Maintaining peri-implant health: An evaluation of understanding amongst dental professionals

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ADEE	Association for Dental Education in Europe
BOP	Bleeding on probing
CAL	Clinical attachment level
CIST	Cumulative interceptive supportive therapy
CODA	Commission on Dental Accreditation
DH/Ts	Dental hygienists and therapists
DHTS	Dental hygiene and therapy schools
DSR	Digital subtraction radiography
Er:YAG	Erbium-doped: yytrium, aluminium and garnet
EWOP	European Workshop on Periodontology
GBR	Guided bone and tissue regeneration
GDC	General Dental Council
IL	Interleukin
ISQ	Implant stability quotient
NHS	National Health Service
OMFS	Oral and maxillofacial surgeons
OS	Oral surgeons
PD	Probing depth
PDT	Photodynamic therapy
PICF	Peri-implant crevicular fluid
PMN	Polymorphonuclear cells
PTG	Porous titanium granules
PTV	Periotest value
RCSE	Royal College of Surgeons of England
RD-UK	Restorative Dentistry-UK
U.S.	United States
UK	United Kingdom

Abstract

Background: The amount of teaching of dental implants between individual dental schools is variable. The General Dental Council expects dentists, dental therapists and hygienists (DH/Ts) to be competent at maintaining peri-implant health. With more implants being placed and a rising incidence of peri-implantitis, dentists and DH/Ts will be exposed to the issue of implant maintenance.

Objective: This study aims to assess the current status of dental implant teaching within dental undergraduate and dental hygiene and therapy schools (DHTS) in the United Kingdom (UK) and Ireland; the confidence levels of DH/Ts within Wales regarding the management of peri-implant health and their opinions about implant education and current implant practice amongst university and hospital restorative dental specialists in the UK and Ireland.

Materials and Methods: Online questionnaires were distributed to (i) 18 dental undergraduate schools and 23 DHTS in the UK and Ireland (ii) 257 DH/Ts within Wales and (iii) 150 university and hospital restorative dental specialists in the UK and Ireland.

Summary: All responding dental undergraduate schools and DHTS provided implant training for their students. There was significant improvement in the amount of implant education across dental undergraduate schools since previous surveys however direct clinical experience remained low in restoring (31%) and placing (6%) dental implants. The majority of DHTS provided direct clinical experience in peri-implant maintenance although not every student received this experience. In 64% of schools, students gained clinical experience in the management of peri-implantitis. The main barriers to developing the implant programme for dental undergraduate schools and DHTS were funding and lack of suitable cases. Results from the survey of DH/Ts within Wales indicated that dental implant care was within the remit of

service for 92% of respondents. A high proportion of DH/Ts in Wales did not feel entirely confident in carrying out procedures relating to peri-implant maintenance and only 27% felt confident in clinically assessing dental implants. The majority (83%) felt that postgraduate training in peri-implant maintenance should be obligatory. Out of the sample of university and hospital restorative dental specialists that responded, 70% indicated that they provided implant treatment and there was a significant variation in the amount of implant treatment provided. 79% worked with oral surgeons or oral and maxillofacial surgeons as an implant team. There was general agreement by specialists on the factors that may contra-indicate implant placement. Irradiation and smoking were considered the most important medical factors in patient selection for implant placement whilst untreated periodontitis and poor oral hygiene were the most important dental factors. In conclusion, there has been an increase in the amount of implant education across DHTS and dental undergraduate schools however there remains the concern that the level of education does not satisfactorily address the needs required for general practice.

Chapter 1: Introduction

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According to the 2009 United Kingdom (UK) Adult Dental Health Survey, 1% of the population has dental implants and there is growing consensus that this figure is likely to increase (Chenery 2011). Dental implants have become a widely accepted treatment option for the replacement of missing teeth, with reported long-term success and survival rates to be greater than 95% (Jung et al. 2012). Tooth loss can impair oral function or aesthetics and negatively impact on the oral health-related quality of life (OHRQoL) of patients. In certain cases, studies have demonstrated that oral rehabilitation using dental implants can provide advantages and better improvements in OHRQoL over other conventional treatments (Marx and Morales 1998; Vogel et al. 2013; Sargozaie et al. 2017). Implant overdentures have been shown to result in better outcomes, which include patient satisfaction and improved nutritional intake in contrast to conventional dentures (Morais et al. 2003; Muller et al. 2008). The use of two-implant overdentures is considered the first choice standard of care for the edentulous mandible (Thomason et al. 2012). For single-tooth replacement, where a resin retained bridge is not indicated, a dental implant avoids preparation and damage of the adjacent teeth, which would otherwise be necessary for fixed conventional bridgework. Where patients have acquired or congenital maxillofacial hard or soft tissue defects e.g. cancer or cleft palate, they can often experience improved oral prosthetic rehabilitation outcomes using dental implants over traditional methods (Arcuri et al. 1994; Marx and Morales 1998). As a result of the increase in demand and popularity of dental implants, which was once limited to specialists, straightforward implant treatments are now more frequently performed by general dental practitioners (Koole et al. 2014). Considering that implant dentistry has become an increasingly mainstream part of dental care, there is a necessity for dental undergraduate and dental hygiene and therapy schools (DHTS) within the UK to provide the relevant implant training in order to fulfil the standards set by the General Dental Council (GDC).

The GDC's document '*Preparing for practice – Dental team learning outcomes for registration*' expects dentists, therapists and hygienists in the UK to be competent at maintaining peri-implant health and describing the risks related to dental implant therapy (General Dental Council 2015b). Furthermore, dentists are expected to recognise and explain to patients the range of implant treatment options, their impact, outcomes and limitations. The documents '*Training Standards in Implant* Dentistry' (2012) by the Faculty of General Dental Practice (UK) and '*A Dentist's Guide to Implantology'* (2012) by the Association of Dental Implantology, were published to ensure that dentists have the necessary competence to perform safe implant dentistry. In conjunction with this, a policy statement issued by the GDC in 2008 emphasised that UK-qualified general dental practitioners would not be competent to carry out implant dentistry without further training (British Dental Journal 2008). A global shift to further develop and integrate dental implant education into predoctoral or undergraduate programmes is evident. In 2008, the Association for Dental Education in Europe (ADEE) formed a working group to promote consensus on implant dentistry education in European universities. Subsequently, guidelines on both undergraduate and postgraduate education were published (Cowpe et al. 2010). In the United States (U.S.), set accreditation standards were issued by the Commission on Dental Accreditation (CODA) to promote and monitor the continuous quality and improvement of U.S. teaching in implant dentistry (Commission on Dental Accreditation 2018).

Surveys of UK and Irish dental schools have shown an increasing trend in the amount of implant teaching provided within undergraduate programmes (Watson 1993; Young et al. 1999; Addy et al. 2008; Blum et al. 2008). However, a significant variation in the level of teaching between UK dental schools was observed. These findings are similarly shown in schools worldwide, such as Europe, U.S. and Canada (Petropoulos et al. 2006; Addy et al. 2008; De Bruyn et al. 2009; Atashrazm et al. 2011). The most recent survey of UK and Irish dental schools, conducted in 2008, revealed that the majority of schools (87%)

offered implant training for their undergraduates (Addy et al. 2008). In spite of this, only a limited number of schools provided students with direct clinical experience in treatment planning (46%), restoration (27%) and placement (7%) of dental implants. Concerns were raised that UK dental implant education was failing to keep pace with current developments and other schools worldwide (Addy et al. 2008; McAndrew et al. 2010). In Europe, a survey in 2008 found that most dental undergraduate schools offered implant training and 70% provided direct clinical experience in restoring dental implants (De Bruyn et al. 2009). This figure increased in 2014 with 75% providing direct clinical experience in restoring dental implants. In addition, schools were devoting an average of 74 hours in comparison to 36 hours in 2008 (De Bruyn et al. 2009; Koole et al. 2014). Comparable findings can be found in U.S. and Canadian dental schools. In 2006, 86% of predoctoral programmes provided their students with clinical experience in restoring dental implants (Petropoulos et al. 2006). A following survey in 2017 revealed an overall increase in both clinical experience and preclinical exercises (Kihara et al. 2017).

Contrary to undergraduate dentistry, there exists very little data on implant teaching in DHTS across the UK and worldwide and it is therefore difficult to evaluate and discuss the current status of implant education within the dental and hygiene and therapy curricula. Some U.S. data by Ward et al. (2012) revealed that in a U.S. survey of 213 dental hygienists, 51% of respondents did not receive any training on implant care while attending dental hygiene school. These findings do not directly assess implant education and are insufficient to draw any conclusions. Certainly, further research is warranted in this area and considering the popularity of implant treatment, it is important to know whether dental hygienists and therapists (DH/Ts) are receiving the necessary implant training as they will likely be increasingly involved with the provision of peri-implant maintenance.

It is apparent that further integration and development of implant education into the UK and Irish undergraduate curricula are required, however, this is not without its challenges. Commonly reported barriers in the UK and worldwide include funding, inadequate curriculum time, limited patients and staff training (Addy et al. 2008; Atashrazm et al. 2011; Koole et al. 2014). Despite these barriers, there is evidence to show successful incorporation of implant dentistry into undergraduate programmes (Jahangiri and Choi 2008; Wilcox et al. 2010; Kroeplin and Strub 2011). There is no doubt that significant effort is required to overcome these barriers and for the necessary changes to occur, there needs to be more effective collaboration between organisations, namely educational providers, dental implant companies, regulators, amongst many others.

In general, litigation in UK dentistry has risen substantially, with more patients complaining than previously. The document “Riskwise” published by Dental Protection in 2015 reported an increase in the number and frequency of complaints relating to implants in the UK (Dental Protection 2015). In 2015, implants accounted for 28.8% of UK claims by value, the 2nd highest claim under periodontal cases at 44.7%. Multiple factors contributing to this rise include inadequate consent, treatment planning and record keeping, unrealistic patient expectations together with inadequate risk assessment, inadequate post-treatment monitoring and after care and lack of experience in the relevant procedures involved. In addition, a higher number of cases (5.5% claims by value) relating to peri-implantitis and peri-implant mucositis have been reported and there is growing consensus that this is likely to increase in the future. Notably, it was found that amongst these claims, clinicians that did not place or restore the implants, usually the general dental practitioner or dental hygienist, were subject to claims and complaints for alleged supervised neglect of implant cases. So concerning was this issue of peri-implantitis, that it was also raised by Baroness Gardner of Parkes at the House of Lords in July 2014 (Hansard 2014). She stated that ‘peri-implantitis is now a serious possible consequence of implantation’ and highlighted that

the ‘Royal College of Surgeons points out that long term assessment and maintenance need to be assured’ whereby the ‘GDC should introduce minimum standards of education and training for complex dental treatment, such as implants, to ensure patients are treated by a qualified professional. It supports the view that the GDC should include peri-implant assessment and maintenance in the undergraduate curriculum. Too often the practitioner who inserts the implant does not provide long-term support for the patient, discharging them back to their general dental practitioner’. It is clear that this worrying situation further emphasises the need to implement structured and comprehensive implant training both at an undergraduate/trainee and postgraduate level to ensure patient safety and minimise the risk regarding claims and complaints against dental professionals.

In view of the fast-paced developments in implant dentistry and the pressures faced by educational providers, the dental profession and various other organisations need to ensure that patients are receiving safe implant treatment. It is in the interest of this research project to firstly review the current literature on peri-implant diseases and thereafter address the research aims and objectives.

Chapter 2: Literature review on peri-implant diseases

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2.1 Definition

The classification of peri-implant diseases is similar to the classification of periodontal diseases (Armitage 1999), in that pathological inflammatory changes that develop in the tissues surrounding implants can be classified under the term 'peri-implant diseases'. Within this classification, there consist two forms: peri-implant mucositis and peri-implantitis (Lang and Berglundh 2011). The 6th European Workshop on Periodontology (EWOP) has established that peri-implant diseases are infectious in nature (Lindhe and Meyle 2008).

Peri-implant mucositis is defined as an inflammatory lesion that resides in the mucosa, while peri-implantitis also affects the supporting bone (Lang and Berglundh 2011). Experimental studies have shown the reversibility of peri-implant mucositis at biomarker level (MMP 8, IL-1 beta) from crevicular fluid samples after 3 weeks (Salvi et al. 2011), confirming that peri-implant mucositis is reversible (Lang and Berglundh 2011).

Despite agreement on the description of peri-implant diseases, the set diagnostic criteria for peri-implantitis still remains unclear and this will be discussed in more detail later.

2.2 Epidemiology

Prevalence can be defined as 'the number of cases of a disease at one point in time', while incidence describes 'the number of new cases of a specific disease occurring during a certain period' (Newman Dorland 1994). In order to determine incidence and prevalence of a disease, longitudinal studies are required for the former, while cross-sectional studies are used for the latter.

There are currently limited research studies which examine the incidence of peri-implant diseases due to a lack of prospective longitudinal studies, which can often be difficult to conduct (Derks and Tomasi 2015). Studies to date have predominantly reported the prevalence of peri-implant diseases primarily using a cross-sectional design. For periodontal diseases, the epidemiology research similarly describes prevalence data rather than incidence data (Eke et al. 2012).

In 2015, Derks et al. conducted a systematic review and meta-analysis into the epidemiology of peri-implant diseases. The review highlighted that the prevalence studies available had obvious limitations and it addressed the need to improve future research methods to ensure that data collected can be representative of the target population with a minimum risk of bias. Limitations discussed concerned the use of convenience samples, low sample sizes, a wide range of implant function times (some as short as 12 months) and a lack of consensus on the case definitions used. The need to improve such research methodologies was also addressed at the 8th EWOP (Sanz and Chapple 2012). The consensus group recommended that future studies should apply consistent case definitions, assess random patient samples of adequate size and function time.

Prevalence data for peri-implant diseases are often reported in studies either as the percentage of subjects affected (subject level) or the numbers of implants affected (implant level). At the 8th EWOP, it was agreed that assessing prevalence of peri-implant diseases should be based at the subject level rather than the implant level. It was considered that the outcome of interest was the impact of peri-implant diseases upon individuals rather than individual implants (Sanz and Chapple 2012).

From the literature reviewed, Derks et al. (2015) described the prevalence of peri-implant mucositis to be between 19 to 65%, with an estimated mean prevalence of 45% at subject level. The studies that were reviewed included a cross-sectional study conducted in 2012 by

Mir-Mari et al., who assessed 245 subjects with a mean follow-up of 6 years and identified peri-implant mucositis in 39% of subjects and 22% of implant sites. Another study by Cecchinato et al. (2013,2014) who assessed 100 subjects with a mean follow-up of 11 years found that peri-implant mucositis occurred in 65% of patients and 70% of implants.

The prevalence of peri-implantitis is reported to be between 1 to 47%, with an estimated mean prevalence of 22% at subject level (Derks and Tomasi 2015). Fransson et al. (2008) investigated 662 subjects who had implants in function for approximately 10 years, and identified peri-implantitis in 28% subjects and 12% implant sites. Roos-Jansaker et al. (2006), on the other hand, investigated 216 subjects with a similar follow-up time and identified peri-implantitis in 16% of subjects and 7% of implant sites. A summary of the data described is shown in table 1.

Table 1. Summary of prevalence data for peri-implant mucositis and peri-implantitis

First author, year	Study design & function time	Site and setting	Sample size assessed	Prevalence of peri-implant mucositis	Prevalence of peri-implantitis
Derks et al. (2015)	Systematic review and meta-analysis	Gothenburg University, Sweden	11 studies	45% (subject level)	22% (subject level)
Mir-Mari et al. (2012)	Cross-sectional 1-18 years	Spain, Private Institutional	245	39% (subject level) 22% (implant level)	16% (subject level) 9% (implant level)
Cecchinato et al. (2013, 2014)	Cross-sectional ≥ 8 years	Italy, Private Industry	100	65% (subject level) 70% (implant level)	23% (subject level) 11.3% (implant level)
Fransson et al. (2008)	Cross-sectional 5-20 years	Sweden University, Not reported	662	>90% (implant level)	28% (subject level) 12% (implant level)
Roos-Jansaker et al. (2006)	Cross-sectional 9-14 years	Sweden University, Institutional	216	48% (subject level) 16% (implant level)	16% (subject level) 7% (implant level)

The heterogeneity in case definitions, particularly for peri-implantitis has been one of the limiting factors in determining the prevalence of peri-implant diseases due to the difficulty in being able to facilitate comparisons between studies. It is therefore likely that the available data remains an incorrect estimate of the prevalence and caution with interpretation should be exercised. The variation in thresholds for bone loss or bone levels to define peri-implantitis has been one of the well-known reasons for heterogeneity in data, due to its potential influence on the rate of disease occurrence (Derks and Tomasi 2015). As an example, Zetterqvist et al. (2010) set a high threshold for bone loss at 5mm and subsequently reported a very low prevalence of 1%. In contrast, Koldsland et al. (2010) had a low threshold of 0.4mm bone loss and reported a very high prevalence of 47%.

The need to standardise disease thresholds is required and has been highlighted by the 8th EWOP working group. To facilitate this, the group provided suggestions for case definitions that were developed from previous EWOP consensus workshops (Lindhe and Meyle 2008; Lang and Berglundh 2011). For defining a case as peri-implantitis, the following components must be present: (i) changes in the level of crestal bone, (ii) presence of bleeding on probing and/or suppuration (iii) with or without concomitant deepening of peri-implant pockets. For studies investigating prevalence of peri-implantitis, in the absence of baseline radiographs, a bone level of 2mm from the expected level together with clinical inflammation was set as a threshold to determine the disease. For studies investigating the incidence of peri-implantitis, baseline clinical and radiological measures are necessary and a threshold of detectable bone loss of 1-1.5mm in combination with inflammation was recommended (Sanz and Chapple 2012).

In addition to prevalence and incidence data, recommendations have also been made for future research to report on the extent and severity of peri-implant diseases (Derks and Tomasi 2015). Extent can be defined as “the number of affected implants in affected patients” and severity as “the

degree of bone loss" (Sanz and Chapple 2012). At present, this is rarely reported in the literature and if undertaken, would be valuable in obtaining a comprehensive understanding of the epidemiology of peri-implant diseases.

2.3 Aetiology

The aetiology of peri-implant diseases is thought to be multifactorial. The most common aetiological factors associated with development of peri-implant diseases are the presence of bacterial plaque and host response.

2.3.1 Microorganisms associated with peri-implant health and disease

It is widely accepted that microorganisms are the predominant cause of the development of gingivitis and periodontitis (Socransky 1977; Slots 1979). Researchers have therefore sought to establish whether a similar relationship exists with peri-implant diseases by investigating the microbiota associated with peri-implant tissues in humans (Rams et al. 1984; Mombelli et al. 1987).

In 1984, Rams et al. first studied the subgingival microbial flora associated with human dental implants using phase-contrast microscopy (Rams et al. 1984). Thirteen subjects that had dental implants in place for at least six months were reviewed. Plaque samples from the most apical portion of the peri-implant pockets were collected for microbiological analysis. Results showed that in healthy implant sites, high proportions of non-motile coccoid cells with infrequent levels of spirochaetes were seen. In sites where there was extensive bone loss and advanced pocket formation (> or equal to 10mm), high proportions of subgingival spirochaetes were observed.

Subsequent to this study, Mombelli et al. (1987) investigated twelve edentulous patients that either had failing or successfully osseointegrated

titanium implants (in an implant retained overdenture population). Supra- and sub-gingival samples were collected and assessed. Similarly, it was reported that in healthy implant sites, a high proportion of coccoid cells, infrequent numbers of fusiform species and the absence of spirochaetes was found. In unsuccessful sites, there was a significant elevation of spirochaetes, fusiform bacteria and motile and curved rods compared to the successful sites. Gram-negative anaerobic rods occupied greater than 50% of the microbiota and bacteroides was found regularly (>30%), with *B.intermedius* being the predominant species. *Fusobacterium spp* was also a common feature (15%).

Healthy implant sites in patients that had failing implants (unsuccessful group) were also investigated and compared to patients that only had healthy implants (successful group). Other than an elevated number of *Actinomyces naeslundii* in the unsuccessful group, both groups comprised similar compositions of microbiota, frequently consisting of facultative anaerobic bacteria and Ornidazole resistant organisms with a small trace of black pigmented *Bacteroides* and *Fusobacterium spp*. On the basis of this finding, it is suggested that peri-implantitis is a site-specific infection.

Numerous studies have examined intra-individual transmission of pathogens from periodontal sites to implant sites. It is clear from the research that periodontitis is a risk factor for peri-implantitis, as it has been found that periodontally compromised teeth harbour periodontal pathogens that can cross-infect into peri-implant tissues (van Winkelhoff et al. 2000; De Boever and De Boever 2006). This will be discussed in detail later.

It is apparent that the ecosystems in peri-implant health and disease are comparable to that of periodontal health and periodontitis. Similar to peri-implant health, the flora associated with gingival health consists of predominantly coccoid cells. While in periodontitis, like peri-implantitis, high counts of gram-negative anaerobic bacteria are reported which

include members of the red complex (i.e. *Porphyromonas gingivalis, Treponema denticola and Tannerella forsythia)* and orange complex species (i.e. *Fusobacterium spp.* and *Prevotella intermedia*) (Socransky et al. 1998). Red and orange complexes were originally reported by Socransky et al. (1998) and described as groups of species thought to be strongly associated with periodontitis. *Aggregatibacter actinomycetemcomitans, Staphylococcus aureus*, enteric rods and *Candida albicans* have also been identified at peri-implantitis sites (Alcoforado et al. 1991; Hultin et al. 2002). Black pigmented bacteroides appear to play a vital role in the pathogenesis of periodontitis and peri-implantitis and the proportions of Spirochaetes are shown to increase with the severity of the disease (Slots 1979; Mombelli et al. 1987). Some reports have indicated that occasionally, a different profile of microflora can be found in peri-implantitis that represents more closely to that associated with infections of implanted medical devices than periodontitis (Christensen et al. 1989; Furst et al. 2007). In these cases, high counts of peptostreptococci (i.e. *P.micra*) and staphylococci (i.e. *S.aureus* and *S.epidermidis*) were identified.

Ecological conditions may also vary depending on the depth of the pocket. It is reported that the composition of peri-implant microflora differs from shallow to deep pockets (Mombelli and Decaillet 2011). However, research to determine the spatial organisation of naturally grown biofilm surrounding implants is lacking, as sample collection methods are currently inadequate as they involve disrupting the biofilm. There is also a need for further investigation into the microbiological differences between the two forms of peri-implant diseases. Maximo et al. (2009) reported no distinct differences between the flora in peri-implant mucositis and peri-implantitis, suggesting that a gradual progression occurs from the peri-implant mucositis to peri-implantitis.

