

# Cemented Implant Restorations and the Risk of Peri-implant Disease: Current Status

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## Abstract

The relationship between implant disease and cement has evolved from multiple sources. Initially case studies, then a positive link, was established by Wilson. More evidence is presented by evaluating failed, removed implants and establishing if cement was present on the body of the implant. Although this does not explain why the peri-implant disease occurs, it does highlight significant problems dentists are having when restoring implants with cemented restorations.

## Introduction

Dental implants have changed the way many dentists work and have improved the lives of countless patients. However, along with these positive changes have come some issues. One such example is the link between luting cements used for cement-retained implant restorations and peri-implant disease. How and why these materials cause an issue

specifically with implants is currently under investigation. This chapter explores what we currently know about the interaction of cements, implants, and peri-implant diseases. The research and case reports presented here will hopefully provide an insight into the complexities of these disease processes. By providing a better understanding of what is occurring, it may be possible to reduce or even eliminate many of these problems.

The American Academy of Periodontology recently released a report reporting on peri-implant disease and risk factors.

The following are risk factors for peri-implant disease:

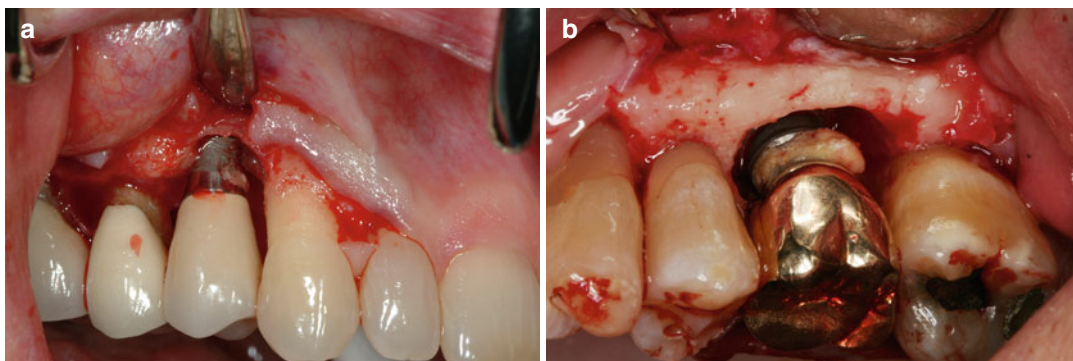
- Previous periodontal disease
- Poor plaque control/inability to clean
- Residual cement
- Smoking
- Diabetes
- Occlusal overload
- Potential emerging risk factors (alcohol, rheumatoid arthritis, loading too late)

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**Fig. 2.1** (a, b) These two examples show residual excess cement and how it relates to the destruction of the implant-supporting tissues. Is it possible that the cement behavior

was active in this process, or did it simply occur because the cement presented an overhang of material?

When the list is critically reviewed, it is clear that some of these risk factors are within the control of the restorative dentist, especially providing a reconstruction that is accessible to cleansing adequately, and more importantly, the complete elimination of residual excess cement when a cement-retained restoration is used.

Cement-retained restorations for implants were introduced over 20 years ago, with many claimed advantageous such as control of esthetics, occlusion, cost, ease of fabrication, and passive fit. However, it is more likely that this type of restoration became popular because dentists were familiar with the cementation process, it being a part of traditional tooth form dentistry. What is of interest to note is that most patients, when surveyed, do not mind whether they receive a screw- or cement-retained restoration; therefore, it appears to be predominately the clinician's choice to use a cement-retained restoration.

