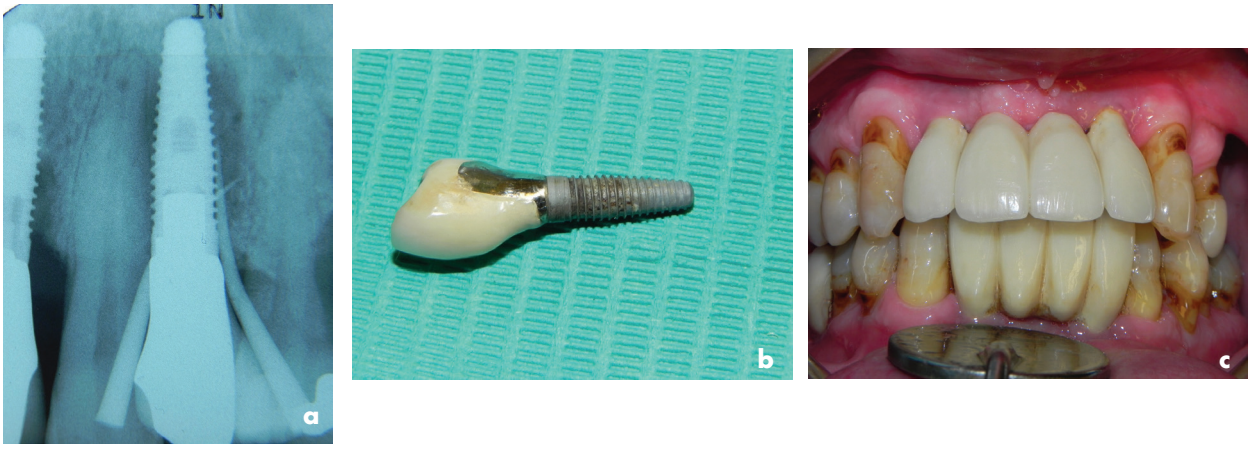

Figure 9.
Case selection is critical for implant treatment planning. Some patients are not ideal candidates. CIST protocol E: 48-year old male, heavy smoker with inadequate oral hygiene and semi-regular periodontal maintenance. Originally seen in 2014 and treatment followed conservative CIST protocol ABC. Implants were placed by another practitioner in 2009 in areas 12, 22, 24, 32, 42 and 46. Unfortunately, area 24 continued to deteriorate and required removal. Currently, even implants 12, 22 are now misbehaving and a partial denture scenario is being discussed. Patient was not acceptable of periodontal surgery. Recently as well, tooth 26 was lost due to periodontal infection. a: Radiograph demonstrating 95 per cent bone loss around implant 24 and 50 per cent bone loss around implant 22. b: Never a good sign when this happens. c: Smoking and inadequate oral hygiene are major factors that influence both periodontal and peri-implant health; notice tooth staining and inflamed gingival margins which indicate a "non-ideal" periodontal scenario. This case example emphasizes the need to screen patients carefully to avoid PI. PI treatment failed because of lack of compliance with respect to daily oral hygiene and excessive smoking in spite of regular periodontal recall appointments.