It is assumed that peri-implant mucositis precedes peri-implantitis and that the bacterial biofilm on the implant surface is the initial event in the development of peri-implantitis. Hypothetically, removal of the biofilm by

means of mechanical debridement and systemic antibiotics may be effective in treating the disease (Mombelli and Lang 1992). However, it was concluded that such treatment was limited and influenced by factors not yet fully understood (Claffey et al. 2008; Renvert et al. 2008b). As an example, it has been demonstrated that local factors can also be considered as the primary cause of peri-implant disease rather than the bacterial biofilm. Submucosal residual cement or fracture of an implant will produce favourable ecological conditions for bacteria to thrive resulting in secondary infection. If the primary cause is not removed, then therapy by debridement or systemic antibiotics will unlikely resolve the infection (Hammerle et al. 1996; Tarnow et al. 2000; Wilson 2009). It is therefore imperative for the clinician to establish the true cause of the disease in order to determine the appropriate treatment solution.

2.4 Pathogenesis

2.4.1 Health of the gingiva and peri-implant mucosa

In health, experimental studies have shown variations in the junctional epithelium and supracrestal connective tissue when comparing gingival tissue to peri-implant mucosa (Berglundh et al. 1991). Collagen fibres in the peri-implant mucosa are arranged parallel to the long axis of the implant and insert into the bone, while in gingival tissue there are circular fibres in the supra alveolar and marginal gingival connective tissue as well as fibres that attach to the root cementum which advance in a perpendicular direction into the lateral portions of the soft tissue.

In peri-implant mucosa, more collagen and less fibroblasts occupy the marginal portion of the peri-implant mucosa than the gingival tissue. The implication of this is not yet fully understood, however it may signify a slower tissue turnover rate in the peri-implant mucosa than the gingiva and this may impact on onset and progression of peri-implant mucositis. At both tooth and implant sites, the junctional epithelium terminates 1-1.5mm coronal to the alveolar bone crest. The junctional epithelium at the

implant site ends at a varying distance from the gingival margin consistently leaving a connective tissue portion coronal to the bone crest in direct contact with the titanium surface. In the tooth site, the junctional epithelium terminates at the cemento-enamel junction. Despite the differences mentioned above, what has been established is that implants possess a similar epithelial seal to that of teeth (Lang and Berglundh 2011).

2.4.2 Host response to bacteria

Peri-implant disease is said to occur as a result of bacterial colonisation into the peri-implant tissues that leads to an unfavourable host immune response and subsequent tissue destruction (Heitz-Mayfield 2008b). Experimental studies have demonstrated a cause and effect relationship between biofilm formation on teeth and gingivitis, and similarly on implants and peri-implant mucositis in humans (Zitzmann et al. 2001). When plaque is allowed to accumulate undisturbed around implants and teeth, clinical signs of inflammation start to appear in the adjacent soft tissues within a few days. Removal of the plaque results in resolution of the inflammation. Early plaque formation (3 weeks old) surrounding teeth induce a similar chronic inflammatory cell reaction within the adjacent soft tissues to that of implants. This is characterised by increased migration of leukocytes through the junctional epithelium, collagen breakdown and the establishment of a connective tissue lesion (Berglundh et al. 1992). The current research indicates that the host response to the biofilm in peri-implant sites is equal to that of the tooth sites.

It is assumed that the progression from peri-implant mucositis to peri-implantitis is transitional and occurs earlier than that of gingivitis and periodontitis (Lang and Berglundh 2011). In the later stages of peri-implant mucositis, when there is longstanding plaque biofilm on the implants (6 months old plaque), predominantly plasma cells and lymphocytes can be seen in the chronic inflammatory lesion in the connective tissue of the peri-implant mucosa with an apical extension

restricted to the barrier epithelium (Zitzmann et al. 2002). As disease progression occurs into peri-implantitis, the inflammatory lesion consistently extends apical to the pocket epithelium with the biofilm residing on the implant surface. Plasma cells and lymphocytes as well as polymorphonuclear leukocytes cells and macrophages are seen in high numbers in the lesion (Gualini and Berglundh 2003; Berglundh et al. 2004).

Periodontitis and peri-implantitis lesions possess similar histopathological features whereby the connective tissue is infiltrated by a high proportion of lymphocytes and plasma cells (Berglundh et al. 2011). However, some differences exist which suggest that the two disease processes may not be identical (Heitz-Mayfield and Lang 2010). In peri-implantitis, the apical extension of the inflammatory infiltrate is more prominent than in periodontitis and neutrophil granulocytes and macrophages occur in higher proportions. Unlike periodontitis, in peri-implantitis the neutrophil granulocytes are also present in the peri-vascular compartments in the distant areas apical to the pocket area rather than just in the pocket-epithelium-associated areas. Peri-implantitis lesions when compared to periodontitis lesions demonstrate signs of acute inflammation and large numbers of osteoclasts that line the surface of the crestal bone. It is also believed that more rapid tissue destruction occurs in peri-implantitis compared to periodontitis due to the absence of fibres inserting into the implant, thereby increasing susceptibility to bone loss. In addition, tissues around natural teeth consist of supracrestal gingival fibres that separate the inflammatory lesion from the alveolar bone, while in peri-implant tissues the inflammatory lesion extends to the bone. Furthermore, the characteristic circumferential pattern of bone loss in peri-implantitis is unknown but it is thought that this may be due to the absence of periodontal ligament or lateral spread of infection on the implant surface. The significance of the above results is not yet fully understood, but the findings imply that the onset and progression of peri-implantitis and periodontitis are different.

2.5 Diagnosis of peri-implant diseases

Comprehensive assessment and regular monitoring of peri-implant health is crucial for the early diagnosis and treatment of peri-implant diseases. The set diagnostic criterion for peri-implant diseases currently remains unclear as information on the biology of peri-implant tissues and the diagnostic potential of many biological features still warrants further investigation (Mombelli 1997; Salvi and Lang 2004).

Ideally, diagnostic parameters used to monitor peri-implant health should be of high sensitivity (i.e. ability to detect a disease) and specificity (i.e. ability to detect health), be simple to measure and provide reproducible data (Salvi and Lang 2004). It is generally accepted that no single reliable diagnostic tool currently exists for peri-implant diseases and therefore it is necessary to rely on a range of parameters to diagnose peri-implant diseases. Diagnostic parameters that have so far been described in the literature are discussed below.

2.5.1 Implant mobility

The pattern of hard tissue destruction in peri-implantitis is represented by vertical bone loss that begins marginally and advances apically (Lang et al. 2000). Thus, in the late stages of peri-implantitis, an implant can stay clinically stable so long as it remains osseointegrated at the apical portion. Mobility will occur in the final stages of the disease when total loss of osseointegration has occurred and removal of the implant is indicated (Heitz-Mayfield 2008b).

Mobility is therefore highly specific because it will detect total loss of osseointegration. However, it is not a highly sensitive parameter for monitoring clinical stability nor is it useful for early diagnosis of peri-implant disease (Heitz-Mayfield 2008b).

Routine assessment of implant mobility has been recommended by the American Association of Periodontology not only for the detection of lack of osseointegration but also for the benefit of identifying any broken or loose components, which can in turn initiate peri-implant disease (American Association of Periodontology 2013). In some cases, evaluation of mobility may not be possible or reliably assessed. Examples include inaccessibility of the implant (i.e. unretrievability of the suprastructure) or inability to assess individual implants (e.g. if part of a bridgework unit) (Mombelli and Lang 1994). Mobility assessment is not regarded as an essential parameter for the diagnosis of peri-implant disease but can still be useful alongside other parameters (Lang et al. 2000).

The Periotest (Siemens, Bensheim, Germany) is an electronic device that has been recommended as a method to measure levels of subclinical implant mobility using an ultrasonically vibrating probe (Olive and Aparicio 1990). The result is displayed as a Periotest value (PTV) between -8 (low mobility) to 50 (high mobility). Its use was initially intended for measuring the dampening effect of the periodontium around natural teeth, which closely correlates to the clinical mobility of teeth. Periotest values on implants have low readings and typically range between -5 to 15 because they exhibit much stiffer characteristics being surrounded by bone as opposed to teeth that are supported by the periodontal ligament (Cranin et al. 1998). The prognostic accuracy of the Periotest for the diagnosis of peri-implantitis and early signs of implant failure has been the subject of debate. Despite several studies reporting the success of Periotest (Aparicio 1997; Cranin et al. 1998), there have been conflicting results in terms of Periotest values between jaw types, its resolution, sensitivity and susceptibility to operator variables (Meredith 1998). Further research is therefore warranted in order to support its use as a diagnostic tool.

Resonance frequency analysis is a non-invasive device that has been designed to measure primary implant stability and monitor implant stability over time. A transducer connected to a frequency response

analyser (Osstell; Integration Diagnostics, Goteberg, Sweden) is used to evaluate the stiffness of the bone-implant interface. The value is recorded as the 'implant stability quotient' (ISQ), which is displayed as a number that ranges between 1 (low stability) to 100 ISQ (high stability). ISQ levels for successfully integrated implants are reported to range from 57 to 82 after 1 year of loading (Shokri and Daraeighadikolaei 2013). Clinical studies have reported an increase in ISQ values during osseous healing and a decrease in ISQ values when crestal bone loss occurs (Meredith et al. 1997; Barewal et al. 2003). These findings suggest that ISQ values correlate well with levels of bone-implant contact and demonstrate the diagnostic potential of resonance frequency analysis in the detection of bony changes surrounding implants. However, there still remains a lack of conclusive data to fully support its clinical applicability and therefore further research is required (Gupta and Padmanabhan 2011).

2.5.2 Bleeding on probing

Bleeding on probing (BOP) can be defined as the presence of bleeding on penetration of a periodontal probe into the peri-implant sulcus using light pressure (0.25N) (Lang et al. 2000). BOP is routinely used to predict future attachment loss around teeth and is interpreted to represent the presence of inflammation in the periodontal tissues. Absence of BOP is an effective indicator for periodontal stability with a negative predictive value (i.e. the proportion of subjects with a negative test who do not have the disease) of 98.1%, whereas bleeding on probing is less effective an indicator when predicting disease progression with a positive predictive value (i.e. the proportion of subjects with a positive test who do have the disease) of <30% (Lang et al. 1990).

Similar to teeth, the use of BOP to assess peri-implant status has been studied. Lang et al. (1994) conducted a study that showed increased BOP at mucositis (67%) and peri-implantitis (91%) sites in contrast to absence of BOP in healthy implant sites. Similarly, in a cross-sectional study by Fransson et al. (2005), it was reported that 94% of implants

affected by peri-implantitis exhibited BOP. Luterbacher et al. (2000) further supported these findings and demonstrated that BOP around implant sites (≥50% BOP frequency) compared to tooth sites demonstrated a higher positive predictive value of 100% as opposed to 40% in tooth sites. The negative predictive value of BOP to indicate peri-implant stability varied between 50% and 64% (>20% BOP frequency). BOP is hence a reliable indicator of peri-implant disease and is a key parameter for monitoring changes in peri-implant tissue conditions and for the diagnosis of peri-implant disease. The absence of BOP is indicative of peri-implant health however it is not as reliable as when compared to using BOP for determining periodontal health (Zitzmann and Berglundh 2008). Based on the statements at the 7th EWOP, in peri-implant mucositis, BOP is the main feature of peri-implant mucositis, while the main feature in peri-implantitis consists of changes in bone crest level with associated BOP (Lang and Berglundh 2011).

Mombelli et al. (1987) adapted the sulcus bleeding index (Muhlemann and Son 1971) to create the modified sulcus bleeding index specifically for implants (Table 2). In general, indices are of particular use for clinical research trials.

Table 2. Modified sulcus bleeding index (Mombelli et al. 1987)

Score	**Description**
0	No bleeding when a periodontal probe is passed along the gingival margin adjacent to the implant
1	Isolated bleeding spots visible
2	Blood forms a confluent red line on margin
3	Heavy or profuse bleeding

2.5.3 Probing depth and clinical attachment loss

Probing depth (PD) is an essential diagnostic parameter for the evaluation of peri-implant status. Studies have demonstrated that an increase in PD over time is associated with attachment and bone loss in experimental peri-implantitis models (Lang et al. 1993; Schou et al. 1993). For natural teeth, periodontal PD and clinical attachment levels (CAL) are the most frequently used clinical parameters for the diagnosis of periodontal diseases and for measuring the outcome of success after periodontal treatment. An increase in periodontal PD and CAL is indicative of periodontal disease, whereas a reduction in PD and CAL relates to success after periodontal therapy (Mombelli and Lang 1994).

The extent of probe penetration around implants and teeth is influenced by factors such as probing force and angulation, probe tip diameter, shape and surface texture of the implant or root, the inflammatory state and firmness of the marginal tissue. Compromised access due to prosthesis design may also limit probe penetration (Salvi and Lang 2004).

The conditions for PD measurements between teeth and implants are not fully comparable due to variations in soft tissue composition, organisation and attachment between the gingiva and root surface versus the peri-implant mucosa and implant surface (Berglundh et al. 1991; Mombelli and Lang 1994; Schou et al. 2002). Around healthy teeth and in gingivitis, Armitage et al. (1977) demonstrated that the probe tip consistently failed to reach the histological level of the connective tissue attachment. While in periodontitis, the probe tip consistently exceeded the level of connective tissue and penetrated into the inflamed tissue. Several studies have demonstrated that healthy implants permit approximately 3mm of probe penetration (Adell et al. 1981; Apse et al. 1991). In healthy implants and peri-implant mucositis, Lang et al. (1994) demonstrated that probes were consistent in identifying the connective tissue attachment levels. Around healthy screw-type implants, the probe tip appeared to stop 1.4mm coronally to the bone level using radiographic evaluation

(Quirynen et al. 1991). In peri-implantitis, the probes penetrated close to the alveolar bone. The findings demonstrate the excellent sealing effect of the soft tissue collar in health and gingivitis/peri-implant mucositis, while the severity of inflammation significantly influenced the degree of probe penetration around implants and teeth. In comparison to teeth, a greater degree of probe penetration into the supracrestal connective tissue is seen around implants and this may be explained by the fact that collagen fibres in the supracrestal connective tissue compartment run mostly parallel to the implant axis (Listgarten et al. 1991).

The magnitude of probe force can also affect probe penetration. A comparison of tissue resistance to probing penetration at different force levels around healthy implants and teeth was investigated by Mombelli et al. (1997). The study demonstrated that peri-implant probing depth measurements were more sensitive to force variation (e.g. 0.25, 0.50, 0.75, 1.00 and 1.25N) than periodontal pocket probing. At 0.5N and greater, the probe tip was in close proximity to the peri-implant marginal bone. A similar finding was observed in an experimental study by Ericsson and Lindhe (1993) whereby a probing force of 0.5N at implant sites resulted in the probe tip penetrating the connective tissue and reaching close to the marginal bone. At tooth sites, the tip of the probe terminated close, but consistently coronal, to the apical cells of the junctional epithelium. Etter et al. (2002) demonstrated that the peri-implant mucosal seal is capable of re-establishing after 5 days following clinical probing (0.25N). It is concluded that clinical probing with a gentle force of 0.25N is a reliable and sensitive diagnostic tool to determine peri-implant health and disease and will not damage the peri-implant tissues (Lang et al. 1994; Schou et al. 2002; Heitz-Mayfield 2008a). It is also recommended that an electronic pressure sensitive probe be used in order to obtain reproducible PD measurements (Christensen et al. 1997). Similarly, a probing force of 0.25N is recommended for tooth sites due to the high possibility of traumatising the gingival tissues if a force exceeding 0.25N is applied, as demonstrated in a study by Lang et al. (1991).

Data regarding the influence of probe design and probe material on peri-implant probing is currently lacking. It is generally accepted that a probe tip diameter of 0.4mm is appropriate for peri-implant probing based on successful use in periodontal studies (Lang et al. 1991). There are also concerns that the use of a metallic probe can damage the implant surface and that probing may result in the introduction of bacteria into the peri-implant tissues however the evidence for this remains inconclusive (Ericsson and Lindhe 1993; Schou et al. 2002).

In contrast to periodontal probing, whereby the reference level is typically the CEJ in order to determine CAL, in implants a fixed reference point (e.g. implant shoulder or crown margin) relative to the soft tissue margin should be chosen. Since PD in isolation cannot record marginal recession, recording CAL (recession + PD) is important to determine connective tissue attachment loss, which is representative of bone loss. Measurements of peri-implant PD and CAL at baseline (i.e. at time of prosthesis delivery) are essential in order to monitor tissue changes accurately. This is important especially for deep implants that are clinically healthy but may present with increased PD (Salvi and Lang 2004). It should also be noted that in some cases, it might be difficult or impossible to perform peri-implant probing. Implant systems can have designs such as concavities, step or shoulders that do not allow for the correct probe angulation. Removal of the restoration to gain direct access for probing would be necessary to obtain an accurate measurement. There is the issue however that repeated disconnection and reconnection of prosthetic components can compromise the epithelial attachment seal around implants and lead to apical migration of the bone levels (Abrahamsson et al. 1997). Therefore, to avoid this situation from arising, it is always important to plan for an implant restoration that allows direct access for probing where possible. Otherwise, surface roughness of the implant (e.g. plasma-coated, sandblasted or threaded implants) can result in the probe tip engaging the side of the implant which may be mistaken

for the base of the pocket, thus resulting in underestimation of PD (Bauman et al. 1992).

Peri-implant PD and CAL are considered key diagnostic parameters for the long term monitoring of peri-implant mucosal tissues but it is important that they are still used in conjunction with other parameters (e.g. radiographs, BOP, suppuration, pain, swelling, redness) for accurate diagnosis (Lindhe and Meyle 2008; American Association of Periodontology 2013; Coli et al. 2017).

2.5.4 Radiographic interpretation

2.5.4.1 Conventional radiography

Conventional radiography is a reliable and useful technique for the diagnosis and monitoring of peri-implant diseases. Good quality radiographic examination is valuable for detecting marginal bone level changes and interproximal bone loss (Kullman et al. 2007). Orthopantomograms have a poor resolution and are prone to image distortion (De Smet et al. 2002). Hence, the long cone parallel technique is regarded as the first choice technique provided optimal beam angulation is applied (Kullman et al. 2007).

A baseline radiograph at the time of definitive restoration placement is essential for future reference and to confirm optimal restoration seating (Alani and Bishop 2014a). Bone loss can be expected in the first year of functional loading likely as a result of bone remodelling and establishment of the biological width, and this should not be mistaken for peri-implant disease (Albrektsson et al. 1986). Peri-implantitis lesions can vary in presentation but are most commonly seen as a saucer shaped pattern of bone loss (Lang et al. 2000).

The distance from the implant shoulder to the bone crest (DIB) is recognised as a reliable radiographic parameter for long term clinical

monitoring of peri-implant health and disease (Lang et al. 2000). Currently, there is no clear consensus on bone level thresholds for the classification of peri-implantitis. It is suggested that ≥ 2mm of bone loss compared to baseline at delivery of the prosthetic device in combination with BOP would be an indication to suspect peri-implantitis (Klinge and Meyle 2012). In the absence of baseline radiographs, the consensus group at the 8th EWOP suggested that ≥ 2mm of bone loss from the expected level following remodeling post-implant placement with signs of clinical inflammation should be the threshold for diagnosis of peri-implantitis (Sanz and Chapple 2012).

Despite its diagnostic value, it is important to recognise that conventional radiography has its limitations. Due to the two-dimensional view, the buccal and palatal/lingual bone levels are not easily identifiable on radiographs. Minor changes in bone levels are also difficult to detect and only become visible once they have reached a significant size and shape (Bragger 1988). In addition, radiographic evidence of bone-to-implant contact cannot confirm osseointegration at a histological level (Sewerin et al. 1997).

2.5.4.2 Digital subtraction radiography

Digital subtraction radiography (DSR) is a non-invasive and sensitive method for detecting early density changes in the peri-implant tissues (Bragger 1988). It has been shown to increase the sensitivity of radiographs by means of digitally superimposing radiographic images and subtracting them from the baseline image to identify subtle changes in the level and density of the alveolar bone (Bragger 1988; Nicopoulou-Karayianni et al. 1997). An increase in bone density is representative of functional loading, while a decrease in bone density represents peri-implant infection. DSR does however rely on standardised radiographs obtained with a high degree of accuracy and clinicians that are adequately trained in using this technique. Despite its successful use in longitudinal studies, it is a relatively complicated and time-consuming procedure (Bragger 1988; Wakoh et al. 2006).

2.5.4.3 Cone Beam Computed Tomography

Research on the use of cone beam computed tomography (CBCT) for diagnosis of peri-implantitis is still currently lacking. CBCT imaging can potentially offer the advantage of three-dimensional visualisation of peri-implant defects (Golubovic et al. 2012). However, a relatively recent cadaver study by Kühl et al. (2016) revealed that CBCT was inferior to conventional intraoral radiography for the detection of peri-implant defects. From the results, the overall sensitivity and specificity was reported as 74% and 51% respectively for intraoral radiography, as compared to 60% and 31% for CBCT. It was found that the presence of metal artefacts surrounding the dental implants interfered with the diagnostic quality of the CBCT images. Therefore, further studies are required to determine whether the use of CBCT over conventional radiography can be justified, especially since there is a higher radiological exposure (Alani and Bishop 2014a).

2.5.5 Suppuration

The presence of pus occurs as a result of inflammation and infection and is highly indicative of advanced peri-implantitis (Mombelli and Lang 1994; Heitz-Mayfield 2008b). Large inflammatory cell infiltrates, including polymorphonuclear (PMN) cells, are seen to occupy the connective tissue infiltrate in advanced peri-implantitis lesions, which may explain the presence of suppuration at these sites (Rams et al. 1984). A study by Roos-Jansaker et al. (2006) showed that the presence of pus correlated to implants with bone loss to the level of ≥ 3 threads. Suppuration is therefore a key parameter for the diagnosis of advanced peri-implantitis and should prompt the clinician to undertake urgent investigation and treatment as necessary (American Association of Periodontology 2013).