Controversies exist about this disease process, and the aim of this chapter is to explore what is currently known about peri-implant disease and question why implants are so susceptible to a process dentistry has been using for over 100 years with great success vis-à-vis cementing restorations onto natural teeth. Peri-implant disease is now considered to be comprised of two general categories: peri-implant mucositis and periimplantitis. Some authorities consider peri-implant mucositis to be similar in nature to gingivitis, in that it is restricted to the soft implant-supporting

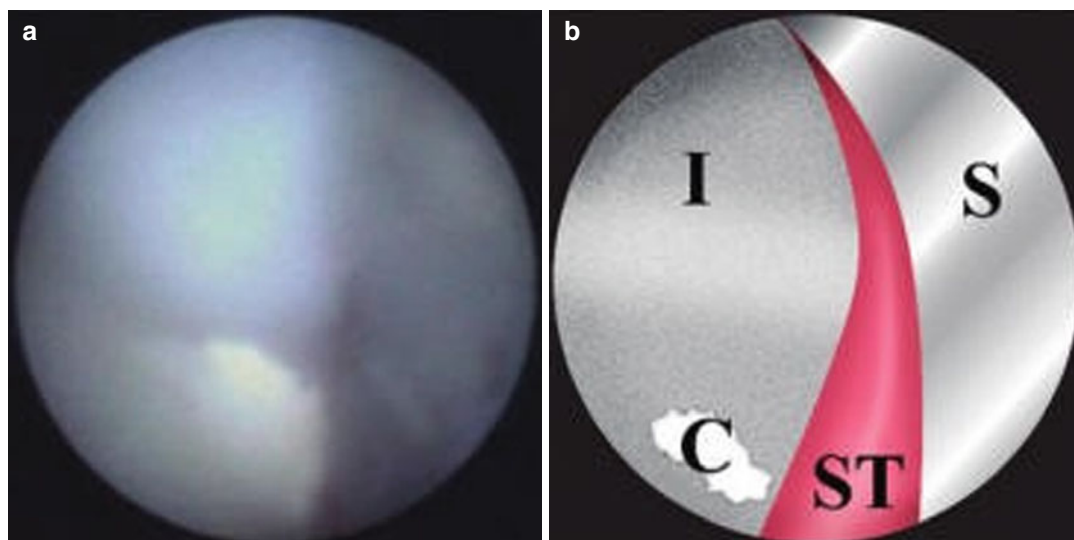
tissues and is considered reversible if treated early. In contrast, periimplantitis is a irreversible disease process that affects the supporting bone tissues, and, although considered similar to periodontitis, it is noted to be far more aggressive and difficult to control.

Although the peri-implant disease process has several risk factors, where residual excess cement is concerned, it may be that the cement has an active etiological role rather than simply behaving as a mechanical trap for bacteria such as an overhang (Fig. 2.1a, b). Peri-implant disease may be promoted by the presence of residual excess cement due to bacterial interaction, allergic response, foreign body reaction to cement, or by the cement altering the surface of the implant resulting in inflammation around the site.

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### **The Science and Studies—Microbial Interaction: T.G. Wilson's Study on the Clinical Relationship Between Residual Excess Cement and Peri-implant Disease**

By definition, peri-implant diseases are inflammatory in nature. Many of the same pathogenic bacteria associated with periodontal diseases are also associated with peri-implant disease. Several case reports found these inflammatory lesions (peri-implant mucositis and periimplantitis) were associated with residual cement.



**Fig. 2.2** (a) A piece of cement, 0.5 mm in diameter, attached to the implant surface is seen in the lower left quadrant of the screen grab from the endoscope. (b) An

illustration of A. *I* implant, *S* shield, *C* cement, *ST* soft tissue (Reproduced with permission from the American Academy of Periodontology: Wilson (2009))