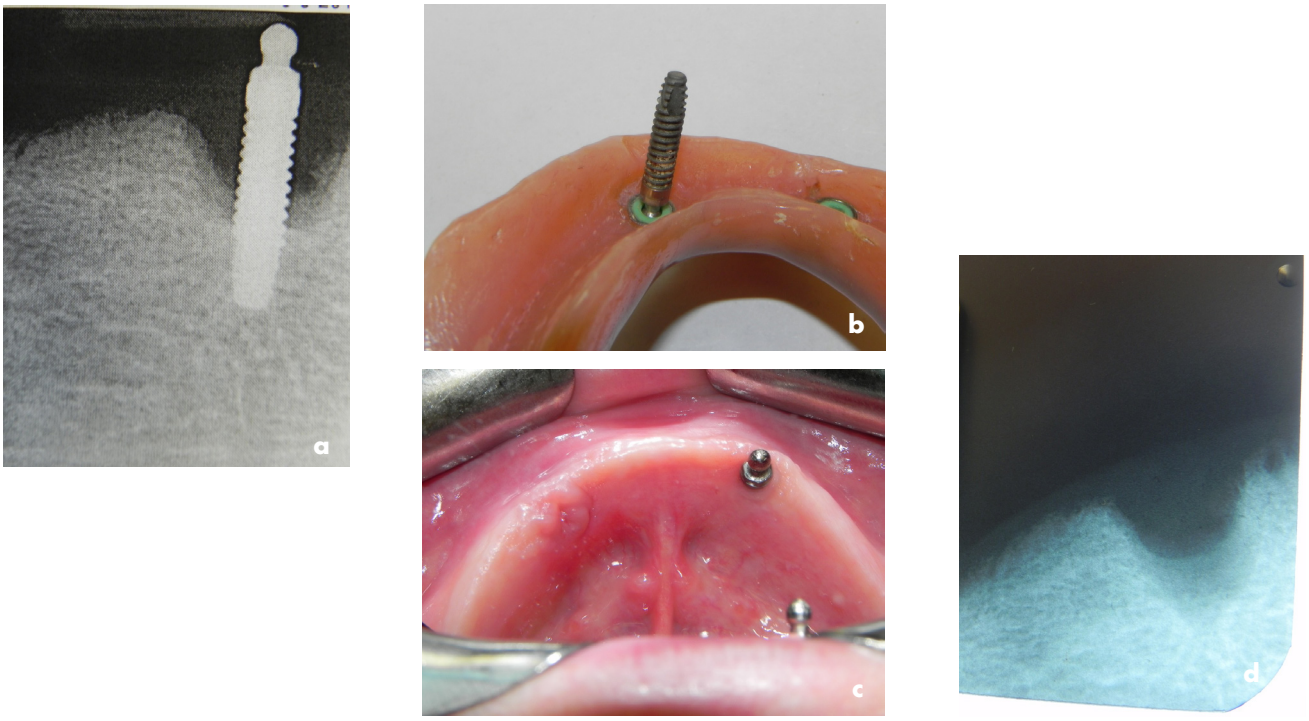

Figure 10.
We cannot ignore systemic influences on PI development. CIST protocol E: 82-year old, non-smoking female had two mini-implants placed in 2009 by another practitioner and was referred for management of PI implant 43 in September 2015. CIST Protocol ABCD regenerative therapy was planned but had to be delayed due to ill health (respiratory). Patient postponed follow-up for one year. Unfortunately, implant 43 exfoliated the day before the re-assessment appointment. Medical history also included chemotherapy for multiple myeloma in the past. The previous night, she removed her partial denture as per "usual" and was "shocked" to find that it was "attached" to her denture. Never a happy scenario. At this time, the patient was encouraged to use denture adhesive to help support her chewing function. This patient is not a good candidate for the placement of another implant in site 43. a: Radiograph September 2015 demonstrating 70 per cent bone loss around implant 43. b: Implant attached to patients' full lower denture. c: Clinically, implant 33 is stable but exfoliated implant 43 leaves a gingival crater. d: When PI is not detected early, peri-implant infection can cause large craters of bone loss as is depicted in this radiograph. Sometimes adjacent teeth can suffer the wrath of peri-implant disease as well. Delayed treatment and systemic complications influenced the loss of implant 43.

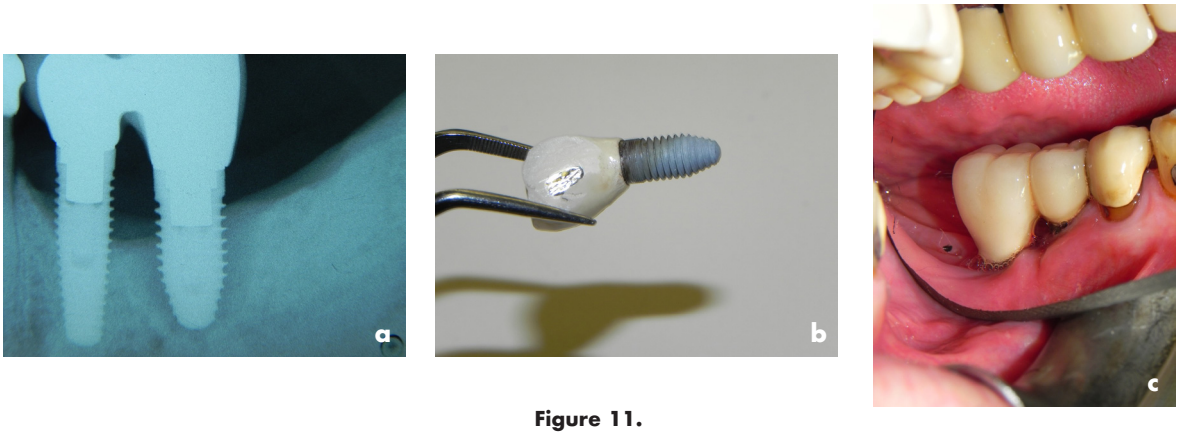

Figure 11.
Smoking appears not to be an absolute contraindication to implant placement. CIST protocol E: 79-year old heavy smoking male that had many implants placed by another practitioner in areas 14, 13, 12, 22, 23, 24, 25, 35 and 36. Patient was originally seen in 2014 and implant 36 already was experiencing 80 per cent bone loss. These scenarios are not conducive for predictable regenerative periodontal therapy. Very good oral hygiene and regular recall visits were maintained with this gentleman and implant 36 lasted an additional three years with conservative CIST protocol ABC therapy. All of the other implants are doing well in spite of the smoking habit. Implant 36 was different however in that there was no attached gingiva supporting it on the buccal aspect. This suggests that risk factors could be additive with respect to PI predisposition. Even though a heavy smoking habit exists, the patient was not completely happy about the loss of his implant. a: One hundred per cent bone loss around implant 36 in 2017; bone loss circumscribes the apex of the implant. b: Implant 36 "fell out" as soon as the contact point was separated. c: Mirror image of area 35-36 demonstrating major frenum pull on area 36 but attached gingiva is stable around implant 35.

Figure 12.
PI can cause significant cosmetic deformity when attached gingiva is deficient. Example of a reparable mucogingival difficulty around an exposed implant in a non-aesthetic zone: 73-year old female with a smoking habit but has regular periodontal maintenance visits and very good, consistent oral hygiene habits. Implant 34 demonstrated continued gingival recession and 40 per cent bone loss, major frenum pull and no attached gingiva. Mucogingival grafting surgery was provided. a: Clinical presentation of a failing implant due to mucogingival instability. b: Radiograph demonstrating 40 per cent bone loss around implant 34. c: Surgical exposure of defect always shows a larger involvement once the weak alveolar tissue is released; implant surface detoxification took the form of citric acid (mirror image). d: A free autogenous gingival graft was placed and secured over area 33-35 to repair the gingival defect around implant 34; when detected early, PI can be successfully managed, with this "cosmetically compromised" exposed implant not being in a cosmetically sensitive area (mirror image), thus when the patient smiles, this area is invisible. e: Early healing (three weeks) demonstrates rehabilitation of lost attached gingiva; however, the "new" tissue is having a difficulty embracing the exposed implant threads, as this procedure has obvious limitations in the aesthetic zone.

this question is that implants will last as long as they are properly maintained, provided they were designed and manufactured properly and delivered to the right patient by the right clinician. The wrong answer is the short answer, 'Forever'" (17).

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