2.5.6 Peri-implant crevicular fluid and saliva analysis

There has been considerable interest in the use of peri-implant crevicular fluid (PICF) and saliva analysis technology to identify biomarkers for peri-implant disease and progression (Kao et al. 1995; Behneke et al. 2000; Renvert et al. 2017). Inflammatory mediators and enzymes associated with bone destruction and inflammation around implants have become the focus of current research as being potential biomarkers. A vast number of biomarkers have shown promising results in differentiating peri-implant health from disease. Such biomarkers include Interleukin 1-beta, plasma tumour necrosis factor alpha, prostaglandin E_2, matrix metalloproteinase and myeloperoxidase. As well as having a diagnostic potential, PICF and saliva analysis offer the advantage of being a non-invasive and repeatable method. However, due to inconsistent results and studies being of a cross-sectional design, more robust research (i.e. randomised clinical trials) are required to validate their use as a diagnostic tool for peri-implant diseases (Dursun and Tozum 2016).

2.5.7 Microbiological analysis

Bacterial culturing to monitor the subgingival microflora has been proposed as a potentially useful diagnostic method to determine an elevated risk for peri-implantitis (Mombelli and Lang 1998). Current bacterial sampling methods are however inadequate and studies to date show conflicting results with regard to the microbial flora around diseased and healthy implants (Leonhardt et al. 1999; Renvert et al. 2007; Renvert et al. 2017). Microbiological testing for the diagnosis of peri-implant diseases thus remains a poorly understood subject and further research is warranted to determine its diagnostic value (American Association of Periodontology 2013).

2.5.8 Plaque assessment

Oral hygiene is considered one of the most important factors associated with peri-implant marginal bone loss (Lindquist et al. 1988). This is unsurprising given that plaque is considered a main aetiological factor in the development of peri-implantitis. Plaque assessment therefore plays a key role for oral hygiene monitoring and reinforcement purposes as a preventive measure against peri-implant diseases. The modified plaque index (Mombelli et al. 1987) was developed to quantitatively assess and document plaque levels around implants and is beneficial from a clinical and research perspective (Table 3).

Table 3. Modified plaque index (Mombelli et al. 1987)

Score	Description
0	No detection of plaque
1	Plaque only recognised by running a probe across the smooth marginal surface of the implant. Implants covered by titanium spray in this area always score 1
2	Plaque can be seen by the naked eye
3	Abundance of soft matter

2.5.9 Mucosal conditions

Inflammation of the mucosa due to peri-implant diseases can often present as swelling and redness of the marginal tissues (Rams et al. 1984; Mombelli et al. 1987). The texture and colour of the soft tissues is however dependent on the recipient tissues before implant placement and the material characteristics of the implant surface (Listgarten et al. 1991). In some cases, gingival enlargement can occur if implants are located in an area of non-keratinised mucosa or if the restoration is removable. Recession and exposure of the implant threads may also be evident when peri-implant bone loss has occurred (Alani et al. 2014). The

simplified gingival index (Apse et al. 1991) may be useful for assessing mucosal conditions around oral implants (Table 4).

Table 4. Simplified Gingival Index (Apse et al. 1991)

Score	Description
0	Normal mucosa
1	Minimal inflammation with colour change and minor oedema
2	Moderate inflammation with redness, oedema and glazing
3	Severe inflammation with redness, oedema, ulceration, and spontaneous bleeding without probing

2.5.10 Width of keratinized mucosa

The presence of keratinised mucosa around implants is thought to strongly correlate with optimal soft and hard tissue health. Since keratinised mucosa possesses more hemidesmosomes, this is reported to provide greater strength to the implant soft tissue interface (Gulati et al. 2014). The lack of keratinised mucosa has been suggested to increase the susceptibility of plaque-induced peri-implant tissue destruction and restrict oral hygiene performance (Salvi and Zitzmann 2014). Numerous studies have investigated the relationship between the width of keratinised tissue and the health of peri-implant tissue (Adell et al. 1981; Albrektsson et al. 1986; Warrer et al. 1995). However, the current results are conflicting with some studies showing no differences in progression of peri-implantitis lesions in sites with or without keratinised mucosa, while other studies showing a difference. Further research is therefore required to determine the influence of keratinised mucosa on long-term peri-implant health (Salvi and Zitzmann 2014).

2.5.11 Pain or discomfort

Pain or discomfort is not a common feature of peri-implant disease. However, its presence may be associated with implant mobility or an acute infection, thus indicative of a failing implant (Lekholm et al. 1994). Percussion of the implant may be useful for evaluating discomfort or pain and should be performed in both lateral and apical directions (Alani et al. 2014). The percussion tone can also be assessed whereby significant bone loss may result in a duller tone compared to a high pitch in a clinically healthy implant. However, caution with interpretation should be exercised, due to the lack of evidence supporting this method.

2.5.12 Summary of recommendations for the diagnosis of peri-implant diseases

At the 7th EWOP, the consensus group agreed the following recommendations for diagnosis of peri-implant diseases: (Lang and Berglundh 2011; Sanz and Chapple 2012):

- The time at which baseline criteria should be recorded is at the time of prosthesis installation.
- At baseline, radiograph and peri-implant probing (i.e. probing depth, suppuration, bleeding on probing) should be performed.
- If changes in clinical parameters indicate disease (BOP, increased probing depth), a radiograph should be taken. Probing depths >5mm from baseline in combination with BOP indicates a higher disease progression.
- The key parameter for diagnosis of peri-implant mucositis is bleeding on gentle probing (<0.25N).
- Peri-implantitis is characterised by changes in marginal bone levels in conjunction with BOP and/or suppuration with or without concomitant deepening of the peri-implant pockets. The threshold for a diagnosis of peri-implantitis is ≥ 2mm of bone loss from the expected level (in the absence of a baseline radiograph).

2.6 Risk factors for peri-implant diseases

A risk factor can be defined as “an environmental, behavioural or biological factor that if present, directly increases the probability of a disease occurring and if absent or removed, reduces that probability” (Genco 1996). Several risk factors that may lead to the development and progression of peri-implant diseases have been reported in the literature. Knowledge of these risk factors is essential for appropriate treatment planning so as to avoid the disease from occurring.

2.6.1 Oral Hygiene

Poor oral hygiene is reported as one of the most important risk factors for peri-implant diseases (Lindquist et al. 1988). Patients with poor oral hygiene are reported to have 14 times greater odds of developing peri-implantitis (Heitz-Mayfield et al. 2014). A study by Lindquist et al. (1997) found that poor oral hygiene at 10-year follow up correlated to greater levels of peri-implant bone loss.

Smokers were also more affected by poor oral hygiene, whereby they experienced three times more marginal bone loss than non-smokers. In 2006, Ferreira et al. (2006) conducted a study in a Brazilian population and demonstrated that an increase in total plaque scores was statistically associated with the severity of peri-implant disease, thus highlighting the strong and dose dependent relationship between oral hygiene and peri-implant disease. It is therefore paramount that the patient establishes optimal plaque control before implant treatment and continues to maintain excellent oral hygiene after implant treatment to prevent peri-implant disease from occurring.

2.6.2 Professional implant maintenance therapy

Implant maintenance therapy has a favourable effect on the prevention of peri-implant diseases (Monje et al. 2016). Patients that do not receive a

structured monitoring and maintenance program are more likely to develop peri-implantitis (Rinke et al. 2011; Costa et al. 2012; Roccuzzo et al. 2014). A five year follow up study by Costa et al. (2012) found that the incidence of peri-implantitis was 18% in individuals that received maintenance therapy compared to 44% for individuals that did not receive maintenance therapy. Similarly, Roccuzzo et al. (2014) revealed a statistically significant increase in the number of implant sites that required further treatment with surgery or antibiotic treatment in patients that did not fully comply with a supportive therapy program over 10 years of follow up. A systematic review by Ramanauskaite and Tervonen (2016) concluded that poor adherence to maintenance therapy results in significantly higher frequencies of sites with mucosal inflammation and peri-implant bone loss as well as more frequent implant loss.

Professional implant maintenance therapy consists of monitoring and diagnosing peri-implant conditions, providing oral hygiene education, identifying and controlling modifiable risk factors and delivering professional mechanical plaque removal (Ramanauskaite and Tervonen 2016). This supportive therapy is aimed at maintaining peri-implant health and should be individually tailored according to the patient's needs based on their diagnosis and risk profile. Guidelines published by the EWOP working group and international working group consider maintenance therapy as an essential requirement for the prevention of peri-implant diseases and this is discussed in more detail later (Lindhe et al. 2008; Heitz-Mayfield et al. 2014; Jepsen et al. 2015).

2.6.3 History of periodontitis

Patients with a history of periodontitis, those who have current disease as well as those with a previous history of tooth loss due to periodontal disease are more susceptible to peri-implantitis (Renvert and Persson 2009). Several systematic reviews have concluded that patients with a history of periodontitis exhibited significantly greater probing depth, more marginal bone loss, a higher incidence of peri-implantitis and a greater

risk for implant loss when compared to healthy patients (Schou et al. 2006; Quirynen et al. 2007; Ong et al. 2008; Chrcanovic et al. 2014; Renvert and Quirynen 2015; Ramanauskaite and Tervonen 2016).

In partially dentate patients with chronic periodontitis, the incidence of peri-implantitis is reported to range from 3.1% to 66.7% over a five to ten year period (Sousa et al. 2016). In partially dentate patients with aggressive periodontitis, the incidence of peri-implantitis is reported as 26% over a period of 3 to 16 years (Swierkot et al. 2012). Generalised aggressive periodontitis patients are reported to have a three times greater risk of peri-implant mucositis and 14 times greater risk of peri-implantitis when compared to periodontally healthy individuals. Additionally, when compared to chronic periodontitis patients, aggressive periodontitis patients exhibited greater marginal bone loss around implants (Mengel and Flores-de-Jacoby 2005; De Boever et al. 2009).

The increased risk of peri-implant disease in periodontitis individuals is thought to occur as a result of cross-transfer of periodontal pathogens from the residual dentition to the peri-implant tissues (Leonhardt et al. 1993). Within the same individual, similar periodontal pathogens have been detected around natural teeth and implant surfaces, which suggests that natural teeth may act as a reservoir for periodontal pathogens (Pjetursson et al. 2012). A recent study by Cho-Yan Lee et al. (2012) demonstrated that treated periodontitis patients with at least one residual pocket of 6mm or greater around natural teeth had significantly greater peri-implant bone loss, peri-implant pocket depths (>5mm) and bleeding on probing than those that were periodontally healthy. It is also believed that even fully edentulous patients with a history of periodontitis could be susceptible to peri-implant disease due to periodontal pathogens residing within the oral cavity in the saliva or tongue (Van Assche et al. 2009). Studies have otherwise indicated that patients with an unfavourable immune response, especially those with aggressive periodontitis, may be prone to peri-implant disease despite maintaining a periodontally stable dentition (Renvert and Quirynen 2015; Sousa et al. 2016).

Prior to implant provision, it is therefore important to undertake a thorough clinical history and examination in order to identify any current or previous history of periodontitis. Where active periodontitis is present, this requires stabilisation and follow-up to ensure compliance. Optimal plaque control and a periodontally stable dentition are essential before undertaking implant treatment. After implant placement, provision of long-term periodontal monitoring and maintenance is recommended so as to avoid the risk of peri-implant disease occurring (Renvert and Quirynen 2015).

2.6.4 Smoking

A number of systematic reviews have concluded that there is an increased risk of peri-implant disease in smokers compared with non-smokers, with odds ratios ranging from 3.6 to 4.6 for peri-implantitis (Hinode et al. 2006; Klokkevold and Han 2007; Strietzel et al. 2007; Heitz-Mayfield and Huynh-Ba 2009). To aid clarification in the context of this topic, the odds ratio can be defined as the ratio of the odds of having the outcome (i.e. peri-implantitis) in the experimental group (e.g. smokers) relative to the odds of having the outcome in the control group (e.g. non-smokers). The odds ratio therefore compares how likely peri-implantitis will occur in smokers compared with non-smokers. A study by Haas et al. (1996) found that smokers showed a higher score in bleeding index, mean peri-implant probing depth and degree of peri-implant mucosal inflammation and radiographic bone loss. More recently, Rinke et al. (2011) conducted a cross-sectional study and demonstrated that smokers compared with non-smokers had an odds ratio of 3.8 and 31.6 of developing peri-implant mucositis and peri-implantitis respectively. Additionally, smokers have been shown to have poor compliance with oral hygiene and greater amounts of plaque compared to non-smokers (Preber et al. 1980; Andrews et al. 1998).

Patients should therefore seek to stop smoking prior to implant treatment as well as to continue smoking cessation indefinitely thereafter. Failure to do so will render the patient susceptible not only to developing peri-implant disease but to implant loss as well.

2.6.5 Systemic diseases

There are only two studies available that demonstrate an association between diabetes and peri-implant disease. Ferreira et al. (2006) reported that diabetic patients with poor glycaemic control were statistically associated with a greater risk of developing peri-implantitis. A cross-sectional study by Daubert et al. (2015) demonstrated that peri-implantitis was associated with subjects that had diabetes at the time of implant placement. Additional research is required to substantiate these findings (American Association of Periodontology 2013; Renvert and Quirynen 2016).

Studies have shown that peri-implantitis may be more prevalent in patients with cardiovascular disease (Renvert et al. 2012; Marrone et al. 2013). However, there is a current lack of evidence to clarify this association. Data regarding other systemic diseases is also lacking. It is thought that patients with chronic conditions affecting bone turnover such as radiotherapy and osteoporosis may be considered at a greater risk of peri-implant disease (Chambrone et al. 2013; Lopez-Cedrun et al. 2013). Additionally, patients that have an impaired immune function, undergoing chemotherapy or taking long-term corticosteroids may be at a higher risk too (Dvorak et al. 2011). Further research is required to verify this.

2.6.6 Genetic traits

The presence of genetic polymorphisms may make individuals more susceptible to peri-implant diseases. Pro-inflammatory cytokines such as interleukin (IL) -1α, IL-β, IL-6 and tumour necrosis factor α, play a key role in the regulation of the inflammatory response. If an individual is

genetically predisposed to overproducing pro-inflammatory cytokines, this can result in an increase in tissue destruction, which may have an influence on peri-implant disease progression (Renvert and Quirynen 2015).

A systematic review in 2008 found that there was inadequate evidence to support or refute the association between the IL-1 genotype and marginal bone loss as a surrogate marker of peri-implantitis (Huynh-Ba et al. 2008). Another systematic review concluded that a tendency should be underlined showing a potential link between IL-1 genotype and peri-implantitis (Dereka et al. 2012). In 2015, a systematic review by Renvert et al. (2015) reported that the available data on the relationship between peri-implantitis and genetic traits were unclear. It was stated that a great variation of polymorphisms had been studied with conflicting results, therefore limiting the possibility to draw conclusions on the importance of genetic traits as a risk factor for peri-implantitis. Thus, the authors concluded that the available data currently did not support genetic testing for assessing risk of peri-implantitis and that future studies are needed.

2.6.7 Occlusal overload

Occlusal overload may occur in cases where the occlusal scheme is sub-optimal, in individuals with parafunctional habits or in edentulous cases where shared loading is not possible with natural teeth (Alani and Bishop 2014a). Patients that parafunction are likely to exert non-axial loads on both teeth and implants for long periods (Isidor 1996). Unlike teeth, implants do not possess a periodontal ligament and therefore have a lower capacity to accommodate excessive stresses. Increased loading on implants results in stress concentrated at the marginal bone surrounding the implant (Stanford 1999). The bone will remodel in response to strain, however excessive stresses can cause microfracture within bone and eventual bone loss (Miyata et al. 2002). When bone loss has occurred, the implant surface may become exposed and populated with microorganisms subsequently leading to the development of peri-

implantitis. A systematic review by Fu et al. (2012) suggested that occlusal overload was positively associated with peri-implant marginal bone loss, however poor oral hygiene was still the key causative factor. The role of occlusal overload on peri-implantitis still remains unclear and further research is required (American Association of Periodontology 2013).

2.6.8 Presence of keratinised mucosa

The presence of 2mm of keratinised gingiva with at least 1mm of attached gingiva has been demonstrated to play an important role in the maintenance of periodontal health around the natural dentition (Mombelli et al. 1987; Lindhe et al. 1992). However, the significance of keratinised width around dental implants for the maintenance of peri-implant health remains inconclusive. Gobbato *et al.* (2013) conducted a systematic review and found that a narrow zone of keratinised width (<2mm) appeared to be associated with clinical parameters indicative of inflammation and poor oral hygiene (i.e increased plaque accumulation and peri-implant bone loss). Increased sensitivity or insufficient cleaning access into the mucosal sulcus was suggested as an explanation for these findings (Wennstrom et al. 1994). Despite this, it was concluded that the current evidence was too limited to confirm that keratinised width had a significant impact on peri-implant health. Another systematic review by Lin (2013) found that an inadequate keratinised width was associated with higher plaque levels, tissue inflammation, mucosal recession as well as loss of peri-implant attachment. It was concluded that 1-2mm of keratinised width might be beneficial in decreasing plaque accumulation, tissue inflammation, marginal recession and attachment loss. In addition, the authors suggested that there might be therapeutic advantages to surgically augmenting the keratinised mucosa width for the prevention of peri-implant disease. However, it was stated that further studies were required first to demonstrate the benefit of this treatment to patients (Esposito et al. 2012; Lin et al. 2013).

2.6.9 Aetiological factors

Excess cement residing in the peri-implant sulcus following cementation of implant restorations has been reported as an iatrogenic risk factor for peri-implant disease (Gapski et al. 2008). The exact mechanism is poorly understood, however it is believed that bacterial colonisation of the foreign material results in local inflammation of the peri-implant tissues, which can consequently lead to peri-implant attachment loss (Wilson 2009). Very few clinical studies have investigated this subject likely due to ethical reasons and most of the literature is described as case reports. In 2009, a prospective study by Wilson (2009) demonstrated a positive association between cement excess and peri-implant disease. The study revealed residual cement around 81% of implants with clinical and radiographic signs of peri-implant disease. Four weeks after removal of the residual cement, complete resolution was reported in 74% of these sites.

Several factors have been identified that are linked with excess cement. Submarginal restorations with deep margins have been shown to leave more excess cement than shallow margins (Linkevicius et al. 2011; Linkevicius et al. 2013). A study by Korsch *et* (2015) revealed that larger implant diameters were significantly associated with excess cement in the peri-implant tissues. Composition of the cement may also play a role in the host response, which may influence peri-implant disease development and progression. An *in vitro* study (Rodriguez et al. 2017) showed that zinc oxide (non-eugenol) dental cement (Temp Bond NE^{TM}, Kerr, Michigan, USA) appeared to affect the host cellular response significantly less than other cements, such as zinc phosphate, zinc oxide (eugenol) and acrylic resin (Rodriguez et al. 2017).

Visual and tactile methods of detecting excess cement can be difficult and complete removal of cement when the abutment crown margin is deeper than 1mm below the gingival margin is nearly impossible (Wilson 2009). The use of retraction cord and floss post-cementation is advisable

when the abutment is subgingival (Alani and Bishop 2014a). Ideally, where deep implant placement can be avoided this would be preferred. However, if this is not possible, then a screw-retained connection should be considered in the first instance or otherwise if aesthetics is not a concern the abutment shoulder should be placed epimarginally or supragingivally for a cement-retained restoration (Korsch et al. 2015). The reliability of radiographic evaluation to identify excess cement is variable depending on the location, radiopacity and the amount of cement (Wadhwani et al. 2012). Selection of a radiopaque cement and undertaking a post-cementation radiograph may however still be beneficial to aid detection of excess cement (Wadhwani et al. 2012; Alani and Bishop 2014a).

Failure to achieve a prosthesis design that takes into account ease of access for home and professional cleaning can result in biofilm retention and peri-implantitis (American Association of Periodontology 2013). This can be related to implant mal-positioning and meeting patient expectations for aesthetics, phonetics and function. An implant placed too superficially or too palatally can lead to an abrupt emergence profile creating a shelf with greater plaque retention. Implants placed too deeply will have a long sub-mucosal component to the restoration and so plaque may be inaccessible to patient oral hygiene measures. Implants placed too buccally are at risk of developing recession resulting in bacterial colonisation and peri-implant infection (Alani and Bishop 2014a). Additionally, implants that are placed too close together or the presence of a ridge-lap pontic design can compromise access for mechanical cleaning with interdental brushes and floss. Careful planning of implant placement and prosthesis design is therefore necessary to facilitate maintenance and monitoring so as to avoid development of peri-implant diseases (American Association of Periodontology 2013).

Individuals with screw-retained prostheses may be subject to peri-implant disease due to iatrogenic causes. Failure to seat the restoration and abutment correctly or inadequate tightening of the screw to the

recommended torque level can create a gap at the implant-abutment-restoration interface that allows microorganisms to populate which then predisposes the patient to peri-implant disease (Lang and Berglundh 2011).

2.6.10 Alcohol consumption

There is emerging evidence to suggest that alcohol consumption is associated with peri-implantitis. A study by Galindo-Moreno *et al.* (2005) found that peri-implant marginal bone loss was significantly related to a daily consumption of >10g of alcohol. Alcohol consumption also induced greater marginal bone loss compared with tobacco use. The association between alcohol and peri-implantitis remains poorly understood, however, it is thought that alcohol consumption results in delayed healing response, impaired immune function, altered bone turnover and decreased levels of coagulation. In addition, individuals that consume excessive alcohol often have poor oral hygiene, inadequate nutrition and vitamin deficiencies (Galindo-Moreno et al. 2005). It is believed that these various factors increase patient susceptibility to peri-implantitis, however, further studies are required to substantiate this.

2.6.11 Implant surface characteristics

Some studies have suggested a possible link between implant surface characteristics and peri-implant disease. Surface modifications of implants are commonly undertaken to improve osseointegration and these include surface roughening (e.g. sandblasting or acid-etching) and coating (e.g. hydroxyapatite) (Dahiya et al. 2014).

Rough surface implants have the advantage of enhancing osseointegration when compared to smooth surface implants (Lang and Jepsen 2009). However, it is believed that rougher surfaces and surfaces with high free surface energy (e.g. titanium) have a higher affinity for plaque thus rendering them more prone to peri-implant disease (Teughels

et al. 2006). Implants with a rough surface may also be more difficult to clean than those with a smooth surface (Renvert et al. 2011). This could explain the findings of several studies that have demonstrated a higher frequency of peri-implantitis in rough (titanium plasma sprayed) implants when compared to smooth implants that are exposed to the oral environment (Ellegaard et al. 1997; Astrand et al. 2004; Baelum and Ellegaard 2004). It is also possible that implant features such as exposed threads may be difficult to clean and again may predispose the patient to peri-implantitis (Renvert et al. 2011). Otherwise, case reports have shown that delamination or biodegradation of the hydroxyapatite coating from the titanium implant surface can result in peri-implantitis (Chang et al. 1999; Lee et al. 2000). The current evidence for the influence of implant surface characteristics as a risk indicator for peri-implant disease is limited and it is concluded that further research is still required (Heitz-Mayfield 2008b; Renvert et al. 2011).