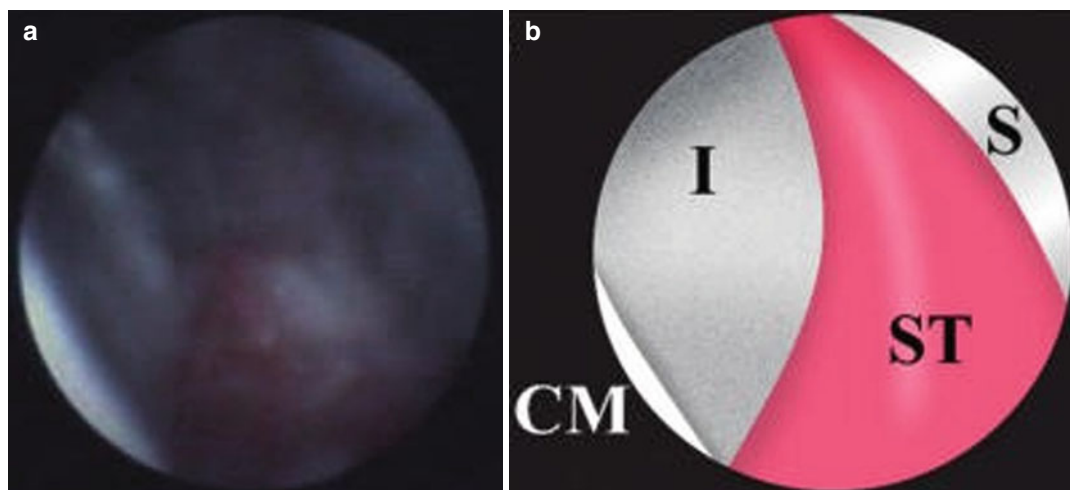
A prospective inception cohort study on the relationship of excess cement to peri-implant disease was published in 2009. A dental endoscope was employed to view the subgingival peri-implant space. Inflammation around fixtures was often found associated with dental cement adhering to the implant superstructure or to the fixture its superstructure.

Individuals presenting with clinical signs of peri-implant mucositis (bleeding upon probing, color change) had the peri-implant space debrided and their oral hygiene reinforced and were instructed to irrigate the affected area with chlorhexidine 0.12 % twice daily for 30 days. If bleeding or other signs of clinical inflammation were still present 30 days later, the patient was entered into the study. Patients who presented with suppuration, had increased probing depths, or had radiographic evidence of continued bone loss were entered directly into the study. Thirty-nine consecutive patients with 42 implants were entered. Twelve of these patients had 20 similar implants that had no signs of peri-implant disease. These last implants served as controls. All test and control implants had received cemented single-unit fixed partial dentures. Both groups had the subgingival peri-implant site explored using a dental endoscope (Fig. 2.2a, b).

The presence or absence of materials adherent to the implant itself, the crown, and any material visualized in the surrounding soft tissues was recorded. This generation of endoscope dental cement has a brilliant white reflectivity; calculus is dull brown and biofilm gray/blue. Biofilm can be easily removed with the tip of the endoscopic explorer. Removal of any adherent material was accomplished using the scope for visualization and combinations of hand and/or mechanical methods until no further material could be visualized. The endoscope explorer was then rotated 180°, and any materials visualized in the soft tissues were removed, if possible (Fig. 2.3a, b).

Cement was found on 81 % of the test implants and on none of the control fixtures. At the 1-month evaluation, after removal of foreign matter, 76 % of the clinical and endoscopic signs of inflammation around the test implants had resolved. Three of the test implants required surgical entries to resolve the inflammatory process. Studies of biopsies from these three cases, as well as a number of additional cases, are currently underway.

One of the most disturbing aspects of this data was that the earliest signs of peri-implant disease



**Fig. 2.3** (a) An endoscopic view of the same implant seen in Fig. 2.1 after cement removal. (b) An illustration of (a). *I* implant, *S* shield, *CM* crown margin, *ST* soft tissue

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did not appear until 4 months after cementation, while the longest was 9 1/2 years after placement (Fig. 2.4). The findings of this study have been duplicated by others.