2.7 Management of peri-implant diseases

At the recent 11th EWOP in 2015, the consensus group established an agreed standard of care for the management of peri-implant mucositis (Jepsen et al. 2015). No established or predictable standard of care for the treatment of peri-implantitis has yet been confirmed. This is primarily due to the lack of high quality prospective long-term follow up studies into the efficacy of existing treatment modalities (Jepsen et al. 2015). The evidence for the management of peri-implantitis is largely based on treatment of periodontal diseases (Thierbach and Eger 2013). However, implants possess distinct differences to natural teeth and it raises the question about the feasibility of applying periodontal treatment techniques for the management of peri-implantitis.

Unlike natural teeth, implants possess screw shaped designs, threads and various degrees of surface modifications that may be more plaque retentive when exposed to the oral environment. These features, in addition to local factors such as complex suprastructure designs, can also compromise access for peri-implant probing assessment and cleaning. Negotiating instruments around complex implant surfaces can provide significant challenges in achieving effective non-surgical debridement. Mechanical instrumentation can additionally damage the implant surface if hand instruments harder than titanium (i.e. stainless steel) or ultrasonic with metal tips are used, predisposing the surface to plaque accumulation (Matarasso et al. 1996). Instruments such as Teflon-coated scalers, plastic scalers and graphite, gold-coated and carbon-fibre curettes and plastic inserts for ultrasonic tips have been employed to overcome this issue. When considering these issues, it can be assumed that implants may be more vulnerable to biofilm formation and peri-implantitis compared to that of their natural teeth counterparts.

Despite the lack of conclusive evidence, the various non-surgical and surgical treatment modalities for peri-implant diseases are discussed.

2.7.1 Conventional non-surgical management

It has been agreed by the 11th EWOP consensus group that professionally- and patient-administered mechanical plaque control is effective for the treatment of peri-implant mucositis (Jepsen *et al.* 2015). Patient-administered mechanical plaque control alone (with manual or powered toothbrush) and professionally-administered plaque control (regular oral hygiene instruction, mechanical debridement employing different hand or powered instruments with or without polishing tools) should be considered as the current standard of care. Existing evidence demonstrates that patient and professional adjunctive measures (i.e. oral rinses, dentifrice, antiseptics, local and systemic antibiotics, air abrasive devices) have limited benefit in reducing clinical inflammation for peri-implant mucositis (Salvi and Ramseier 2015; Schwarz et al. 2015).

In peri-implantitis, conventional non-surgical treatment alone is found to be ineffective (Lindhe and Meyle 2008). Karring et al. (2005) revealed that mechanical debridement with an ultrasonic power device or carbon-fibre curette was not sufficient for the decontamination of implant surfaces with peri-implant pockets of 5mm or greater and exposed threads. Similarly, a randomised controlled trial found no differences in the treatment outcome between titanium hand-instruments and ultrasonic device. Despite a reduction in plaque and bleeding scores, there were no effects on peri-implant probing depth or bacterial load (Renvert et al. 2009).

Alternative or adjunctive non-surgical therapies have therefore been proposed as a means to improve the efficacy of conventional non-surgical treatment at peri-implantitis sites.

2.7.2 Alternative non-surgical management

Ultrasonic with hydroxyapatite fluid polish (Vector), glycine powder air polishing and erbium-doped: yytrium, aluminium and garnet (Er:YAG)

laser treatment are some of the alternative methods of plaque removal that have been investigated.

The Vector system (Durr Dental, Germany) is a novel ultrasonic device that uses a different type of energy transmission and its function is based on a hydrodynamic flow technique combined with fine polishing particles (Karring et al. 2005). This system is shown to be beneficial for natural teeth in the removal of soft and hard subgingival deposits without disturbing the root (Hahn 2000). A pilot study by Karring et al. (2005) found a greater reduction in the number of sites with BOP using the Vector system than carbon-fibre curettes, however no improvements were found in PPD and bone levels in both groups.

Air abrasive devices are thought to be more effective at disrupting the peri-implant biofilm than mechanical debridement (Sahm et al. 2011). Softer powders (e.g. glycine) have been introduced to overcome surface alterations created by abrasive powders (e.g. sodium bicarbonate) and do not alter the implant surface (Schwarz et al. 2009). A randomised controlled trial demonstrated that glycine powder resulted in significantly higher BOP reductions than mechanical debridement with carbon curettes and adjunctive local chlorhexidine therapy. However, CAL gains were comparable and limited in both groups at 6 months (Sahm et al. 2011). In 2012, an *in vitro* study showed that air powder abrasive treatment with hydroxylapatite and tricalcium phosphate removed 99% of the biofilm on contaminated titanium discs with minimal changes to the surface structure (Tastepe et al. 2012). These findings suggest the possible potential of air abrasive treatment for management of peri-implantitis.

Er:YAG lasers are believed to have efficient capability in decontaminating and debriding the implant surface (Goncalves et al. 2010). It is assumed that the unidirectional light beam can gain better access to all parts of the implant surface when compared to conventional manual and ultrasonic instruments (Matsuyama et al. 2003). Schwarz et al. (2005; 2006a)

conducted two randomised controlled trials and found that Er:YAG laser treatment was associated with improvements in BOP, PD and CAL and lower counts of *F.nucleatum* after 1 month of therapy compared to mechanical debridement and adjunctive local chlorhexidine irrigation/application. However, in advanced peri-implantitis lesions, no benefit was seen after 6 months, thus indicating that a single course of laser treatment is inadequate.

2.7.3 Adjunctive non-surgical management

Photodynamic therapy (PDT) is a non-invasive method that is used as an adjunct to mechanical debridement. Bactericidal effects are achieved by generating singlet oxygen and free radicals after application of the photosensitiser (e.g toluidine blue, methylene blue) into the peri-implant pocket with subsequent activation using light at a pre-defined wavelength via a diode laser. This technique can directly target aerobic and anaerobic bacteria, such as *Aggregatibacter actinomycetemcomitans, Porphyromonas gingivalis* and *Prevotella intermedia* and has demonstrated effective antimicrobial results (Al-Ahmad et al. 2013). PDT is considered a safe adjunctive treatment allowing human cells to repair after irradiation due to the low energy dose of the laser light and low concentration of the photosensitiser (Luan et al. 2009). The use of PDT in combination with mechanical debridement has shown beneficial clinical and microbiological outcomes (Soukos and Goodson 2011). Bassetti et al. (2014) found that adjunctive PDT was able to reduce the pathogenic bacterial load and levels of IL-1β in peri-implantitis. A clinical study also demonstrated that in moderate peri-implantitis, adjunctive PDT significantly improved clinical attachment levels and bleeding scores six months after treatment (Deppe et al. 2013). This treatment, however, was ineffective in the management of severe peri-implantitis. Despite insufficient data to conclude the value of PDT, it appears that this approach may have promising potential in the treatment of peri-implantitis.

A number of antiseptic treatment modalities have been investigated for use in conjunction with mechanical therapy to treat peri-implantitis. These include chlorhexidine gel, chlorhexidine irrigation, 2.5mg chlorhexidine chips (PerioChip®; Dexcel Pharma, Or-Akiva, Israel), chlorhexidine mouthrinse and essential oil containing mouthrinses (Listerine®; Johnson and Johnson, New Jersey, USA). At the 6th EWOP, it was concluded that the use of adjunctive chlorhexidine application had limited effects on clinical and microbiological parameters for peri-implantitis (Lindhe and Meyle 2008). Lavigne et al. (1994)) found that hydroxyapatite-coated implants with peri-implant probing depths >3mm failed to demonstrate any clinical or microbiological improvements after irrigation with 0.12% chlorhexidine. In 2008, Renvert et al. (2008a) conducted a randomised controlled trial and found that 1% chlorhexidine gel application resulted in limited reduction in bleeding scores and no reduction in PD in subjects with peri-implantitis. Machtei et al. (2012) however demonstrated that frequent placement of PerioChip in sites with peri-implantitis resulted in significantly greater CAL gain [2.21mm] and PD reduction [2.19mm] compared to the placebo [CAL gain 1.56mm / PD reduction 1.59mm] at 6 months. BOP scores were reduced by half in both groups likely due to provision of mechanical therapy and oral hygiene instruction prior. In a clinical study investigating peri-implant mucositis subjects, the adjunctive use of 0.12% chlorhexidine irrigation, topical application of chlorhexidine gel and 0.12% chlorhexidine mouthrinse twice daily did not provide additional improvements in clinical parameters (PD, bleeding index, CAL) over mechanical debridement alone (Porras et al. 2002). In 1995, Ciancio et al. (1995) conducted a double blind randomised controlled trial and demonstrated that subjects with peri-implant mucositis and peri-implantitis showed significant reduction in plaque index, gingival index, and bleeding after using Listerine mouthrinse for 30 seconds twice daily for 3 months compared to the placebo group. No significant differences in PD or attachments levels were recorded in both groups. These findings therefore suggest that chlorhexidine applied as rinses or gels and Listerine mouthrinse are of limited benefit in peri-implantitis cases, while

chlorhexidine chips may be beneficial.

More recently, a study by Stein et al. (2017) investigated the adjunctive use of repeated sub-mucosal 10% povidone-iodine application in combination with ultrasonic decontamination, soft tissue curettage and glycine powder air polishing for non-surgical therapy of peri-implantitis. The results showed a significant reduction in mean PD [1.4mm], mean CAL [1.3mm] and BOP [33%] at 12 months follow-up. Povidone-iodine shows promising potential compared to previously reported antiseptic treatments as it has a broad antibacterial spectrum, including bacteria that have been associated with periodontal and peri-implant microflora (Sahrmann et al. 2012; Sahrmann et al. 2014). Additionally, it is considered cost-effective, promotes mineralisation activity in the long-term and is less cytotoxic compared to chlorhexidine (Schmidlin et al. 2009; Stein et al. 2017). Further studies are needed to evaluate the antiseptic effect of povidone-iodine in order to substantiate its use.

Adjunctive local and systemic antibiotics have shown to reduce bleeding on probing and probing depths in peri-implantitis (Renvert et al. 2008a; Javed et al. 2013). Buchter *et al.* (2004) found that local adjunctive treatment with doxycycline gel achieved PD reduction and greater CAL gain (0.6mm) in peri-implantitis sites compared with subgingival debridement alone. In a randomised controlled trial, adjunctive local application of 1mg minocycline microspheres achieved significant reductions in PD and BOP compared to adjunctive 1% chlorhexidine gel (Renvert et al. 2008a). Local tetracycline containing fibres also demonstrated similar outcomes (Mombelli et al. 2001). Although all studies showed benefits, local adjunctive therapy did not resolve the lesion in all cases (Renvert et al. 2008a). Regarding systemic antimicrobials, only a few case series reports have described their use as an adjunct to non-surgical debridement. Mombelli and Lang (1992) found that 1000mg ornidazole for 10 days in conjunction with mechanical debridement and 0.5% chlorhexidine irrigation reduced BOP immediately, which remained significantly lower after 1 year than before treatment. A

temporary reduction in anaerobic bacterial load was observed in addition to significant mean PD reduction at 1 year (Mombelli and Lang 1992). Additional case series studies have similarly found improvements in PD and BOP with the use of various systemic antimicrobials that include amoxicillin/clavunanic acid, metronidazole, clindamycin and ciprofloxacin (Mombelli and Lang 1992; Khoury and Buchmann 2001; Renvert et al. 2008b). Due to the paucity of data and the issues surrounding antibiotic resistance, further studies are still needed to establish the value of adjunctive systemic antimicrobials in non-surgical treatment of peri-implantitis (Javed et al. 2013; Carlet 2015).

2.7.4 Surgical management

Surgical treatment of peri-implantitis is recommended where non-surgical treatment does not resolve the lesion (Lindhe and Meyle 2008). Prior to surgical therapy, the acute infection must be resolved and appropriate oral hygiene measures instituted (Mombelli and Lang 1998; Heitz-Mayfield et al. 2014). The primary objective of surgical treatment is to resolve the inflammatory lesion. Regeneration of the peri-implant tissues is also desirable (Lindhe and Meyle 2008).

2.7.4.1 *Access flap surgery (open-flap debridement)*

Surgical treatment offers the advantage of providing improved access and visibility for debridement and decontamination of the implant surface. To date, no randomised controlled trials are available on the use of access flap surgery alone for the therapy of peri-implantitis. An animal study by Schwarz et al. (2006b) demonstrated an overall improved outcome with open debridement compared with closed debridement. After 3 months, both groups demonstrated statistically significant improvements in all clinical parameters (PD, BOP, CAL). However, histological results showed re-osseointegration in up to 44% after open debridement versus 1-1.2% following closed debridement. Radiographic improvements were also not significant after closed debridement

compared to open debridement. Human comparison studies evaluating open-flap debridement alone versus closed-flap debridement are currently lacking.

2.7.4.2 *Resective surgery*

Resective surgical approaches (ostectomy and osteoplasty) have been employed for the management of peri-implantitis. This involves elimination of peri-implant osseous defects and bacterial decontamination of the implant surface in order to achieve disease resolution and soft tissue morphologies that facilitate access for cleaning and enhance peri-implant health (Romeo et al. 2005). Additional to resective surgery, implantoplasty may also be performed which consists of creating a smooth and polished supracrestal implant surface. It is thought that a smooth implant surface will reduce bacterial adhesion and subsequent biofilm formation on the implant surface. Studies investigating this approach for treating peri-implantitis have shown positive outcomes. Serino and Turri (2011) found that resective surgery resulted in complete disease resolution in 48% of subjects. In addition, 77% of patients had no implants with PD ≥6mm with bleeding and/or suppuration after 2 years. In a 3-year randomised clinical trial, Romeo et al. (2005) demonstrated a 100% implant survival rate after resective surgery and implantoplasty when compared to 78% for the resection only. Less marginal bone loss, improved probing depths and BOP scores were also noted for the implantoplasty group. These findings suggest that resective surgery with adjunctive implantoplasty can be an effective treatment option for the management of peri-implantitis. However, it should be noted that this type of surgery might not be suitable for every situation. Greater post-operative recession is a well-recognised complication of resective surgery and is best avoided in areas of high aesthetic demand (Smeets et al. 2014). Otherwise, implants that have advanced bone loss or deep infrabony defects are a contraindication due to unfavourable reduction in bone and attachment levels following osseous recontouring (Serino and

Turri 2011). In these circumstances, regenerative treatment may be a preferred option.

2.7.4.3 *Regenerative treatment*

Complete regeneration and re-osseointegration of peri-implant defects is the desirable treatment outcome to ensure long-term implant survival, function and aesthetics (Smeets et al. 2014). A variety of regenerative techniques, including barrier membranes alone and/or in combination with/without different bone substitutes and a variety of adjunctive therapies have been evaluated, with varying degrees of success.

A systematic review by Sahrmann et al. (2011) evaluated the regenerative treatment of peri-implantitis using bone substitutes and membrane (GBR) with anti-infective treatment. Seventeen articles reporting on 173 implants were included and it was revealed that radiographically, only 10.4% of implants showed complete bone fill and 85.5% demonstrated incomplete defect closure. The review concluded that complete fill of the bony defect caused by peri-implantitis using GBR does not appear to be predictable, however a partial defect fill can be expected. It should be noted that radiographic bony infill does not provide information on re-osseointegration. Histologically, a dense connective tissue capsule may form around the implant rather than the desired bone to implant contact, and this is indistinguishable on the radiograph (Persson et al. 1996). Nonetheless, bone infill into osseous defects via increase in radiographic bone density represents healing and better implant stability (Lang et al. 2000). For obvious reasons, it would be unethical to obtain samples from patients for histological examination to assess re-osseointegration. Histological animal studies have instead shown that partial re-osseointegration post-treatment is possible. Results suggest better outcomes of regeneration and re-osseointegration with bone grafting and membrane compared to membrane only, bone graft only and access flap only treatment groups (Hurzeler et al. 1995; Machado et al. 1999; Schou et al. 2003b). Additionally, allogenic,

synthetic and xenogenic bone grafts appear to be comparable to autogenous materials in terms of treatment outcomes (Schwarz et al. 2006a; Kolk et al. 2012). The method of submerged healing also remains inconclusive and results are conflicting. Singh et al. (1993) found greater re-osseointegration and bone regeneration with this technique whereas Grunder et al. (1993) showed no difference.

Due to significant heterogeneity and a low number of high quality studies, well-controlled trials are needed to establish the role of regenerative procedures in peri-implantitis treatment (Sahrmann et al. 2011). Certainly, careful case selection is necessary when considering this approach as membrane exposure, implant loss and infection are common complications (Simion et al. 1994; Khoury and Buchmann 2001; Schou et al. 2003b). Otherwise, it has been emphasised that regenerative techniques do not address disease resolution but instead are designed to fill the osseous defect. Surface decontamination is considered the key factor to achieving re-osseointegration and disease resolution (Mombelli and Lang 1998).

There is emerging evidence to show that a relatively new method of utilising porous titanium granules (PTG) may provide benefit in the reconstruction of peri-implant defects (Wohlfahrt et al. 2012; Jepsen et al. 2016). These commercially pure titanium granules are between 0.7mm and 1.0mm in size, porous, irregularly shaped and non-resorbable (Alani and Bishop 2014b). Recently, a randomised controlled trial by Jepsen et al. (2016) found that reconstruction with PTG and open flap debridement resulted in statistically significant improvements in peri-implant bone defect fill (79%) versus open flap debridement alone (22%) on radiographic evaluation. For ethical reasons, this study did not perform histological analysis understandably and therefore it could only be assumed that re-osseointegration of the implants occurred. A case report by Wohlfahrt et al. (2012) however did demonstrate in a patient that re-osseointegration of the implant after placement of PTG occurred whereby new bone formed onto the implant surface, onto the PTG and into the

porosities of the granules. Although this novel technique has shown promising results, further histological studies and randomised controlled trials with long-term clinical follow-up are needed to support these findings.

2.7.4.4 *Local decontamination*

Numerous local decontamination protocols of the implant surface have been explored as part of surgical treatment for peri-implantitis. It is still unknown to what extent contaminants have to be removed to achieve a successful outcome (Mombelli 2002). Currently, there is no conclusive evidence to demonstrate that one approach is more effective than the other (Lang et al. 2000). Animal studies have shown comparable results with implants treated using cotton pellets soaked in saline or with pumice and a rotating brush (Persson et al. 1999). Statistically greater short-term improvement in bone levels was observed in GBR cases using carbon dioxide laser treatment compared to conventional debridement (Deppe et al. 2007). No difference could be detected when a carbon dioxide laser or an air-powder abrasive unit was used for open debridement with or without coverage of the defect using an e-PTFE membrane (Deppe et al. 2001). Of note, concerns have been raised regarding the use of air-powder abrasives, which is driven by compressed air. The complications of emphysema or pneumoparotitis are reported to be infrequent (Brown et al. 1992). An animal study conducted by Schou et al. (2003a) observed no differences in surgical treatment outcome for peri-implantitis between air-powder abrasion, air-powder abrasion with citric acid application, gauze soaked in saline followed by citric acid application or gauze soaked alternately in 0.1% chlorhexidine and saline. Defects were subsequently treated using bone grafting and membrane. Almost complete bone fill and significant re-osseointegration was obtained irrespective of the decontamination method used. Shibli *et al.* (2006) conducted a dog model experiment and found that greater bone gain was achieved using PDT with GBR than conventional mechanical debridement with GBR. Re-osseointegration ranged from 31 to 41% for the PDT group versus 0 to

14% in the control group at 5 months. In a study by Schwarz et al. (2012) no clinical difference in outcome was seen for GBR cases when Er:YAG laser or plastic curettes and cotton pellets soaked with saline was used. Based on the current literature, the international working group has recommended that surgical access should include thorough surface decontamination of the implant and restorative components using any of the methods discussed, as there is no evidence to demonstrate superiority of any one approach (Heitz-Mayfield et al. 2014).

There is also emerging evidence to suggest different implant surface characteristics may influence the degree of re-osseointegration to a previously contaminated implant surface. Persson et al. (2001) found that rough surface implants (sandblasted/acid etched) implants had considerably greater levels of re-osseointegration (84%) compared to smooth (turned) implants (22%). Further investigation is needed to substantiate these findings.

2.7.4.5 *Antimicrobial treatment*

So far it is unknown whether local or systemic adjunctive use of antibiotics in surgical therapy of peri-implantitis is necessary (Claffey et al. 2008; Javed et al. 2013). In a review by Javed et al. (2013), it was noted that a significant variation in type of antibiotic, route of administration, dosage and duration of use amongst studies. Most studies additionally did not include a control group, therefore making it difficult to make a comparison. For these reasons, the current data is inconclusive and shows varying degrees of success. Heitz-Mayfield et al. (2012) conducted a prospective study of 36 implants in 24 partially dentate patients with moderate to advanced peri-implantitis. The lesions were treated using open-flap debridement and implant surface decontamination with adjunctive 500mg amoxicillin and 400mg metronidazole three times a day for 7 days. A significant PD reduction was observed whereby all treated implants had a mean PD <5mm while 47% had complete resolution of inflammation after 12 months (Heitz

Mayfield et al. 2012). Leonhardt et al. (2003) found that only 58% of implants with severe peri-implantitis resolved after surgical therapy with individualised adjunctive systemic antimicrobials. As such, further evaluation and research is required (Javed et al. 2013).

2.7.4.6 *Explantation*

In a situation where there is implant mobility or where peri-implant infection can no longer be controlled by treatment, removal of the implant should be considered. Factors influencing this decision include presence of pain, suppuration, BOP, local cellulitis, spread of infection and the severity of probing depth (Lang et al. 2000; Heitz-Mayfield et al. 2014).

2.8 Monitoring and Maintenance

Due to the absence of established or predictable treatment for peri-implantitis, primary prevention of peri-implant disease is a key priority (Jepsen et al. 2015). Studies have shown that patients who do not comply with a structured maintenance programme more frequently develop peri-implantitis compared to compliant patients (Roccuzzo et al. 2010; Costa et al. 2012; Roccuzzo et al. 2012; Roccuzzo et al. 2014).

Guidelines published by the EWOP working group and international working group have suggested the following preventive strategy against peri-implant disease development (Lindhe and Meyle 2008; Heitz-Mayfield et al. 2014; Jepsen et al. 2015):

- Clinical monitoring should be performed on a regular basis and supplemented by appropriate radiographic evaluation. At least, annual monitoring of PD, BOP and suppuration must be assessed.
- Supportive maintenance therapy including reinforcement of effective oral hygiene and professional biofilm removal should be provided on a frequency determined by oral health and the risk profile, likely to be between every 3 to 6 months.
- Regular assessment of peri-implant health is recommended during supportive maintenance therapy to identify disease at an early stage.
- Implant position should be selected and suprastructures should be designed in a way facilitating sufficient access for regular diagnosis by probing as well as for personal and professional oral hygiene measures.
- Individual risk assessment should be reviewed and modifiable risk factors, such as residual increased probing depths in the natural dentition or smoking, should be eliminated.

2.9 Conclusions

Implant treatment has become a widely accepted option for the replacement of missing teeth. However, the number of patients and implants affected by peri-implant disease is growing and this has become a considerable financial and biological concern. Peri-implant diseases are a relatively new disease process and as such the exact aetiology and pathogenesis of this disease process is not yet fully understood.

It is evident that peri-implant diseases are more challenging to detect and treat than periodontal diseases for a variety of factors. Such factors include complex prosthesis design, implant positioning and implant surface complexity. Unlike peri-implant mucositis, there are currently no established or predictable treatment concepts for peri-implantitis and therefore prevention is key. Preventive strategies include regular clinical assessment for early detection of disease, modification of risk factors, oral hygiene instruction and routine supportive therapy. The principles of peri-implantitis treatment are currently centered on the concept of cumulative treatment interceptive supportive therapy (CIST). This approach involves regular clinical monitoring around implants and as peri-implant disease is detected and the severity increases, treatments of increasing complexity are gradually incorporated. Thus, preventive measures and non-surgical treatment with or without adjunctive treatment should always precede surgical treatment first. There is promising evidence to show that partial re-osseointegration and regeneration of peri-implant defects is possible after regenerative treatment, however this does not currently appear to be predictable. Post-treatment monitoring and maintenance is essential. Patients that receive a structured monitoring and maintenance program are less likely to develop peri-implantitis than patients that do not.

Peri-implant diseases are a complex condition and remain poorly understood. Current studies display limitations such as significant heterogeneity, short follow-up times, low sample sizes, different treatment

protocols and a lack of control groups for comparison. In order to prevent and manage this condition effectively, there is an urgent need for high quality studies surrounding most areas of peri-implant disease research, such as epidemiology, diagnosis, risk factors, prevention and management of peri-implant diseases.

Currently, there are variations in the amount of teaching of dental implants between individual dental schools (Addy et al. 2008). The General Dental Council expects dentists, therapists and hygienists to be competent at maintaining peri-implant health and there is therefore a necessity for dental schools to provide the relevant training. In a climate where more dental implants are being placed and where there is an increasing incidence of peri-implant diseases, dentists, therapists and hygienists will inevitably be exposed to the issue of implant maintenance, even if they are not involved with implant restoration or placement. Understanding the present implant knowledge levels and practices of dental professionals may help provide a better understanding of the current challenges that the profession faces with regards to implant maintenance. Such information would be valuable to aid future changes necessary to improve implant education and implant care.

Previous studies have so far evaluated implant education amongst undergraduate dental schools as well as implant practice amongst university and hospital specialists in the United Kingdom (Butterworth et al. 2001; Addy et al. 2008). To the author's knowledge, no recent studies have re-evaluated such topics in relation to the United Kingdom. Additionally, there is a lack of data with regards to provision of implant teaching in dental hygiene and therapy schools within the United Kingdom. Otherwise, a recent survey by Jayachandran et al. (2015) found that current implant education at undergraduate and postgraduate levels in the United Kingdom did not instil confidence to the general dental practitioners in the West Midlands (United Kingdom) to provide and maintain dental implants. No comparable study has assessed the

opinions and level of implant knowledge amongst DH/Ts in the United Kingdom.

The current literature indicates that more information is required on implant education within dental undergraduate and hygiene and therapy schools as well as current implant practice and knowledge amongst DH/Ts and university and hospital specialists. This study aims to evaluate the following:

1. Teaching of implant dentistry in undergraduate dental schools in the United Kingdom and Ireland.
2. Teaching of implant dentistry in dental hygiene and therapy schools in the United Kingdom and Ireland.
3. Understanding of peri-implant maintenance amongst dental therapists and hygienists within Wales, United Kingdom.
4. Current implant practice amongst university and hospital specialists in restorative dentistry within the United Kingdom.

In undertaking the above, the study seeks to achieve the following objectives:

1. Determine whether UK undergraduate dental school teaching in implant dentistry meets the requirement standards set out by the General Dental Council.
2. Determine whether UK undergraduate school of hygiene and therapy teaching in implant dentistry meets the requirements set out by the General Dental Council.
3. Determine whether dental therapists and hygienists are confident and competent in managing peri-implant health.
4. Establish current implant practice amongst university and hospital restorative dental specialists.

Chapter 3: Materials and Methods

Chapter 3: Materials and Methods

3.1 Teaching of implant dentistry in undergraduate dental schools in the United Kingdom and Ireland

An online questionnaire consisting of 32 questions was developed to assess the level of teaching in implant teaching at an undergraduate level from the dental schools of the UK and Ireland (Appendix 1). The online questionnaire was constructed using software developed by Bristol University (Bristol Online Surveys, Bristol, UK). Both 'open' and 'closed' style questions were included. The questionnaire was adapted from a previous study by Addy et al. (2008) and pre-piloted within the Cardiff Dental School. This was subsequently amended, reviewed and approved by the Cardiff Dental School Research Ethics Committee [Reference No: 1703a]

In March 2017, an email was sent to restorative heads of departments in the 18 UK and Irish dental schools, providing them with the html link for the questionnaire together with a participant information sheet. Topics included:

- Current level of teaching of dental implants at their institution.
- Planned changes in this teaching during the subsequent 12-month period.
- The respondent's perception of what dental implant training/education for undergraduates would be like at their institution in five years' time.

Reminder e-mails were sent at two and four weeks from the initial e-mail. After a 6-month reply period, the data was collated and examined. The Bristol On-line Surveys software (Bristol University) program permitted collection and analysis of the data. Descriptive statistics are reported.

3.2 Teaching of implant dentistry in dental hygiene and therapy schools in the United Kingdom and Ireland

An online questionnaire consisting of 31 questions was developed to assess the level of teaching in implant teaching at dental hygiene and therapy schools (DHTS) across the UK and Ireland (Appendix 2). The online questionnaire was constructed using software developed by Bristol University (Bristol Online Surveys, Bristol, UK). Both 'open' and 'closed' style questions were included. The questionnaire was developed and pre-piloted within the Cardiff Dental School. This was subsequently amended, reviewed and approved by the Cardiff Dental School Research Ethics Committee [Reference No: 1703a]

In March 2017, an email was sent to the programme directors of the 23 UK and Irish DHTS, providing them with the html link for the questionnaire together with a participant information sheet. Topics included:

- Current level of teaching of dental implants at their institution.
- Planned changes in this teaching during the subsequent 12-month period.
- The respondent's perception of what dental implant training/education for dental hygiene and therapy students would be like at their institution in five years' time.

Reminder e-mails were sent at two and four weeks from the initial e-mail. Due to a low response rate, a further postal questionnaire was sent. After a 6-month reply period, the data was collated and examined. The Bristol On-line Surveys software (Bristol University) program permitted collection and analysis of the data. Descriptive statistics are reported.

3.3 Maintaining peri-implant health: An evaluation of understanding amongst dental hygienists and therapists within Wales, UK

An online questionnaire consisting of 16 questions was developed to assess the level of understanding regarding maintenance of peri-implant health amongst dental hygienists and therapists within Wales, UK (Appendix 3). The online questionnaire was constructed using software developed by Bristol University (Bristol Online Surveys, Bristol, UK). Both 'open' and 'closed' style questions were included. The questionnaire was developed and pre-piloted within the Cardiff Dental School. This was subsequently amended, reviewed and approved by the Cardiff Dental School Research Ethics Committee [Reference No: 1703a]

In March 2017, an email was sent to all dental hygienists and therapists (DH/Ts) in Wales, UK (n=257), using an e-mail database held by the Welsh Dental Postgraduate department. Participants were provided with the html link for the questionnaire together with a participant information sheet. Topics included:

- Implant experience and practice setting.
- Implant education and opinion of previous implant training received.
- Demographics

Reminder e-mails were sent at two and four weeks from the initial e-mail. After a 6-month reply period, due to a low response rate, paper questionnaires were also distributed at a study day for hygienists and therapists within Wales, United Kingdom. All the data was collated and examined. The Bristol On-line Surveys software (Bristol University) program permitted collection and analysis of the data. Descriptive statistics are reported.

3.4 The provision of dental implants: Current practice amongst university and hospital specialists in restorative dentistry within the UK and Ireland.

An online questionnaire consisting of 12 questions was developed to assess current implant practice amongst university and hospital specialists in restorative dentistry within the UK and Ireland (Appendix 4). The online questionnaire was constructed using software developed by Bristol University (Bristol Online Surveys, Bristol, UK). Both 'open' and 'closed' style questions were included. The questionnaire was developed and pre-piloted within the Cardiff Dental School. This was subsequently amended, reviewed and approved by the Cardiff Dental School Research Ethics Committee [Reference No: 1703a]

In March 2017, an email was sent to all members of Restorative Dentistry-UK (RD-UK), a group of consultant and specialists in restorative dentistry. Emails were also sent to dental hospitals in the UK and Ireland for the attention of all university and hospital specialists in restorative dentistry. This gave a sample size of 150. Participants were provided with the html link for the questionnaire together with a participant information sheet. Topics included:

- Current implant practice and practice setting
- Opinion on factors affecting patient selection for implant treatment

Reminder e-mails were sent at two and four weeks from the initial e-mail. After a 6-month reply period, the data was collated and examined. The Bristol On-line Surveys software (Bristol University) program permitted collection and analysis of the data. Descriptive statistics are reported.

Chapter 4: Results

Chapter 4: Results

4.1 Teaching of implant dentistry in undergraduate dental schools in the United Kingdom and Ireland

Completed questionnaires were received from 16 out of 18 dental schools (88%). It is understood that the responses were completed by the restorative dentistry heads of department or by a senior academic with teaching responsibilities relating to implant dentistry.

Current teaching

All responding dental schools reported that they provided training in implant dentistry for their undergraduates. In addition, all said that there were requirements within their curriculum for undergraduates to receive implant training. Twelve schools stated that implant training occurred during the 4th and 5th years, however six schools also included this teaching in their 3rd year programme.

10 schools (62.5%) reported that teaching was provided solely by the restorative dentistry staff. For the remaining six schools (37.5%), both the restorative dentistry and oral and maxillofacial surgery departments provided teaching.

Table 5 describes the mode of delivery of dental implant teaching to dental undergraduates. Fourteen schools (88%) had a phantom head component to their course with 13 (81%) and 6 (38%) schools utilising a lecture programme and symposium respectively. Five schools (31%) incorporated patient treatment into their teaching programme.

Table 5. Teaching formats used in undergraduate implant programme (n=16)		
Teaching format used	Number of schools	Percentage
Phantom head training	14	88%
Lecture programme	13	81%
Symposium	6	38%
Patient treatment	5	31%

The number of sessions devoted to the implant programme varied between schools. The majority of schools (n=9, 56%) devoted 4 to 6 sessions, five schools (31%) assigned 1 to 3 sessions and two schools provided greater than 6 sessions (13%).

Six schools had recommended texts on implants as part of their undergraduate reading lists. These are listed in Table 6.

Table 6. Recommended textbooks for undergraduate implant programmes
1. Hobkirk J, Watson R M, Searson L. *Introducing dental implants.* Churchill Livingstone, 2003. 2. Palmer R. Clinical Guide Series. *A clinical guide to implants in dentistry.* BDJ books, 2000. 3. Handelsman M. *Surgical guidelines for dental implant placement*. Br Dent J. 2006 Aug 12;201:139-52. 4. Palmer RM. *Risk management in clinical practice. Part 9. Dental implants*. Br Dent J. 2010 Nov 27;209:499-506. 5. Malet J, Mora F, Bouchard P. *Implant dentistry at a glance.* Wiley-Blackwell, 2012. 6. Various authors. *ITI treatment guide series.* Quintessence Publishing.

Respondents were also asked to list what educational resources they had available to undergraduate students relating to dental implants and these are listed in Table 7. In relation to internet based programmes, one school utilised the ITI online programme. 'Other' resources included implant guide stents for clinic, use of locator changing devices and torque drivers as well as use of models and kits in the clinical skills learning environment.

Table 7. Available resources for providing an undergraduate implant programme (n=16)

Resource	Number of respondents	Percentage
Selected papers	11	69%
Blackboard available seminars	8	50%
Video/DVD	5	31%
Other	3	19%
Internet based programmes	2	13%
CAL programmes	1	6%
None	2	13%

In twelve of the 16 schools (75%), students observed live surgery. In ten of the 16 schools (63%), students observed restorative implant procedures. Five schools stated that not all students were guaranteed to observe such procedures.

In thirteen schools (81%), students gained experience of treatment planning patients for implants. Eleven schools (69%) did not provide direct clinical experience in restoring dental implants. The five schools (31%) providing implant restoration experience expected their students to provide treatment for one or two cases. In two schools (40%), cases were completed by students in pairs, while in the remaining schools (60%), cases were completed individually. The types of such cases undertaken were primarily edentulous removable cases (50%), followed by single unit

cases (37.5%) and short span bridgework (12.5%). No fixed edentulous cases were undertaken. Four of the five schools (80%) had measures of competency for restoring dental implants within their undergraduate programmes. Only one school (6%) allowed the placement of dental implants by their undergraduates and these were for single unit cases. In addition, one school detailed the format of implant training within the institution. The school stated that all students are assigned a case for implant maintenance during their clinical training. Some students may shadow a private implant practice, some undertake restoration of implant mandibular overdentures and some participate as assistants on the postgraduate diploma programme.

Fifteen schools (94%) indicated that they received support from implant companies for the provision of implant training. Tables 8 and 9 details the level of support and companies involved. Only 25% (n=4) of dental schools had arrangements for patients to contribute to the cost of treatment.

Table 8. Type of support received by implant companies for the provision of implant training for undergraduate implant teaching (n=15)

Type of support	Number of respondents	Percentage
Provision of simulated models for surgery and implant restoration	14	93%
Provision of implants	7	47%
Provision of restorative components	7	47%
Laboratory funding support	2	13%

Table 9. Implant companies principally involved in supporting undergraduate programmes	
Implant company	Number of respondents
Straumann	8
Nobel Biocare	7
Dentsply	4
3i Biomet	3

Future plans for dental implant undergraduate training – next 12 months

Dental schools that did not provide undergraduate experience for restoring and placing implants were asked whether there were plans to introduce this teaching in the next 12 months. None of the schools stated that they planned to introduce such experience in the next 12 months.

Current challenges to the provision of implant training at an undergraduate level

Table 10 details the current challenges to the provision of implant training at an undergraduate level. One school stated that they did not have any current challenges.

Table 10. Current challenges to the provision of implant training at an undergraduate level	
Issues	Number of respondents
Funding	12
Lack of available time within existing teaching curricula	9
Limited numbers of suitably trained teaching staff	4
Limited patients	1
Lack of clinical space	1
Lack of consensus as to what level of implant training undergraduates should receive	1

Schools were asked to identify what components of fixed or removable prosthodontics teaching programmes they felt would increase or decrease to accommodate the introduction and development of a teaching programme in implant dentistry. The responses are summarised in table 11.

Table 11. Views of respondents on possible changes within existing prosthodontics teaching programmes in response to the development of teaching programmes in implant dentistry			
Area of prosthodontics	Decrease as a results of implant programme	Stay the same	Increase as a result of implant programme
Removable prosthodontics	13%	81%	6%
Fixed conventional bridgework	38%	56%	6%
Resin retained bridgework	6%	94%	0%
Occlusion	0%	94%	6%

Future predictions for implant undergraduate training – 5 years' time

Thirteen out of 16 dental schools (81%) believed that there will be clinical requirements relating to implant placement and restoration for undergraduate students in 5 years' time. Fifteen out of 16 dental schools (94%) reported that they did not think undergraduates would/should be surgically placing implants in 5 years' time. Only one school thought that undergraduates would/should be placing implants for single unit or removable edentulous cases. Table 12 summarises the dental schools' opinion on which type of implant restorations they believe that students would/should be involved in restoring in 5 years' time.

Table 12. The type of implant restorations dental schools thought undergraduates will be/should be involved in restoring in five years' time

Type of restoration	Number of respondents	Percentage
Implant overdenture with ball or stud attachments	12	75%
Single tooth anterior	4	25%
Single tooth posterior	3	19%
Implant overdenture with bar attachment	3	19%
Simple implant retained bridges	1	6%

Respondents were asked to predict what components of the fixed and removable teaching programme would change in five years' time to accommodate the introduction and development of an implant teaching programme. The responses are outlined in table 13.

Table 13. The components of fixed or removable prosthodontics teaching that respondents felt they may see increase or decrease to accommodate the introduction and development of a teaching programme in implant dentistry in five years' time expressed as a percentage			
Area of prosthodontics	Decrease as a result of implant programme	Stay the same	Increase as a result of implant programme
Removable prosthodontics	25%	75%	0%
Fixed conventional bridgework	44%	56%	0%
Resin retained bridgework	6%	94%	0%
Occlusion	6%	94%	0%

4.2 Teaching of implant dentistry in dental hygiene and therapy schools in the United Kingdom and Ireland

Completed questionnaires were received from 14 out of 23 (60%) dental hygiene and therapy schools (DHTS). It is understood that the responses were completed by the programme director or by a senior academic with teaching responsibilities relating to implant dentistry.

Current teaching

All responding schools (100%) reported that they provided training in implant dentistry for their undergraduates. In addition, all said that there were requirements within their curriculum for undergraduates to receive implant training. The time at which implant training was introduced varied. Eleven schools (50%) stated that implant training occurred during the 2nd year. Implant teaching occurred in the 1st year for 23% of schools and in the 3rd year in the other 27% of schools.

Respondents reported that the school of hygiene and therapy primarily provided implant teaching (56%), while seven schools (39%) indicated that the restorative department provided teaching and one school (5%) stated that their oral and maxillofacial surgery staff provided teaching.

Table 14 describes the mode of delivery of dental implant teaching to dental undergraduates. All schools adopted a lecture programme for delivering implant teaching. Ten schools incorporated phantom head training in their curriculum and two schools had a symposium and patient treatment in their course.

Table 14. Teaching formats used in implant programme (n=14)		
Teaching format used	Number of schools	Percentage
Lecture programme	14	100%
Phantom head training	10	71%
Symposium	2	14%
Patient treatment	2	14%

Schools were asked what topics were covered in their implant programme. The replies are summarised in table 15. 'Other' topics included 'peri-implant diseases' and 'the role of the dental hygiene and therapist in the maintenance of implants'.

Table 15. Topics covered in the implant programme (n=14)		
Topics	Number of schools	Percentage
Peri-implant maintenance	13	93%
Implant surgery	12	86%
Implant restoration	10	71%
Treatment planning	10	71%
Other	2	14%

The number of sessions devoted to the implant programme varied between schools. Nine schools (57%) devoted 1 to 3 sessions, five schools (36%) assigned 4 to 6 sessions and one school (7%) provided greater than 6 sessions.

Four schools had recommended texts on implants as part of the programme's reading lists. These are listed in Table 16. One school stated that they recommended mostly contemporary journal articles, which changes and updates every year.

Table 16. Recommended textbooks for the school of hygiene and therapy implant programmes
1. Ireland R. *Clinical Textbook of Dental Hygiene and Therapy*. Blackwell, 2006. 2. Lindhe K, Lang N. *Clinical Periodontology and Implant Dentistry.* Wiley Blackwell 2015. 3. Mitchell L, Mitchell D. *Oxford Handbook of Clinical Dentistry.* Oxford University Press, 2014. 4. Ucer C, Wright S, Scher E, West N, Retzepi M, Simpson S, Slade K, Donos N. ADI Guidelines on Peri-implant Monitoring and Maintenance. Association of Dental Implantology, 2012 5. Ucer C, Wright S, Scher E, West N, Retzepi M, Simpson S, Slade K, Donos N. ADI Guidelines on Management of Peri-implant Diseases. Association of Dental Implantology, 2012

Respondents were also asked to list what educational resources they had available to students relating to dental implants and these are listed in Table 17.

Table 17. Available resources for providing an undergraduate implant programme (n=14)

Resource	Number of respondents (schools)	Percentage
Selected papers	9	64%
Blackboard available seminars	7	50%
Video/DVD	3	21%
Internet based programmes	2	14%
CAL programmes	1	7%

Schools were asked whether all students observed live implant surgery and restorative implant procedures. In two of the 14 schools (14%), students observed live implant surgery. In three schools (21%), students

observed restorative implant procedures. In the majority of schools, students did not observe such procedures.

Schools were also asked whether students gained direct clinical experience relating to peri-implant maintenance. The responses are shown in Table 18. Four schools commented that not all students were guaranteed to receive direct clinical experience and this would be dependent on the availability of suitable cases.

Table 18. Direct clinical experience gained by dental hygiene and therapy students (n=14)

Type of clinical experience	Number of schools	Percentage
Stabilisation of periodontal condition prior to implant placement	10	71%
Preventive care (i.e. oral hygiene instruction and scaling)	12	86%
Non-surgical management of patients with peri-implant mucositis (i.e. mechanical debridement)	10	71%
Non-surgical management of patients with peri-implantitis (i.e. supra/subgingival debridement, antiseptics, antimicrobials etc.)	9	64%

Schools that offered direct clinical experience in non-surgical management of peri-implant diseases were also asked to state the types of implant restorations that students treated. The results are shown in Table 19.

Table 19. Types of implant restoration cases treated by students for the management of peri-implant mucositis (n=10) and peri-implantitis (n=9)		
Type of restoration	Number of schools (%)	
	Peri-implant mucositis	Peri-implantitis
Single unit	9 (90%)	8 (89%)
Edentulous cases - removable	8 (80%)	7 (78%)
Short span bridgework	7 (70%)	7 (78%)
Edentulous cases – fixed	7 (70%)	5 (56%)

Three schools (30%) provided measures of student competencies for non-surgical management of peri-implant mucositis and two schools (22%) provided competencies for peri-implantitis management.