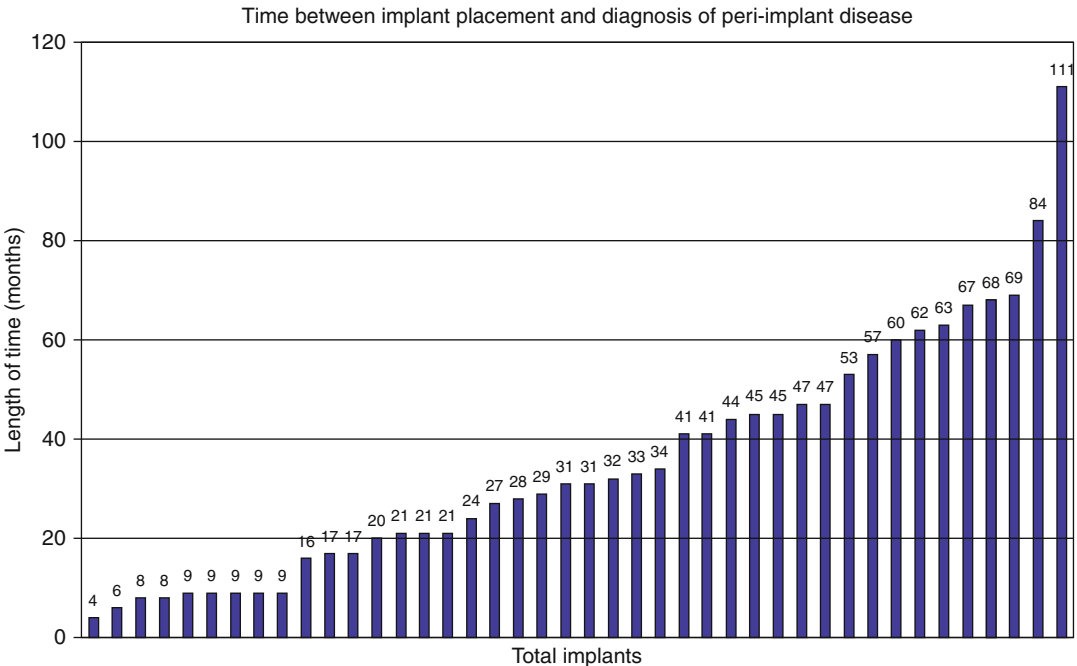
While in this study the type of cement used did not appear to affect the disease process, recent evidence suggests that some cement types may have an active role in the disease process.

As a result of the cumulative information available, so far it appears that modifying surgical and prosthetic approaches when using cemented crowns are important. Prosthetic modifications and the use of alternative types of cement are addressed in other chapters of this book.

Surgical modifications include reduction of excess soft tissues, which may interfere with cement removal, flattening posterior ridges to eliminate redundant soft tissue, the use of implants with smooth gingival collars designed to raise the crown/implant margin coronal to the soft tissues, and placing the coronal portion of the implant as shallow as possible, while keeping esthetic and functional aspects in mind.

Treating implants that have lost bone attachment as a result of periimplantitis remains problematic. At present, the only proven way to stop the progress of periimplantitis is to remove the rough surface of the implant. This presents obvious esthetic and food impaction problems. One of the keys to achieving new bony attachment on an implant surface previously covered by biofilm is the successful removal of the bacteria and their byproducts. While many approaches have been tried, the final answer is not yet available. One technological advance, the video scope, allows increased visualization and a greater potential to remove implant-borne and soft tissue-associated particles. These particles are frequently found to be cement and titanium. Studies on their role in the etiology of peri-implant diseases, as well as the treatment of these diseases, continue.

At present, it is important to educate dental professionals about the problem and to periodically evaluate the peri-implant tissues monitoring for early indications of disease. When peri-implant mucositis is detected early, treatment should be



**Fig. 2.4** The presence of peri-implant disease was discovered as soon as 4 months after cementing the fixed partial denture and as long as 111 months. Each bar represents an individual implant (Mean 2.93 years) (Reproduced with permission from the American Academy of Periodontology: Wilson (2009, 1390))

immediately employed to prevent this evolving into periimplantitis with associated bone loss.

**Case Reports Where Residual Cement Was Associated with Peri-implant Disease**

Figure 2.5a shows a female patient who presented with cervical resorption of the maxillary right canine with symptoms of irreversible pulpitis. Radiograph is shown in Fig. 2.5b. Treatment of choice was extraction and implant placement.

Post extraction, the surgical site was carefully evaluated and bone thickness recorded. This was considered appropriate for immediate implant placement (Implant: Nobel Biocare

Replace). Figure 2.5(c-d) Radiographic imaging showed the implant to be in a good position, the soft tissue was supported by the use of allograft particulate material (Bio-Oss, Giestlich). To prtects and support the soft tissues further a custom healing abutment was fabricated Figure 2.5e. The implant was left to integrate for 3 months prior to referral back to the restoring clinician.