Tables 20 and 21 describes the modes of instrumentation used by dental schools for non-surgical supragingival and subgingival debridement.

Table 20. Types of instruments used by students for non-surgical supragingival debridement of implants (n=10)		
Type of instrument	Number of schools	Percentage
Gold or titanium curettes	6	60%
Ultrasonic with plastic insert tips	6	60%
Graphite curettes	4	40%
Conventional stainless steel curettes	2	20%
Ultrasonic with conventional stainless steel tips	2	20%
Plastic coated scalers	1	10%

Table 21. Types of instruments used by students for non-surgical subgingival debridement of implants (n=9)		
Type of instrument	Number of schools	Percentage
Gold or titanium curettes	8	89%
Ultrasonic instruments	5	56%
Graphite curettes	4	44%
Conventional stainless steel curettes	3	33%

Two out of 14 schools (14%) indicated that they received support from implant companies for the provision of implant training. The companies involved were Dentsply (67%) and 3i Biomet (33%). One school commented that they received resources from the trade for hands on clinical simulation.

Future plans for dental implant training – next 12 months

Seven schools responded when asked whether there were any plans to introduce direct clinical experience in non-surgical therapy for the management of peri-implant diseases (i.e. peri-implant mucositis and peri-implantitis). Only one school stated that they planned to introduce such teaching in the next 12 months.

Current challenges to the provision of implant training

Each dental school was asked what challenges there have been to introducing/developing implant teaching into the dental hygiene and therapy programme. The responses are shown in Table 22.

Table 22. Challenges to the introduction/development of implant teaching into the dental hygiene and therapy programme	
Challenges	Number of schools
Insufficient number of suitable cases	9
Funding	1
Insufficient numbers of suitable trained staff for teaching	1
Lack of available time within existing teaching curricula	1
Overcrowded teaching groups (i.e. too many dental undergraduate students or other trainees on the same rotation)	1

Future predictions for implant teaching – 5 years' time

When asked if there will be clinical requirements relating to non-surgical therapy of peri-implant diseases (i.e peri-implant mucositis and peri-implantitis) for dental hygiene and therapy students within the next five years, seven schools (50%) felt this would be the case, while the other seven (50%) felt that this would not be the case.

4.3 Maintaining peri-implant health: An evaluation of understanding amongst dental hygienists and therapists within Wales, United Kingdom.

Current practice

Completed questionnaires were received from 92 out of 257 (35%) dental hygienists and therapists (DH/Ts) within Wales, United Kingdom. Eighty-five (92%) of the total respondents indicated that providing dental implant care was within the remit of their service.

In order to identify the practice setting, respondents were asked the nature of their practice. Some respondents worked in multiple settings and therefore provided more than one answer. The results are shown in Table 23.

Table 23. Nature of practice (n=85)

Type of practice	Number of respondents	Percentage
Mixed NHS and private	50	53%
Purely private	28	30%
Hospital dental service	8	9%
Community dental service	6	6%
Purely NHS	2	2%

The year of qualification of respondents is shown in Table 24.

Table 24. Year of qualification (n=92)		
Year	Number of respondents	Percentage
1970-1980	10	11%
1981-1990	20	22%
1991-2000	24	26%
2001-2010	18	20%
2011+	20	22%

Forty-six (54%) respondents indicated that the dental setting/s in which they provided dental implant care, offered placement and/or restoration of dental implants to patients. When asked what type of dental care they provided for their implant patients, respondents provided the following responses, shown in Table 25. The two respondents that provided abrasive therapy detailed that they used the air abrasive powder Erythritol.

Table 25. Type of dental implant care provided (n=85)		
Procedure	Number of respondents	Percentage
Oral hygiene instruction	85	100%
Supragingival debridement	83	98%
Subgingival debridement	72	85%
Clinical assessment of peri-implant health	54	64%
Application of topical antimicrobials and/or antiseptics	32	38%
Photodynamic therapy	4	5%
Air abrasive therapy	2	2%

The number of implant patients seen by respondents per month is shown in Table 26.

Table 26. Number of implant patients seen per month (n=84)		
Number of implant patients	Number of respondents	Percentage
1-10	63	75%
11-20	12	14%
21-30	2	2%
>30	7	8%

Respondents were asked how confident they were at providing various procedures relating to peri-implant health maintenance. The replies are shown in Table 27.

Table 27. Confidence levels in provision of procedures relating to peri-implant health (n=85)			
Procedure	Confident	Somewhat confident	Not confident
Clinically assessing dental implants	27%	62%	11%
Instructing patients in methods of plaque control for implants	78%	22%	0%
Providing supragingival debridement of dental implant supported structures	59%	38%	3%
Providing subgingival debridement of dental implant supported structures	37%	45%	19%

Seventy-two (85%) respondents indicated that they scheduled 3-monthly implant maintenance intervals for the majority of their patients, six (7%) respondents scheduled 6-monthly intervals and the remaining seven (8%)

respondents could not provide a definitive answer, stating that their decision varied depending on the patient's needs.

Implant training

Forty-four out of 92 (48%) respondents received dental implant training during their hygiene and therapy training. Twenty-five (57%) indicated that they received theoretical training only, two (4%) received practical training only and seventeen (39%) received both practical and theoretical training.

Seven respondents (16%) felt that they received adequate implant teaching during their training, while thirty-seven (84%) felt that this was inadequate. Of the respondents that felt their teaching was inadequate, twenty-five (67%) indicated that both theoretical and practical aspects were lacking. The remaining twelve (33%) found that the practical aspect only was lacking. Details of which implant subject areas were lacking during their hygiene and therapy training are shown in Table 28.

Table 28. Subject areas that respondents felt were lacking during their hygiene and therapy training (n=37)

Subject area	Number of respondents	Percentage
Subgingival debridement of dental implant supported structures	22	59%
Clinical assessment of dental implants	19	51%
Supragingival debridement of dental implant supported structures	17	46%
Theoretical aspects of restoration of dental implants	12	32%
Instruction on methods of plaque control for implants	10	27%

Respondents that felt their training was inadequate or those that did not receive implant training were asked their opinion of reasons for this. The responses are shown in Table 29.

Table 29. Barriers to implant training (n=44)		
Barriers	Number of respondents	Percentage
Not deemed necessary when I qualified / I qualified before implant treatment was popular	42	95%
Insufficient patients	31	70%
Insufficient time in curriculum	9	20%
School did not feel this was relevant to the programme	4	9%
Availability of teaching staff sufficiently trained to provide implant teaching	1	2%

Further training

Since graduating, 72 out of 92 (78%) respondents stated that they have attended further continuing education courses in implantology. The twenty respondents (22%) that did not attend provided the following reasons as shown in Table 30. One respondent indicated that the location of courses was based mostly in South Wales and this was a barrier for attending.

Table 30. Reasons for not attending further courses in implantology since graduating (n=20)		
Reasons	Number of respondents	Percentage
No available courses	10	50%
Not involved in managing patients with implants	7	35%
Time	5	25%
Cost	4	20%
Location of courses	1	5%
Training obtained with the dentist at work	1	5%

Seventy-six (83%) respondents felt that postgraduate training in the maintenance of dental implants should be obligatory, while sixteen (17%) did not feel this was necessary.

4.4 The provision of dental implants: Current practice amongst university and hospital specialists in restorative dentistry within the UK and Ireland.

Completed questionnaires were received from 41 out of 150 university and hospital specialists in restorative dentistry within the UK and Ireland (27%). Twenty-nine (70%) of the total respondents indicated that they provided implant treatment. All forty-one (100%) respondents indicated that they worked in a university or hospital setting. Tables 31 and 32 show the roles of respondents and the number of years that they have served in this role.

Table 31. Roles of respondents (n=41)

Role	Number of respondents	Percentage
NHS Consultant in Restorative Dentistry	24	59%
Professor of Restorative Dentistry	7	17%
Senior Lecturer	6	14%
Honorary Consultant in Restorative Dentistry	2	5%
Professor of Endodontology	1	2%
Reader	1	2%

Table 32. Number of years in current role (n=39)

Years	Number of respondents	Percentage
0-5	14	36%
6-10	7	18%
11-15	7	18%
16-20	7	18%
21-25	2	5%
26+	2	5%

Respondents were asked whether they had any sub-specialty interests. Table 33 shows the list of replies.

Table 33. Sub-specialty interest (n=60)		
Subspecialty	Number of respondents	Percentage
No sub-specialty interest	4	7%
Fixed and removable prosthodontics	22	37%
Periodontology	13	22%
Endodontics	15	25%
Trauma	2	3%
Head and neck oncology	1	2%
Pain and anxiety control	1	2%
Developmental dental abnormalities	1	2%
Toothwear management	1	2%

Respondents that worked in the NHS hospital setting, were asked to report on the groups that qualified for dental implants. The responses are shown in Table 34. ‘Other’ groups included ‘selective special care cases’ as stated by one respondent and ‘significant failure of complete dentures’ by another respondent. Otherwise, one other respondent stated that only head and neck malignancy would qualify for dental implant treatment. Additionally, a further respondent stated that there was a ‘limited implant service for denture intolerance’.

Table 34. Groups that qualify for dental implant treatment within the NHS (n=41)		
Group type	Number of respondents	Percentage
Hypodontia	39	95%
Malignancy	38	93%
Oro-facial trauma	35	85%
Cleft	34	83%
Denture intolerance	26	63%
Other dental developmental abnormalities (e.g. amelogenesis imperfecta)	23	56%
Gagging	14	34%
Other	2	5%

Nineteen (66%) out of the 29 respondents that performed implant treatment, provided implant treatment within their NHS hospital or university setting only. Nine (31%) performed implant treatment both in a private and hospital or university setting, while one (3%) respondent performed implant treatment solely under private contract.

Results on the type of implant system most commonly used by respondents are shown in Table 35.

Table 35. Most commonly used implant system		
Implant system	Number of respondents	Percentage
Dentsply	11	38%
Nobel Biocare	10	35%
Straumann	5	17%
Neoss	2	7%
Southern Dental Implants	1	3%

Twenty-two (76%) respondents indicated that they placed implants. When asked how many implants they placed per year, the replies are shown in Table 36.

Table 36. Number of implants placed per year (n=22)		
Years	Number of respondents	Percentage
0-10	4	18%
11-20	6	27%
21-30	0	0%
31-40	4	18%
41-50	1	5%
51-60	0	0%
61-70	2	9%
71-80	2	9%
81-90	0	0%
91-100	2	9%
101+	1	5%

Twenty-nine (100%) respondents indicated that they restored implants. When asked how many patients they restored implants for per year, the replies are shown in Table 37.

Table 37. Number of patients provided with implant restorations per year (n=29)		
Years	Number of respondents	Percentage
0-10	4	14%
11-20	9	31%
21-30	7	24%
31-40	5	17%
41-50	2	7%
51-60	0	0%
61-70	0	0%
71-80	0	0%
81-90	0	0%
91-100	0	0%
101+	2	7%

Twenty-three (79%) respondents stated that they worked with oral surgeons (OS) or oral and maxillofacial surgeons (OMFS) as part of the implant team. The procedures that they would ask the OS or OMFS teams to undertake were bone grafting (43%), sinus lifting (35%) and zygomatic implants (22%). When respondents were asked whether they performed any of these procedures themselves, twenty (56%) responded that they did not. Of those that did, seven (19%) undertook sinus lifting, eight (22%) bone grafting and one (3%) performed zygomatic implants. One respondent commented that they would place the bone graft whilst the OS or OMFS teams would harvest it. Another respondent indicated that they would undertake sinus lifting and bone grafting under local anesthetic without requiring the OS or OMFS teams. However, where general anaesthetic cases were concerned, these were jointly planned and carried out together with the OS or OMFS teams.

Respondents were asked to assess the level of importance of various medical and dental factors on patient selection for implant placement. The results are shown in Tables 38 and 39.

Table 38. Views of respondents on medical factors and their level of importance in patient selection for implant placement (n=29)			
Medical factor	Very important	Quite important	Not important
Irradiation	100%	0%	0%
Smoking	90%	3%	0%
Bisphosphonates	86%	14%	0%
Immunocompromised	45%	55%	0%
Immunosuppression	38%	59%	3%
Diabetes	17%	79%	3%
Endocarditis	14%	48%	38%
Osteoporosis	10%	69%	21%
Age	7%	24%	69%
Stress	0%	21%	79%

One respondent stated that they did not regard any of the above medical factors as absolute contraindications for implant placement. Other respondents indicated that bleeding disorders, alcohol dependency and poor wound healing were additional important medical factors to consider.

Table 39. Views of respondents on dental factors and their level of importance in patient selection for implant placement (n=29)			
Dental factor	Very important	Quite important	Not important
Untreated periodontitis	93%	7%	0%
Poor oral hygiene	86%	14%	0%
Uncontrolled caries	79%	17%	3%
Intraocclusal space	75%	21%	3%
Parafunction	69%	31%	0%
Occlusal relationship	66%	31%	3%
Presence of untreated endodontic lesions	59%	38%	3%
Mucosal disease	38%	59%	3%

Respondents stated that failure of previous dental implants, oral access, denture adaptation and tolerance, angulation of adjacent teeth and patient expectations were additional important dental factors to consider. One respondent elucidated that the importance of mucosal disease was dependent on the condition. For example, they considered a flap reconstruction potentially very important as opposed to lichen planus, which was considered not important.

Chapter 5: Discussion

Chapter 5: Discussion

5.1 Teaching of implant dentistry in undergraduate dental schools in the United Kingdom and Ireland

This survey sought to determine the current status of implant education in undergraduate schools across the UK and Ireland. An electronic survey provided a simple means of data collection and in this survey the response rate of 88% was much higher in comparison to other dental questionnaires and deemed favourable (Tan and Burke 1997). The overall results show a notable and promising improvement in the amount of implant education across undergraduate dental schools since previous surveys (Young et al. 1999; Addy et al. 2008). It is encouraging to see that all responding dental schools provided implant training for their undergraduate students and acknowledged that there were curriculum requirements to provide such training. This is a significant development from 2008 whereby only 87% of schools provided implant training and 53% stated that there were curriculum requirements (Addy et al. 2008). It is likely that the introduction of the GDC's publication '*Preparing for Dental Practice – Dental Learning Outcomes for Registration'* updated in 2015 may have facilitated this change (General Dental Council 2015b). This document was preceded by the publications '*First Five Years'* and '*Developing the Dental Team'* and sets out more specific learning outcomes for the implant component in dental undergraduate programmes. The improvements in implant education will further help newly graduated dentists to meet the requirements of this document.

Greater exposure to implant training at an undergraduate level leads to an increased likelihood of students taking on postgraduate implant training after qualification (Huebner 2002; Maalhagh-Fard et al. 2002). Dentists that choose to provide implant restoration or placement must however be competent at performing these procedures. To ensure this is the case, postgraduate training requirements published in 2012 by the Faculty of General Dental Practice (UK) and the Association of Dental

Implantology provide the standards expected of dentists to perform safe implant treatment. Although, the GDC does not expect dentists to place and restore implants, it is a requirement that they are able to communicate to patients the range of implant treatment options, their risks, impacts, outcomes and limitations (General Dental Council 2015b). In addition, there is the issue of peri-implant diseases, which was discussed at the House of Lords by Baroness Gardner of Parkes in July 2014 (Hansard 2014). With the prevalence of peri-implant mucositis and peri-implantitis being so high, it is essential that newly qualified dentists need to be competent at clinically assessing peri-implant health and preventing and managing peri-implant diseases. There is therefore the need to ensure that structured and comprehensive implant training both at an undergraduate/trainee and postgraduate level is implemented to guarantee patient safety and minimise the risk regarding claims and complaints against dental professionals.

Most schools provided implant training for their undergraduates during the 4th and 5th years, with some schools starting in 3rd year, which would be expected. There would be opportunity in this respect for students to first develop the necessary core knowledge and skills in dentistry prior to approaching a subject that is more complex like implant dentistry. Interestingly, a reduction in multi-disciplinary teaching was observed, with schools reporting that restorative dentistry staff predominantly provided the implant teaching (63%) compared to previous findings where most teaching was jointly provided by restorative dentistry and oral surgery specialties (61%). Without further information, it is difficult to speculate on the reasons for this change however this would be worthwhile investigating given that a multi-disciplinary approach in teaching can potentially bring benefit to students understanding of successful dental implant therapy.

Theory and practical study are both important aspects in the acquisition of skills and knowledge necessary for students to fulfill the learning outcomes of implant dentistry. A number of methods have been

employed to deliver theoretical teaching and there appears to be no difference in the effectiveness of one method over another (Gopinath and Nallaswamy 2017). Where practical skills are concerned, phantom head hands-on training provides a safe and controlled environment for students to develop and demonstrate competence in practical procedures prior to treating patients. Previous findings revealed that limited implant teaching was available for undergraduate students and this was delivered mainly in didactic or lecture-based settings with some phantom head hands-on training only (Addy et al. 2008). The current results show a significant improvement in this area with the majority of schools now providing teaching in the form of phantom head training (88%) and lectures (81%). Although these teaching modalities offer an excellent means for students to develop their clinical knowledge and skills, it cannot substitute the broader depth of clinical learning that students can achieve by direct clinical exposure to patients and dental implants in a clinical setting. The results of the survey showed that most dental schools offered students the opportunity to observe live implant surgery (75% vs 33% in 2008) and restorative implant procedures (63% vs 46% in 2008) which is very encouraging given that the majority did not provide this experience in the past (Addy et al. 2008). Another encouraging observation is the significant increase in the number of schools that offered students direct clinical experience in treatment planning (81% vs 46% in 2008). In a climate where UK litigation is rising, especially in implant dentistry, such experience is invaluable for students to appreciate first hand, not just the importance of treatment planning but also aspects such as obtaining informed consent and patient communication. These factors if performed poorly, have been shown to result in patient claims and complaints (Dental Protection 2015).

Despite the improvement in the overall amount of implant teaching, the level of direct clinical experience that dental schools provide students in restoring and placing dental implants remains low and similar to previous findings (Addy et al. 2008). One respondent raised an interesting argument suggesting that there would be little benefit for students to learn

how to do a specialist procedure that requires a multitude of surgical and restorative skills, which students are then unlikely to put into place for at least 2 years post-graduation and as a result, completely de-skill. Instead, it was felt that at this point, it would be more appropriate for the novice dentist to learn and apply such skills properly in a systematic manner. Contrary to this opinion, studies have however shown that dentists are more likely to incorporate implant dentistry into their clinical practice if they received clinical experience during their undergraduate training compared to dentists that did not (Huebner 2002; Maalhagh-Fard et al. 2002). It is therefore in the author's view that dental schools should strive to provide students with clinical experience in implant procedures as this can only serve to improve and enhance students training experience and result in producing dental graduates that are more proficient and willing to manage implant cases in their clinical practice.

When asked about future trends, the majority of dental schools anticipated that there would be clinical requirements relating to implant placement and restoration for undergraduates in five years' time. This may be an indication that most dental schools are aware of developments that are currently taking place in other dental schools worldwide. If this is the case it may explain why they foresee such changes occurring so as to keep up with global trends. In contrast to UK and Irish dental schools, the majority of dental schools in Europe, U.S. and Canada already offer their students clinical experience of restoring dental implants and surgical implant placement. Whilst 31% of responding schools in the UK and Ireland stated undergraduates gained clinical experience of restoring dental implants, surveys found that students in 75% and 98% of responding schools in Europe and North America respectively received experience of restoring implants (Addy et al. 2008; Koole et al. 2014; Kihara et al. 2017). Only one school in the current survey offered clinical experience of surgically placing implants whilst in Europe and North America, 64% and 89% of responding schools respectively provided clinical experience in surgical placement of implants. These findings raise similar concerns to previous studies that dental implant education in the

UK and Ireland is failing to keep up with other dental schools worldwide and there is a particular need to improve the amount of clinical exposure that students receive for dental implant procedures (Addy et al. 2008; Blum et al. 2008). Certainly, incorporation of this type and level of training is challenging, however it is essential that dental school curricula keep pace with current developments and remain evidence-based.

Most schools cited funding, lack of available time within existing teaching curricula and staff training as the main challenges to improving/increasing teaching of implant dentistry and this is commonly reported by other dental schools worldwide (Atashrazm et al. 2011). Support from implant companies can help reduce the funding pressures associated with incorporating implant training into the existing curricula. Ninety-four percent of schools indicated that they received support from implant companies, which is a significant improvement from previous data (60%) (Addy et al. 2008). Most schools (93%) received simulated models for surgery and restoration, however, less than half of responding schools received implant or restorative components and only 13% received laboratory-funding support. It is apparent that dental schools have established stronger ties with implant companies to increase their level of funding since the last survey. In order for additional improvements in future training to be achieved, with consideration that funding is a common barrier, it may be necessary for dental schools to seek further funding support from implant companies. Obtaining sponsored implant or restorative components may alleviate financial pressures related to provision of clinical implant training for example. Curriculum congestion can present a barrier to introducing implant training and often the reduction of other clinical components in the curriculum is required. This survey revealed that 44% percent of schools anticipated a decrease in the teaching of fixed conventional bridgework to accommodate increased implant dentistry teaching over the next five years. It is clear that integrating a high quality implant programme into the undergraduate curricula is not a simple task. Dental schools may therefore benefit from

reviewing existing teaching models from schools that have successfully integrated implant dentistry into their curriculum.

The use of dental implants is rising and it is inevitable that dentists, even those that do not place or restore implants, will play a greater role in discussing implant treatment options and providing care for implant patients. Educational providers therefore have an ever-increasing responsibility to ensure that new dental graduates are sufficiently trained to perform these procedures. Despite the GDC's publication on undergraduate curriculum requirements for implant dentistry, it is evident that the level of coverage of this subject still varies between dental schools, with some schools providing students significantly more clinical experience in implant procedures than others for example. Perhaps there is a need for more rigidity in these requirements in order to standardise implant teaching across dental undergraduate schools. Nevertheless, it is hoped that the findings of this survey will help inform educational providers of the current teaching trends so as to promote standardisation, improvement and development of the undergraduate implant curricula across dental schools in the UK and Ireland.