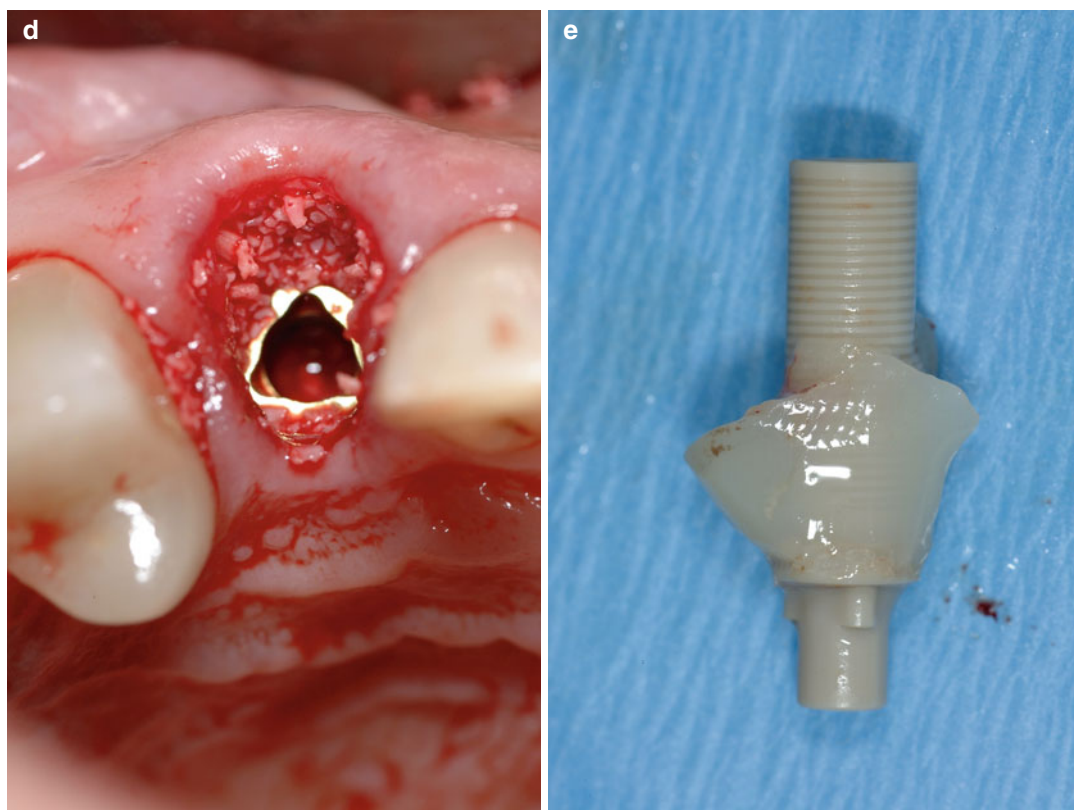
Three years after implant restoration was completed, the patient represented at the periodontist’s office complaining of pain. Figure 2.6a the clinical photograph; note the tissue changes mesial to the implant site. The Radiograph (Fig. 2.6b) indicated bone loss. Full-thickness soft tissue flap elevation revealed the extent of this lesion (Fig. 2.6c). In Fig. 2.6d, the cement



**Fig. 2.5** (a) This female patient presented with cervical resorption of the maxillary right canine with symptoms of irreversible pulpitis. (b) Radiograph is shown. Treatment of choice was extraction and implant placement. (c–e) Post extraction, the surgical site was carefully evaluated and bone thickness recorded. This was considered appropriate for immediate implant placement (Implant: Nobel

Biocare Replace). (c) Radiograph showing implant placed. (d) Cervical area augments with allograft particulate matter (Bio-Oss). (e) Custom healing abutment being fabricated, using a temporary plastic cylinder. This was provided to maintain the soft tissue profile during the healing phase. The implant was left to integrate for 3 months prior to referral back to the restoring clinician