5.2 Teaching of implant dentistry in dental hygiene and therapy schools in the United Kingdom and Ireland

In the UK, it has been acknowledged that effective use of skill mix in dental teams is part of the solution to meeting the nations changing oral healthcare needs and this has resulted in a drive to restructure the UK dental workforce. The GDC's document '*Corporate Strategy 2016-2019'* sets out plans for dental care professionals (DCPs) to play a greater role in the provision of dental care (General Dental Council 2015a). Part of the strategy includes dental hygienists and therapists (DH/Ts) being granted prescribing powers, which has now been implemented by the GDC and known as 'Direct Access', however this has been slow to arrive due mainly to legislative restrictions and NHS regulations (General Dental Council 2015a). Direct Access came into effect from 1st May 2013, and enables DH/Ts to carry out their full scope of practice without needing a prescription from a dentist (General Dental Council 2013). At present, this is optional and those who choose to take advantage of this opportunity must be sure that they are trained and competent to carry out any of the tasks they undertake and indemnified to do so (British Society of Dental Hygiene and Therapy 2016). In the future, it is likely that more DH/Ts, if not all, will take up the opportunity of Direct Access. There is the anticipation that these changes will allow dentists to concentrate on complex procedures while DH/Ts for example, can deliver preventive, educational and general health promotion services (Cowpe et al. 2013; General Dental Council 2015a). Findings from Evans et al. (2007) showed that 43% of clinical time is taken up by activities that could be undertaken by DH/Ts. If prescribing powers were taken up by dental therapists, then this could result in 58% of clinical time being provided by dental therapists. With the forecast that demand for DH/Ts will rise and exceed supply in addition to DH/Ts playing a greater role in the dental workforce, it is more than likely that this will have an impact on the training and education requirements of DH/Ts (Centre for Workforce Intelligence 2014; General Dental Council 2015a).

In the context of implant dentistry, considering the increasing popularity of dental implants, which is reportedly worth a global market value of $3.5 billion Swiss Francs (approximately £2.7 billion) in 2016 (Straumann Group 2016), and the changes in dental workforce structure, it is foreseeable that DH/Ts will become more exposed to the issues of peri-implant maintenance due to an increasing volume of patients and potentially if more DH/Ts take up Direct Access, they will also be responsible for diagnosis and treatment planning of implant patients. Dental hygiene and therapy schools (DHTS) therefore have an increasing responsibility to ensure that students receive the necessary implant training to best prepare them for such future changes. Knowledge on the current status of implant education will help inform various organisations, specifically educational providers, regulators policy makers as to whether curriculum requirements set by the GDC are adequate and currently being met. This information will provide guidance for any potential future changes and developments that are required in implant training and education for DH/T students. Currently there is limited data on the teaching trends of implant dentistry in DHTS across the UK and Ireland and this survey therefore aimed to determine the status of current implant education. An electronic survey provided a simple means of data collection, however, due to a poor response rate, follow-up postal questionnaires were subsequently distributed. The final response rate of 60% was still slightly lower in comparison to other dental questionnaires. It is therefore accepted that interpretation of survey data should take into account this limitation (Tan and Burke 1997).

It is positive to see that all responding DHTS provided implant training for their students and recognised that there were curriculum requirements to provide such training. The GDC's publication '*Preparing for Dental Practice – Dental Learning Outcomes for Registration'* expects DH/Ts to have the competence to 'describe the risks related to dental implant therapy and manage the health of peri-implant tissues' (General Dental Council 2015b). Most schools provided implant training for their undergraduates during the 2nd year, with some schools providing this in

the 1st and 3rd years, which would be expected. There would be opportunity in this respect for students to develop the necessary core knowledge and skills prior to approaching a subject that is more complex like implant dentistry. Primarily the school of hygiene and therapy department (56%) provided implant teaching with some involvement by the restorative (39%) and oral and maxillofacial surgery specialties (6%). A multidisciplinary approach in teaching should be encouraged to enhance students learning and understanding of the subject.

Theory and practical study are both important aspects for the acquisition of skills and knowledge necessary for students to fulfill the DH/T learning outcomes in implant dentistry. A number of methods have been employed to deliver theoretical teaching and there appears to be no difference in the effectiveness of one method over another (Gopinath and Nallaswamy 2017). Where practical skills are concerned, phantom head hands-on training provides a safe and controlled environment for students to develop and demonstrate competence in practical procedures prior to treating patients. Findings revealed that implant teaching was delivered mainly in lecture-based (100%) and phantom head hands-on (71%) settings, both of which are considered effective pre-clinical teaching modalities. Most schools, but not all, covered core topics in their implant programme which included peri-implant maintenance (93%), implant surgery (86%), treatment planning (71%) and implant restoration (71%). To fulfil the GDC's curriculum requirements however, it would seem reasonable to expect every school to cover these topics. Clinical learning is best achieved by direct clinical exposure to patients and dental implants in a clinical setting. Only very few schools offered students the opportunity to observe live implant surgery (14%) and restorative implant procedures (21%). Observing implant procedures allow students to see first hand the complexities associated with implant placement and restoration especially given that these procedures are outwith the scope of DH/T practice. Certainly, if students are to fully appreciate the impact these procedures can have on the outcome of treatment and future

implant maintenance, it would seem necessary for all schools to provide observation experience for their students.

Although the majority of schools provided students with direct clinical experience in procedures related to ‘managing the health of peri-implant tissues’ (GDC curriculum requirement), some schools stated that not all students were guaranteed to receive such experience. Preventive care, stabilisation of the periodontal condition prior to implant placement and non-surgical management of peri-implant diseases encompass the key clinical components of managing the health of peri-implant tissues. Fewer schools (64%) offered clinical experience in non-surgical management of peri-implantitis compared to the other clinical components. The cases that were treated included mostly single unit and edentulous removable cases. A limited number of schools provided measures of competencies for the management of peri-implant diseases. The most common instruments used for non-surgical supra- and sub-gingival debridement were gold or titanium curettes, ultrasonic with plastic insert tips and graphite curettes. Ultrasonic with metal tips and mechanical instrumentation using materials harder than titanium may damage the implant surface and make it susceptible to biofilm formation thereby increasing susceptibility to peri-implantitis (Matarasso et al. 1996). Guidelines published by the Association of Dental Implantology (2012) recommends the use of titanium scalers for mechanical debridement and advises against the use of plastic instruments due to reduced efficiency in removing subgingival plaque from implant surfaces. Interestingly, a small number of schools indicated that they used plastic coated scalers, stainless steel curettes and ultrasonic devices with stainless steel tips for mechanical debridement of implants.

Incorporating additional implant teaching into the curricula is challenging, however it is essential that DHTS keep pace with current developments and remain evidence-based. The overriding challenge faced by most schools was the lack of suitable cases which is an interesting contrast to dental undergraduate schools whereby funding, lack of available time and

staff training were the main challenges. Increasing the number of cases for the implant programme may be overcome by establishing stronger relationships with other departments that provide implant treatment or receive implant referrals. There may be scope to request cases from referring practitioners or otherwise, arrange for students to treat implant patients in pairs to compensate for the shortfall in patients. Although, only one school stated that funding was a challenge, there is likelihood that in the future, increasing demands to provide implant training may place funding pressures on schools. Currently, only two schools received support from implant companies for the provision of implant training. Schools should therefore seek to establish stronger ties with implant manufacturers who can play an important role in increasing the quality of implant training through provision of educational resources.

Despite the majority of schools providing implant training, the overall findings show that further development and improvement of implant teaching in DHTS is required. There is particular concern that not every school is providing students with direct clinical experience in the clinical components required to be competent at 'managing the health of peri-implant tissues'. It is interesting that there was divided opinion amongst schools when asked to predict if there will be clinical requirements relating to non-surgical therapy of peri-implant disease for students in 5 years' time. Given the increasing trends in the use of implants, it is in the author's opinion that such requirements should already be an essential requisite in the implant curricula. There is also the worry that not every student is guaranteed to receive direct clinical experience in implant training, which can be considered a fundamental component for meeting the GDC's curriculum requirements.

It is hoped that the findings of this survey will help inform educational providers of the current teaching trends so as to promote standardisation, improvement and development of the implant curricula across DHTS in the UK and Ireland. With an increasing number of implant patients, it may be that in the future, peri-implant maintenance could be as common as

periodontal maintenance and there is an urgent need for schools to accommodate further implant training into their programmes and introduce measures of competencies to ensure that newly qualified DH/Ts are competent to manage the health of peri-implant tissues. To the author's knowledge, this is the first survey to focus on this particular topic and there are no previous studies or data to compare with other countries. The results shown in this survey are vastly different from the findings relating to implant education for dental undergraduate students. Therefore it is necessary that this survey be repeated in 5 years time to assess implant education trends specific to dental hygiene and therapy training in order to determine whether further improvements to implant education within DHTS are necessary to meet the expectations of the GDC. Collection of this information may also help determine whether more patients are receiving dental implants and if the needs of the population are increasing.

5.3 Maintaining peri-implant health: An evaluation of understanding amongst dental hygienists and therapists within Wales, United Kingdom.

The GDC expects dental therapists and hygienists in the UK to be competent at maintaining peri-implant health and describing the risks related to dental implant therapy (General Dental Council 2015b). Limited data is presently available on the DH/T workforce in the UK and worldwide relating to provision of implant care and the current level of implant education. Collection of such information is useful to assist educational providers, policy makers and various other organisations as to the improvements and developments required for this sector of the dental team. Since 2008, the numbers of DH/Ts in the UK have steadily been increasing and this is expected to continue to rise to accommodate plans to increase utilisation of skill mix in dentistry (Department of Workforce Intelligence 2014). It is likely that in the future, DH/Ts will have greater responsibilities towards the care of patients as they will be exposed to larger volumes of patients (General Dental Council 2015a). In addition, more DH/Ts, if not all, may take up the opportunity to carry out their full scope of practice without needing a prescription from a dentist and this is known as 'Direct Access', which was implemented by the GDC on the 1st May 2013 (General Dental Council 2013). Such prescribing powers are currently optional and have been slow to take effect due mainly to legislative restrictions and NHS regulations (General Dental Council 2015a). Relevant to implant dentistry, it is concerning that litigation in the UK has increased, notably involving peri-implantitis cases (Dental Protection 2015). Given the changes in the dental team structure, DH/Ts are likely to take on a larger role in the maintenance of implant patients and may therefore be at greater risk to issues such as claims and complaints. There is therefore the ever-increasing need to ensure that the current DH/T workforce have the necessary skills and knowledge to provide safe implant care to patients as well as to establish whether developments and improvements in support and education is required.

Wales has a unique position in the UK as it is served by one dental teaching hospital and school located at its capital, Cardiff. It is fortunate that data on DH/Ts is held centrally within the Postgraduate Department of Medical and Dental Education. This allowed the author an opportunity to investigate, as a whole, the knowledge and practicing methods of implant care among the nation's DH/Ts. An electronic survey provided a simple means of data collection, however, due to a poor response rate, follow-up questionnaires were subsequently distributed at a study day for DH/Ts in Wales. The final response rate of 35% was low in comparison to other dental questionnaires (Tan and Burke 1997). It is possible that the topic being addressed may be complex and consequently not a priority to many participants. It is therefore accepted that interpretation of survey data should take into account the low number of respondents and the risk of participant bias. Data from 92 DH/Ts does however provide useful information on the implant practice patterns and knowledge amongst this group of dental care professionals.

The majority of DH/Ts that provided implant care worked in mixed NHS and private (53%) or purely private (30%) dental settings, with some respondents indicating that they worked in multiple settings. A previous survey suggests that this trend is not specific to those providing implant care, whereby as a whole, 59% and 47% of dental hygienists worked in mixed NHS and private and purely private dental settings respectively and it was frequent for dental hygienists to work in multiple settings (Gibbons et al. 2001). Sixty-eight percent of respondents qualified after 1990 and provided a useful insight into the views of more recently qualified DH/Ts, which is relevant to help inform current needs and development in support and training.

Ninety-two percent of respondents stated that dental implant care was within the remit of their service, which is encouraging to see. In relation to volume of patients, 75% of respondents treated 1 to 10 implant patients per month. It was anticipated that DH/Ts working in dental settings that provided dental implant placement and/or restoration formed a large

majority of those providing implant care. Interestingly, this was not the case and only 54% of respondents provided implant care in such settings. Another interesting finding is that 29% of DH/Ts working in purely private practice stated that their practice did not offer implant placement or restoration. These results indicate that provision of implant care is common amongst DH/Ts across all types of practice settings, even if the practice setting does not provide implant placement or restoration. In addition, not all private practices offer implant placement and restoration, however DH/Ts within these practices are providing implant care. Eighty-five percent of respondents indicated that they scheduled 3-monthly implant maintenance intervals for the majority of their patients. At present there are no fixed guidelines on recall intervals, however the international working group suggests that this is likely to be between 3 to 6 months depending on the patients risk profile (Heitz-Mayfield et al. 2014).

Preventive care, monitoring and diagnosing peri-implant conditions and delivering professional mechanical plaque removal can be considered the key clinical components that are required to maintain peri-implant health (Ramanauskaite and Tervonen 2016). DH/Ts are therefore expected to be competent at performing such procedures to meet the GDC's requirements. All respondents stated that they performed oral hygiene instruction, while 98% performed supragingival debridement, 85% subgingival debridement and 64% clinical assessment of peri-implant health. It is encouraging to see that all DH/Ts provided oral hygiene instruction, which is an important part of preventive care. There is the concern however that not all respondents provided non-surgical debridement therapy or performed clinical assessment of peri-implant health. These findings indicate that DH/Ts are falling short of the implant treatment that they are expected to provide. When respondents were asked how confident they were at clinically assessing dental implants and instructing patients in methods of plaque control for implants, it was alarming to find that only 27% and 78% respectively felt confident. It was also worrying to find that only 59% and 37% of respondents felt confident in providing supragingival and subgingival debridement of dental implant

supported structures. These findings highlight a deficiency in implant education and training amongst DH/Ts in Wales, and there is a need to address this issue urgently so as to ensure that patients are receiving the appropriate implant care.

Studies have shown that a lower level of implant training at dental undergraduate school can negatively influence the practicing patterns of newly qualified dentists (Huebner 2002; Maalhagh-Fard et al. 2002). This concept can similarly be applied to DH/Ts, whereby lack of implant teaching during dental hygiene and therapy training may explain the current deficiencies in implant education, training and implant care provision by DH/Ts in Wales. Only 48% of respondents stated that they received dental implant teaching during their hygiene and therapy training, of which 64% felt that their training was inadequate. Aspects that were lacking included both theoretical and practical components, with 57% indicating that they received theoretical training only. The most commonly cited deficient subject areas were non-surgical debridement of implants as well as clinical assessment of dental implants. Some respondents also cited oral hygiene instruction and theoretical aspects of restoration on dental implants to be deficient. The main reasons for the lack of implant training included ‘not deemed necessary when qualifying’, ‘qualified before implant treatment was popular’ and ‘insufficient patients’. A survey by Ward et al. (2012) similarly found that over half of responding dental hygienists in the U.S. did not receive formal training on dental implant maintenance and it was suggested that implants may not have been part of their curriculum at that time. A summary of the above findings may explain the potential reasons for the low level of confidence amongst respondents in performing the range of procedures expected for implant maintenance, an issue that requires urgent attention.

Supervised and focused continuing education improves clinical skills and knowledge and helps delay declining clinical competence. The majority of DH/Ts (78%) stated that they had attended further education courses in implantology, which is reassuring to note. The main reasons given by

respondents that did not attend courses included ‘no available courses’ (50%) and ‘not involved in managing patients with implants’ (35%). There is the concern that respondents are not able to gain access to implant courses. Educational providers, particularly the postgraduate deanery, should therefore review the availability and demand of implant DH/T courses and increase the numbers as required. It is encouraging to report that the majority of DH/Ts (83%) felt that further continuing education courses in implantology should be obligatory. Given the direction that the dental workforce is heading and the increasing popularity of implants, DH/Ts will be first in line, if not already, for providing peri-implant maintenance. It is therefore essential that measures be put into place to ensure DH/Ts receive the necessary support to be sufficiently trained to deliver safe implant care to patients. Based on the opinions of respondents in this survey therefore, the overall results highlight that there is an urgent need to (1) review, improve and develop implant teaching in DHTS and (2) review and implement further postgraduate education and teaching support, such as courses, in implant maintenance for the DH/T workforce in Wales.

5.4 The provision of dental implants: Current practice amongst university and hospital specialists in restorative dentistry within the UK and Ireland.

NHS-funded dental implants are provided in NHS secondary care settings within restorative dentistry or OS/OMFS departments. Restorative specialists are considered ideal to lead the implant team as they provide the requisite skill mix for such a role but depending on local arrangements this may not always be possible (Royal College of Surgeons of England 2012). Due to demand outweighing the resources available, dental implant treatment within the NHS is often limited to specific high priority groups via locally agreed acceptance criteria (Andrews et al. 2010). Guidelines by the Royal College of Surgeons of England (RCSE) were published in 1997, and updated in 2012, to assist commissioners of clinical dental services to make an informed assessment of patients considered suitable for treatment for NHS-funded dental implants. Previous data showed a marked variation in the number of patients treated with dental implants within UK hospitals (Butterworth et al. 2001). With the growing demand for dental implants, knowledge of current implant provision amongst university and hospital specialists and their selection criteria would provide useful information to help guide future changes and developments, however recent data is currently lacking. This survey therefore sought to determine current implant practice amongst university and hospital specialists in restorative dentistry within the UK and Ireland and their opinions relating to criteria for implant treatment. An electronic survey provided a simple means of data collection and in this survey the response rate of 27% was much lower in comparison to other dental questionnaires (Tan and Burke 1997). It is possible that the topic being addressed may not have been a priority to many participants. It is therefore accepted that interpretation of survey data should take into account the low number of respondents and the risk of participant bias. Data from 41 specialists does however provide useful information on the implant provision trends and opinions on selection criteria within this group.

Seventy percent of respondents provided implant treatment and the majority worked as NHS consultants in restorative dentistry, serving 0 to 5 years in their current role. Those that provided implant treatment most commonly cited fixed and removable prosthodontics as their sub-specialty interest (36%), which can be expected given that this subject area is closely associated to work related to implant placement and restoration. Previous findings from a survey by Butterworth et al. (2001) showed similar results, however a greater proportion provided implant treatment within this group compared to the previous survey (70% vs 50% in 2001). Acceptance criteria for NHS-funded dental implant treatment is determined locally and based on a variety of factors such as the needs of the local population and funding availability. Hypodontia, malignancy, oro-facial trauma and cleft were the most frequently stated groups to qualify for NHS-funded dental implants. Interestingly, findings from a previous survey revealed that denture intolerance constituted the greatest caseload for implant treatment in 2001 (Butterworth et al. 2001). This suggests that either a decline in the demand for implant treatment has occurred in this group or more likely that there has been a shift in prioritisation of implant service delivery towards other groups.

Of the respondents that provided implant treatment, 76% percent placed implants, while all respondents restored implants. Sixty-six percent performed implant treatment under the NHS hospital setting only, with the majority placing between 11-20 implants and restoring implants for 11 to 20 patients per year. Two respondents placed greater than 90 implants per year, while one restored implants for more than 100 patients per year. Thirty-one percent of respondents performed implant treatment both in private and hospital settings, the amount of implants placed varied, ranging from 0-10 up to 100 per year, with the majority (44%) restoring implants for 21 to 30 patients per year. In this group, one respondent restored implants for greater than 100 patients. The overall findings show that there is a large variation in the number of patients treated by each respondent annually.

Due to an increase in demand for dental implants, the global dental implant market has steadily grown with annual sales of approximately $3.5 billion Swiss Francs (approximately £2.7 billion) reported in 2016 (Straumann Group 2016). Europe remains the strongest region and in combination with North America account for approximately three quarters of the global market value. The Asian dental implant market has also rapidly grown and is increasing twice as fast as North America. This extremely profitable industry has naturally resulted in strong competition between numerous dental implant manufacturers. Straumann, Nobel Biocare and Dentsply are examples of established and well-known implant systems that have demonstrated high predictability and high survival rates with comparable outcomes (Eckert et al. 2005). Previous data in 2001 found that the Branemark system (Nobel Biocare) was the most commonly used system by restorative consultants in the UK (Butterworth et al. 2001). In this survey, the results showed that Denstply (38%) and Nobel Biocare (35%) were the most commonly used implant systems. The reasons for the choice of dental implant system was not investigated in this study, however it can be assumed that factors including cost, ease in use and handling, operator preference, quality of service and predictability of the product would have influenced the respondents choice.

Where patients are missing considerable hard and soft tissues and teeth, involvement of OS and OMFS teams may be required especially if the implant treatment necessitates procedures that are outwith the scope or expertise of the restorative dentist. The concept of multidisciplinary team working is highly recommended in complex cases as advocated by several guidelines to ensure that patients receive the best implant treatment planning and management possible (Gotfredsen et al. 2008; Royal College of Surgeons of England 2012; The Faculty of General Dental Practice UK 2012). It is therefore encouraging to note that the majority of respondents (79%) worked with OS or OMFS specialties as part of the implant team. The procedures that respondents requested OS

and OMFS teams to undertake were bone grafting (43%), sinus lifting (35%) and zygomatic implants (22%). Only a minority of respondents (19%) stated that they performed such procedures themselves.

Risk factors that may negatively impact on the outcome of implant treatment must be considered and discussed with patients for the purpose of obtaining informed consent and to minimise failure of treatment. The RCSE guidelines include the relevant medical, social and dental factors that should be considered prior to implant provision. Respondents were asked their opinion on the relevance of such factors and their influence on patient selection for implant treatment. In relation to medical and social factors, there was strong agreement on the importance of irradiation, smoking and bisphosphonates in influencing patient selection for implants. Immunocompromised, immunosuppressed, diabetes, endocarditis and osteoporosis were considered quite important factors but not as important as those previously mentioned. Age and stress were rated as the least important of the medical factors. With regards to age, it can only be assumed that respondents were referring to the upper age limit when answering the questionnaire, as provision of implants in young patients when growth is incomplete would be considered a contraindication to implant placement (Royal College of Surgeons of England 2012). The previous survey showed similar findings, however, the majority of respondents also ranked psychiatric illness as ‘very important’ (Butterworth et al. 2001). In this survey, psychiatric illness was unintentionally omitted from the questionnaire, but based on these previous findings, it is assumed that this factor would have ranked as ‘very important’ too. In relation to dental factors, there was strong agreement that presence of untreated periodontitis, poor oral hygiene, uncontrolled caries and interocclusal space were important factors that would contra-indicate implant placement. Similarly, these findings were comparable to previous data (Butterworth et al. 2001). Parafunction, occlusal relationship, presence of untreated endodontic lesions and mucosal disease were considered important but not as high as those previously mentioned.