**Fig. 2.5** (continued)

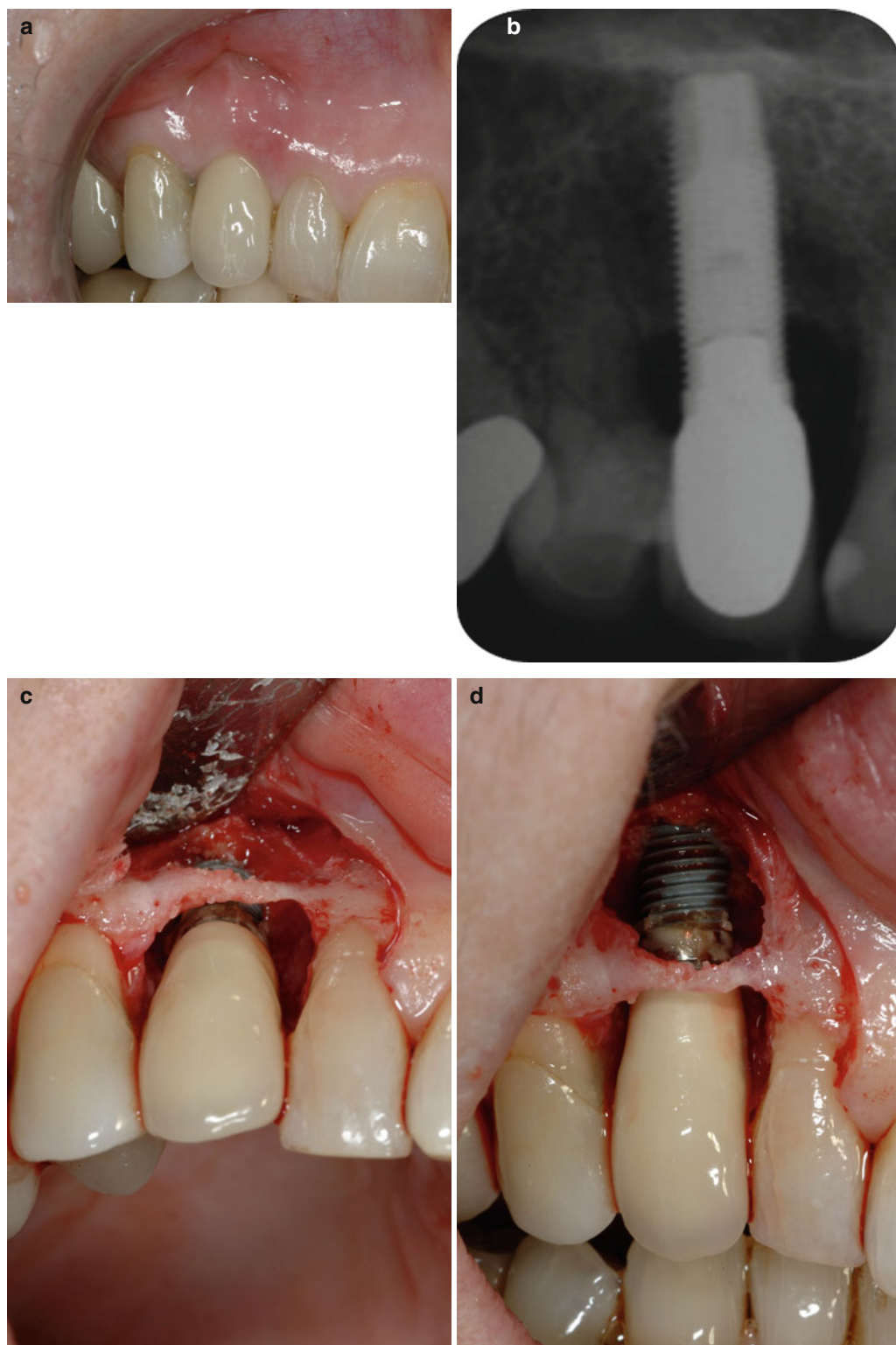
is clearly visible. This case and the associated treatment outcome is described further in chapter 11.

### **Prevalence of the Cement-Induced Peri-implant Disease Issue**

Thomas Wilson is credited with being the first investigator to describe the link between residual excess cement and peri-implant disease. To date no data exists on how many implants fail that may be the result of an interaction with cement extrusion. Even if cement is not the direct cause of implant loss, it would be of value to determine

how frequently it is found associated with implants that fail.

In August 2011, Nobel Biocare, USA, allowed a sample of returned failed implants over a 6-week period to be evaluated. The implants and associated information (patient data, date placed, date failed, potential failure causes, etc.) were recorded. The implants with their restorations were photographed, and any material attached to the implant or abutment was subject to energy dispersive spectroscopy (EDS). This allows a nondestructive identification of foreign material adhesions to the surface of failed and returned implants that were inspected for materials attached (Figs. 2.7, 2.8, 2.9, 2.10, 2.11, 2.12, and 2.13).



**Fig. 2.6** (a–d) Three years after implant restoration, the patient re-presented at the periodontist's office complaining of pain. (a) Clinical photograph, note tissue changes

mesial to the implant site. (b) Radiograph indicates bone loss. (c) Full-thickness soft tissue flap elevation shows the extent of this lesion. (d) The cement is clearly visible





**Fig. 2.7** Example of a failed implant with residual excess cement. XRF analysis determined this as RelyX luting cement

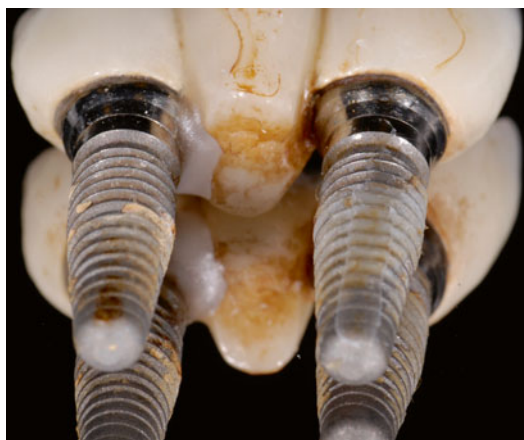
## Data Collection Technique and Results

Elemental analysis of materials is useful in many scientific disciplines, providing quantitative and qualitative data on the elemental composition of materials. However, this often results in destruction of the specimen being tested, which in some fields is highly undesirable. Medical X-ray fluorescence spectroscopy (XRF) provides a nondestructive means of estimating elemental composition in humans and has been used in research for in vitro and in vivo for many years. The XRF instrument uses low-level gamma radiation to provoke the emission of fluorescent photons from the target area being tested. The photons are detected and counted over the wave-



**Fig. 2.8** This failed implant (with mirror) had a note from the surgeon stating the patient was a smoker and that may have contributed to the implant failure. The material was examined and determined to be calculus on top of a resin-based cement

length spectrum from which characteristic emission patterns unique to each element may be recorded. The XRF machine can be used for



**Fig. 2.9** Failed implant bridge after 8 years of service. The implant documentation stated the implants were placed in October 2001, restored in April 2002, and removed in May 2010



**Fig. 2.10** Another failed implant with residual excess cement noted all the way down onto the screw threads. It should be stated that cement may not be the cause of failure in some cases; however, the lack of control of the clinician with the cementing technique is clear

varying degrees of material penetration, which affects the level of electron shell emission. Weaker penetrating X-rays are usually used for non-mineralized tissues and have been used in vivo to investigate tissue structures such as the eye, skin, prostate, kidney, liver, thyroid, spleen, and lungs. For mineralized materials, such as bone, where deeper penetration of the X-rays is desired, the K-shell ( $K\alpha$ ) emissions are considered more useful.

Identification of materials used in dentistry is also important, especially when the material has



**Fig. 2.11** Cement is clearly visible at the margin of this specimen. It also extended halfway down the implant. The other materials noted were bone mineral deposits extending to the full length of the implant



**Fig. 2.12** This example had cement, calculus, and bone mineral deposits the full length of the implant body. The size of defect on removal of this failed implant is unimaginable!

an adverse effect on the surrounding tissue. One such example that has recently come to light is the detection of residual cement material extruded at the crown margin, used for cement-retained implant restorations. A positive link has been established between excess cement extrusion and peri-implant disease, identified with an endoscopic device. Excess cement can also be detected radiographically, given the cement is radiopaque enough: described in chapter 5. One problem is confirming the material tested if it is in fact dental cement and not mineral deposits such as calculus



**Fig. 2.13** Some cements could be clearly identified by their physical characteristics; this pink cement was Premier implant cement

or bone. If the cement can be removed, it may be further analyzed using a variety of techniques including visual, light microscope, and SEM or even subject to elemental analysis using traditional methods such as mass spectroscopy. However, many of these methods require the sample be modified or degraded and are time consuming and costly. Some also require that the specimen be destroyed.

The need to evaluate foreign materials on the surface of dental implants may provide clues as to the understanding of how and why implants fail. Here we describe a simple nondestructive technique for the identification of residual foreign material attached at the margin of a cement-retained implant restoration or on the surface of the body of the implant.

## Procedure

A handheld wide-range elemental analyzer (TRACeR III-V; Bruker AXS Inc., Madison, Wisc) (Fig. 2.14) connected to a personal com-



**Fig. 2.14** The Bruker TRACeR III-V X-ray fluorescence analyzer (Photo courtesy of Bruker Elemental, Kennewick, WA, USA)

puter running the Bruker S1PXRF software was used. The instrument was based on energy dispersive X-ray fluorescence (XRF) technology and contains a high-resolution, thermoelectric cooling, silicon PIN (Si-PIN) diode detector. As this device can identify the elemental makeup of a product, it was necessary to have sample cements evaluated for their elemental spectra. To create the reference spectrums, six commonly used cements were mixed according to the manufacturers' instruction (Table 2.1) and used to fabricate the disc specimens as a control for calculus, and human bone was also tested. As a control, spectrums of deposits removed from cervical regions of lower anterior teeth are known to be calculus, and bone fragments removed from extraction sites of human teeth are also created. All specimens were autoclave sterilized prior to XRF analysis. Each specimen was placed over the aperture of the machine and exposed for 60 sec at 40 kV and 20  $\mu$ A. The resultant fluorescence data, recorded as intensity counts, was displayed in spectral form on the computer. Elements in the spectra data were identified using the predefined major peaks ( $K\alpha$  or  $L\alpha$ ) of the S1PXRF program.

The failed implants with excess foreign material around the implant surface were placed in the

**Table 2.1** Major peaks of spectra of commonly used cements, bone, and calculus

Material	Major peaks	Examples
ZnO-type cement	ZnK $\alpha$ 1	TempBond NE, IRM
Glass ionomer cement	SrK $\alpha$ 1, ZrK $\alpha$ 1	RelyX Unicem
Polycarboxylate cement	SrK $\alpha$ 1, SnK $\alpha$ 1	Duralon
Resin cement	No major peak	PIC <sup>a</sup>
Alveolar bone	CaK $\alpha$ 1	–
Dental calculus	CaK $\alpha$ 1	–

TempBond NE – Kerr Corp; IRM – Dentsply Caulk; RelyX Unicem – 3 M ESPE; Duralon – 3 M ESPE

<sup>a</sup>PIC– Premier Implant cement, Premier Products Co, Plymouth, Pennsylvania

XRF evaluation chamber on the aperture and analyzed with the same parameter used for the controls. With the implant body partially overlying the aperture, a peak for the element titanium was expected as well as peaks for the attached test material. The XRF also quantifies elements within the test area, with the largest elemental peak height representing the most abundant element. The peaks of the unknown sample spectrum were identified and labeled using the “ID” and “Elem” tools of the S1PERF program. The Bruker has a spectrum overlay function which allows superimposition of a known material with a test material for comparison. The spectra of the unknown sample was put in the background in red and the reference spectra derived from known composition of the samples (cement, calculus, and bone) overlaid.

In total, 189 implants were examined with the spectrometer. Sixty-five percent had cement extrusion remnants found on the major screw threads of the implant. Although it is not possible to state to what extent the cement extrusion played in the role of these implant failures, it is clear that the cementing technique of the operators leaves much to be desired; the cement should be controlled so as never to extrude beyond the cement margins.

## Conclusion

Residual excess cement has been positively linked in clinical studies with peri-implant disease. The identification of material on the implant body itself does not explain how this disease process develops and is not conclusive of a cause/effect relationship. It does, however, still validate how the cementing techniques widely used in restoring implants are poorly controlled. The depth the cement reached indicated in the failed implant study is also of great concern.

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