In summary of the findings, it is encouraging to note that the majority of respondents undertake a multidisciplinary approach with implant treatment where necessary. There is otherwise general agreement about the factors that were considered important when selecting patients for implant treatment. The results also highlight that there is a difference in the number of implant patients treated by each respondent annually. Without further information, it is difficult to ascertain the reasons for this variation, however it can be assumed that factors such as funding and clinician availability may play a role in this variation. NHS-funded implant treatment is limited to specific groups, most likely due to resource limitations. In addition, prioritisation of patient groups varied between different units. There is the concern that rising demand for implant treatment and increasing NHS funding pressures may mean that prioritisation of patient groups could become even more challenging than it already is. In enabling comparison to current implant practice trends and opinions on implant selection criteria, it is hoped that the results of this survey may help guide future changes and developments in implant provision individually, locally or nationally for those involved in dental implant provision, particularly NHS implant provider units and university and hospital specialists in restorative dentistry.

5.5 Overall discussion

Dental implants have become an integral treatment option for the replacement of missing teeth and this has allowed dentists to provide improved outcomes, particularly in complex cases whereby success with conventional treatment may not be possible. Implant dentistry is rapidly evolving with continual advancement in technologies and as such, it is important for those involved in implant care to keep abreast of current developments. Educational providers, regulators and various organisations therefore have the responsibility to ensure that the dental team are adequately trained to provide safe implant care to patients. Health authorities and NHS provider units otherwise have the duty to ensure that access to NHS-funded implant treatment is consistent against locally agreed acceptance criteria and based on the current demands of the population.

The overall findings of this study highlight that improvement and development in implant teaching within dental undergraduate schools is required to meet curriculum requirements in implant training as set by the GDC. It is promising that there is a large body of evidence looking at trends in implant education within undergraduate schools worldwide. The ability to compare UK and Irish undergraduate implant teaching against worldwide trends enables educational providers and those involved to push for developments and changes in order to keep pace with other teaching units worldwide. It is recommended therefore that this survey be repeated on a 5-yearly basis to review the status of implant education in UK and Irish dental undergraduate schools to ensure that implant teaching is improving and fulfils the standards set by the GDC.

In contrast, there is a lack of evidence available on implant teaching within DHTS nationally and worldwide. To the author's knowledge, this is the first survey to focus on this particular topic. There is the concern that little is known about current implant teaching trends, especially given that DH/Ts will likely be at the frontline for managing peri-implant diseases in

the future. There is an urgent need for more data from teaching units nationally and worldwide, and ideally for this to be reviewed on a 5-yearly basis. This would be beneficial and will enable educational providers to compare against current trends and help promote improvements and standardisation of education in implant teaching across DHTS within the UK, Ireland and worldwide.

This study also highlighted that dental hygienists and therapists in Wales are not entirely confident in managing peri-implant health and there is an urgent need to address this issue most likely through provision of support, education and training. There is currently a lack of national and worldwide data and it is recommended that collection and sharing of such information on a 5-yearly basis be undertaken. This would assist in appreciating the extent of this issue and identifying methods to best manage this situation.

Otherwise, it is interesting to note that NHS service delivery for dental implants has shifted priority to groups such as oncology and hypodontia, where previously this appeared to be denture intolerance. Realistically, it is unlikely that all groups will have access to NHS-funded implant treatment due to funding pressures. It is recommended that repeat of this survey on a 5-yearly basis be undertaken as it would be beneficial to review implant practice trends, which can help guide future changes and developments.

Chapter 6: Conclusions

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All dental undergraduate and DHTS in the UK and Ireland provide implant teaching, however the amount of teaching varied from school to school. Barriers to implementing and developing the dental undergraduate implant programme include funding and lack of available time in the curriculum. For the dental hygiene and therapy programme, the main barrier was the lack of suitable cases. To fulfil the GDC curriculum requirements, further development and improvement of implant teaching in dental undergraduate and DHTS is required, particularly with respect to the amount of direct clinical experience provided.

A high proportion of DH/Ts practicing in Wales do not feel entirely confident in carrying out procedures relating to peri-implant maintenance and the majority feel that postgraduate implant training should be a requirement. Otherwise, a significant variation exists in the amount of implant treatment provided by university and hospital specialists in restorative dentistry within the United Kingdom and Ireland. There is general agreement by specialists on the factors that may contraindicate implant placement. NHS-funded implant treatment is limited to specific groups, most commonly oncology and hypodontia groups. Prioritisation of patient groups also varied between different units.

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Appendix 1: Teaching of implant dentistry in dental undergraduate schools in the United Kingdom and Ireland

1. Are there any requirements within your curriculum for dental undergraduates to receive implant training?

Yes ☐ No ☐

2. Do dental undergraduates at your institute receive training in implant dentistry?

Yes ☐ No ☐ (if no please got to question 22)

---

3. In which year(s) do dental undergraduates receive this training? (tick all that apply)

1st ☐ 2nd ☐ 3rd ☐ 4th ☐ 5th ☐

4. Who provides this training?

Restorative Dentistry ☐ Oral and Maxillofacial Surgery ☐ Both ☐

5. In what format is the programme delivered? (tick all that apply)

Lecture programme ☐ Phantom head training ☐ Symposium ☐
Patient treatment ☐ Other ☐ (please state) …….

6. How many sessions are devoted to your implant programme?

0 ☐ 1-3 ☐ 4-6 ☐ >6 ☐

7. Is there a recommended text on implants in your reading lists?

Yes ☐ No ☐

If yes which ones/s? ……

8. Do all students observe live implant surgery?

Yes ☐ No ☐

9. Do all students observe restorative implant procedures?

Yes ☐ No ☐

10. Do you have your own dental implant resources?

None ☐ Selected papers ☐ Video/DVD ☐

Blackboard available seminars ☐
Internet based programmes ☐ CAL programmes ☐
Others ☐ (please state) …….

---

11. Do students presently acquire direct clinical experience of treatment planning patients for implants?

Yes ☐ No ☐

Comments ……

12. Do students presently acquire clinical experience in restoring dental implants?

Yes ☐ No ☐ (If no, please go to question 17)
Comments ……

---

13. How many cases do you expect them to be involved in restoring during their undergraduate training?

0 ☐ 1 ☐ 2 ☐ 3 ☐ >3 ☐

14. Are these cases completed by individual students or in pairs?

Individual ☐ In pairs ☐ N/A – no cases are restored by undergraduates ☐

15. If students acquire direct clinical experience in restoring implants, what range of restorative treatments do they undertake?

Single unit cases ☐
Short span bridgework ☐
Edentulous cases – fixed ☐
Edentulous cases – removable ☐

16. Are there any clinical tests / practical's within the undergraduate programme for restoring dental implants?

Yes ☐ No ☐

---

17. Do all students acquire "hands on" clinical experience of implant placement?

Yes ☐ No ☐

18. If Yes, in which type of cases are students' placing implants?

Single unit cases ☐
Short span bridgework ☐
Edentulous cases – fixed ☐
Edentulous cases – removable ☐

---

19. Does your institute receive support from any implant companies in the provision of implant training?

Yes ☐ No ☐

19a. If Yes, which of the following does this include?

Provision of implants ☐ Provision of restorative components ☐
Laboratory funding support ☐ Funding for clinical staff ☐
Provision of simulated models for surgery and implant restoration ☐
Other ☐ (please state) …….

19b. Which implant companies are involved in supporting the programme? (tick all that apply)

Nobel Biocare ☐
Straumann ☐
Dentsply ☐
3i Biomet ☐
Other ☐ (please state)……..

---

20. Are there arrangements at your institute for patients to contribute to the cost of treatment?

Yes ☐ No ☐

---

21. If no undergraduate experience in RESTORING dental implants is currently gained, are there plans to introduce such experience in the next 12 months?

Yes ☐ No ☐ N/A ☐

22. If no undergraduate experience in PLACING dental implants is currently gained, are there plans to introduce experience of surgical implant placement in the next 12 months?

Yes ☐ No ☐ N/A ☐

---

23. What challenges are there/have there been to introducing / developing implant teaching into the dental undergraduate programme? (please tick all that apply)

Lack of available time within existing teaching curricula ☐
Insufficient numbers of suitably trained staff for teaching ☐
Funding ☐
Other ☐ (please state) ……..

---

24. Currently, what components, if any, of fixed and removable prosthodontics teaching do you see decreasing or increasing to accommodate the introduction and development of teaching programmes in implant dentistry?

	Increased as a result of implant programmes	Decreased as a result of implant programmes	Stayed the same
Removable prosthodontics	☐	☐	☐
Fixed Conventional Bridgework	☐	☐	☐
Resin Retained Bridgework	☐	☐	☐
Occlusion	☐	☐	☐
Other			

24a. Are there any components not stated in the table, and do you see this decreasing, increasing, staying the same?

---

25. When predicting the next 5 years, what components, if any, of fixed and removable prosthodontics teaching do you see decreasing or increasing to accommodate the introduction and development of a teaching programme in implant dentistry?

	Increased as a result of implant programmes	Decreased as a result of implant programmes	Stayed the same
Removable prosthodontics	☐	☐	☐
Fixed Conventional Bridgework	☐	☐	☐
Resin Retained Bridgework	☐	☐	☐
Occlusion	☐	☐	☐
Other			

25a. Are there any components not stated in the table, and do you see this decreasing, increasing, staying the same?

---

26. Do you think that there will be clinical requirements relating to implant placement / restoration for undergraduate students in your school within the next five years?

Yes ☐ No ☐

27. In 5 years time, which type of implant restorations do you think undergraduates will / should be involved in restoring? (tick all that apply)

Implant overdenture with ball or stud attachments ☐
Implant overdenture with bar attachment ☐
Single tooth anterior ☐
Single tooth posterior ☐
Simple implant retained bridges ☐
Other ☐ (please state) …..

28. In 5 years time do you think undergraduates will / should be surgically placing implants?

Yes ☐ No ☐

28a. If Yes, for which type of restoration?

Single unit cases ☐
Short span bridgework ☐
Edentulous cases – fixed ☐
Edentulous cases – removable ☐

---

29. Which institution do you work at?

Aberdeen University School of Dentistry ☐
Birmingham University School of Dentistry ☐
Bristol University School of Oral and Dental Sciences ☐
Cardiff University School of Dentistry ☐
Central Lancashire University School of Dentistry ☐
Cork University Dental School ☐
Dundee University School of Dentistry ☐
Glasgow University Dental School ☐
King's College London Dental Institute ☐
Leeds University School of Dentistry ☐
Liverpool University School of Dental Sciences ☐
Manchester University School of Dentistry ☐
Newcastle University School of Dental Sciences ☐
Peninsula School of Dentistry ☐
Queens' University Belfast Centre for Dentistry ☐
Sheffield University School of Clinical Dentistry ☐

30. What is/are your role(s) within the dental school? Please state all.

……..
……..
……..

Thank you for taking the time to complete this questionnaire
Please click the send button below to return

Appendix 2: Teaching of implant dentistry in dental hygiene and therapy schools in the United Kingdom and Ireland

1. Are there any requirements within your curriculum for hygiene and therapy students to receive implant training?

Yes ☐ No ☐

2. Do hygiene and therapy students at your institute receive training in implant dentistry?

Yes ☐ No ☐ (If no, please go to Question 25)

3. In which year(s) do hygiene and therapy students receive implant training? (please tick all that apply)

1st ☐ 2nd ☐ 3rd ☐

4. Who provides this training? (please tick all that apply)

School of Hygiene and Therapy ☐ Restorative Dentistry ☐
Oral and Maxillofacial Surgery ☐

5. In what format is the programme delivered? (tick all that apply)

Lecture programme ☐ Phantom head training ☐ Symposium ☐
Patient treatment ☐ Other ☐ (please state)

……
…….

6. What topics are covered in the implant programme? (tick all that apply)

Treatment planning ☐ Implant surgery ☐

Implant restoration ☐ Peri-implant maintenance ☐
Other (please state) ☐

……
…….

7. How many sessions are devoted to your implant programme?

1-3 ☐ 4-6 ☐ >6 ☐

Clinical teaching - Observation

8. Do all students observe live implant surgery?

Yes ☐ No ☐

9. Do all students observe restorative implant procedures?

Yes ☐ No ☐

10. Do students presently acquire direct clinical experience in: Providing oral stabilisation <u>prior</u> to implant placement?

Yes ☐ No ☐ (Comments)
……

<u>Clinical teaching – direct clinical experience</u>

11. Do students presently acquire direct clinical experience in: Providing <u>preventative care</u> e.g. OHI/scaling to implant patients? (i.e. to prevent peri-implant disease)

Yes ☐ No ☐ (Comments)
……..

12. If yes, what procedures are involved? (please tick all that apply)

Oral hygiene instruction ☐
Scaling ☐

13. Do students acquire direct clinical experience in: Non-surgical therapy for the management of patients with peri-implant <u>mucositis</u>? (i.e. mechanical debridement)

Yes ☐ No ☐ (Comments)
……..

14. If yes, what cases are involved? (please tick all that apply)

Single unit cases ☐
Short span bridgework ☐
Edentulous cases - fixed ☐
Edentulous cases – removable ☐
Other ☐ (please state)
……..

15. Do you provide any measures of student competency for this procedure?

Yes ☐ No ☐

16. Do students acquire direct clinical experience in: Non-surgical therapy for the management of patients with <u>peri-implantitis</u>? (i.e. supra/subgingival debridement, antiseptics, antimicrobials etc)

Yes ☐ No ☐ (Comments)
……..

17. If yes, what cases are involved? (please tick all that apply)

Single unit cases ☐
Short span bridgework ☐
Edentulous cases - fixed ☐
Edentulous cases – removable ☐
Other ☐ (please state)
…...…….

18. Do you provide any measures of student competency for this procedure?

Yes ☐ No ☐

19. If applicable, what instruments do students use for *SUPRA*-gingival debridement of implants (please tick all that apply)

Conventional stainless steel curettes ☐
Graphite curettes ☐
Gold or titanium curettes ☐
Ultrasonic with conventional stainless steel tips ☐
Ultrasonic with plastic insert tips ☐
Other ☐ (please state)
…….

20. If applicable, what instruments do students use for *SUB*-gingival debridement of implants (please tick all that apply)

Conventional stainless steel curettes ☐
Graphite curettes ☐
Gold or titanium curettes ☐
Ultrasonic instruments ☐
Other ☐ (please state)

……

Educational resources

21. Do you provide recommended texts on dental implants as part of the student hygiene and therapy reading lists? (tick all that apply)

Yes ☐ No ☐ If yes, which one/s
……

22. What educational resources are available to the hygiene and therapy students relating to dental implants? (tick all that apply)

None ☐
Selected papers ☐

Video/DVD ☐
Blackboard available seminars ☐
Internet based programmes ☐
CAL programmes ☐
Other ☐ (please state)
……
…….

23. Does your institution receive support from any implant companies in the provision of implant training for hygiene and therapy students?

Yes ☐ No ☐

If yes, what is received?
……..……
.

24. Which implant companies are involved in supporting the programme? (tick all that apply)

Nobel Biocare ☐
Straumann ☐
Dentsply ☐
3i Biomet ☐
Other ☐ (please state)
……..

<u>Final section – Future teaching</u>

25. If no experience in dental implant training is currently gained, are there plans to introduce such experience in the next 12 months for dental hygiene and therapy students?

Yes ☐ No ☐

26. If no direct clinical experience in non-surgical therapy for the management of peri-implant disease (i.e. peri-implant mucositis & peri-implantitis) is currently gained, are there plans to introduce such experience in the next 12 months for the dental and hygiene therapy students?

Yes ☐ No ☐

27. What challenges are there (or have there) been to introducing (or developing) implant teaching into the dental hygiene and therapy programme? (please tick all that apply)

Lack of available time within existing teaching curricula ☐
Insufficient numbers of suitably trained staff for teaching ☐
Insufficient numbers of suitable cases ☐
Funding ☐

Other ☐ (please state)
…….

28. Do you think that there will be clinical requirements relating to non-surgical therapy of peri-implant diseases (i.e. peri-implant mucositis and peri-implantitis) for dental hygiene and therapy students within the next five years?

Yes ☐ No ☐

29. Which institution do you work at?

……
…….

30. What is/are your role(s) within the school of hygiene and therapy? Please state all.

……
……

Thank you for your participation in the study
Please return questionnaires using the pre-paid envelope provided

Appendix 3: Maintaining peri-implant health: An evaluation of understanding amongst dental hygienists and therapists within Wales, UK

1. Is providing dental implant care within the remit of your services?

Yes ☐ No ☐ (If no, please go to question 8)

2. In which dental settings do you provide dental implant care? (tick all that apply)

Purely NHS practice	☐	Mixed Practice and Private	☐
Purely Private	☐	Community Dental Service	☐
Hospital Dental Service	☐		

3. Do the dental setting/s (in which you provide dental implant care) offer placement and/or restoration of dental implants to patients?

Yes ☐ No ☐ Comments
……

4. What dental care do you provide for your implant patients? (please tick all that apply)

Clinical assessment of peri-implant health	☐
Oral hygiene instruction	☐
Supra-gingival debridement	☐
Sub-gingival debridement	☐
Application of topical antimicrobials/antiseptics	☐
Photodynamic therapy (e.g. Periowave or other)	☐
Other (please specify)	☐

……
……

5. How many implant patients do you see per month?

1-10 ☐ 11-20 ☐ 21-30 ☐ 30+ ☐ Comments
……..

6. How confident are you at:

	Confident	**Somewhat confident**	**Not confident**
Clinically assessing dental implants	☐	☐	☐
Instructing patients in methods of plaque control for implants	☐	☐	☐
Providing **supra**-gingival debridement of dental implant supported structures	☐	☐	☐
Providing **sub**-gingival debridement of dental implant supported structures	☐	☐	☐

7. What implant maintenance interval do you schedule for the majority of your patients?

3 monthly ☐ 6 monthly ☐ Annually ☐ Other (please specify) ☐
…….

8. Did you receive dental implant training during your hygiene and therapy training?

Yes ☐ No ☐ (If no, please go to question 13)

9. If yes, what dental implant training did you receive?

Theoretical ☐ Practical ☐ Both ☐

10. Do you feel that you received adequate dental implant teaching during your hygiene and therapy training?

Yes ☐ No ☐

11. If No, what aspect did you feel was lacking?

Theoretical ☐ Practical ☐ Both ☐

12. In detail, which subject areas did you feel were inadequate? (please tick all that apply)

Theoretical aspects of restoration of dental implants ☐
Clinical assessment of dental implants ☐
Instruction on methods of plaque control for implants ☐
Supra-gingival debridement of dental implant supported structures ☐
Sub-gingival debridement of dental implant supported structures ☐
Other ☐ (please specify)……

13. What reasons do you think would explain this inadequate implant training? OR if you did not receive implant training, please tick the reasons why you think you did not receive this training? (Please tick all that apply)

Not deemed necessary when I qualified / I qualified before implant treatment was popular ☐
School did not feel this was relevant to the program ☐
Insufficient patients ☐
Insufficient time in curriculum ☐
Cost ☐
Other ☐ (please specify)……

14. Have you attended any continuing education courses in implantology since graduating?

Yes ☐ No ☐

15. If no, please tick all the reasons for not attending?

Not involved in managing patients with implants ☐
No perceived benefit ☐ No available courses ☐
Cost ☐ Time ☐
Other ☐ (please specify)
…….

16. Do you feel postgraduate training in maintenance of dental implants should be obligatory?

Yes ☐ No ☐

17. What year did you graduate?

1970-80 ☐ 1981-90 ☐ 1991-2000 ☐ 2001-2010 ☐ 2011+ ☐

This is the end of the questionnaire. Thank you for your participation in the study.

Appendix 4: The provision of dental implants: Current practice amongst university and hospital specialists in restorative dentistry within the UK and Ireland

1. Do you provide implant treatment?

Yes ☐ No ☐

2. Do you work in a university / hospital setting?

Yes ☐ No ☐

a. Which dental setting/s do you work in? (please tick all that apply)

Private practice ☐
Community dental service ☐
Other ☐ (please specify)……..

ii. Do you have a sub-specialty interest?

No sub-specialty interest ☐
Fixed and removable prosthodontics ☐
Periodontology ☐
Endodontics ☐
Other …… ☐

b. If yes, what is your role? (e.g. NHS consultant in Restorative Dentistry) ……..

i. How long have you been in this role for?

0-5 years ☐
6-10 years ☐
11-15 years ☐
16-20 years ☐
21-25 years ☐
26 + years ☐

ii. Do you have a sub-specialty interest?

No sub-specialty interest ☐
Fixed and removable prosthodontics ☐
Periodontology ☐
Endodontics ☐
Other …… ☐

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2. When performing implant treatment is this provided under:

Private contract only ☐
NHS hospital setting/university only ☐
Both ☐
Other (please specify) …….

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3. If applicable, what patient groups qualify for dental implants at your institution? (please tick all that apply)

Denture intolerance ☐ Gagging ☐ Oro-facial trauma ☐

Hypodontia ☐ Other dental developmental abnormalities (e.g. AI) ☐

Malignancy ☐ Cleft ☐

Other ☐ (please specify)……

---

4. Do you place implants?

Yes ☐ No ☐

4a. If yes, approximately how many <u>IMPLANTS</u> do you <u>place</u> per year?

0-10 ☐ 11-20 ☐ 21-30 ☐ 31-40 ☐ 41-50 ☐ 51-60 ☐

61-70 ☐ 71-80 ☐ 81-90 ☐ 91-100 ☐ 101+ ☐

5. Do you restore implants?

Yes ☐ No ☐

5a. If yes, approximately how many <u>PATIENTS</u> do you <u>restore</u> implants for per year?

0-10 ☐ 11-20 ☐ 21-30 ☐ 31-40 ☐ 41-50 ☐ 51-60 ☐

61-70 ☐ 71-80 ☐ 81-90 ☐ 91-100 ☐ 101+ ☐

6. What implant system do you most commonly use?

Nobel Biocare ☐

Straumann ☐

Dentsply ☐

3i Biomet ☐

Other ☐ (please specify)……..

7. Do you work with oral/oral and maxillofacial surgeons as an implant team?

Yes ☐ No ☐

8a. If yes, do you use your oral/oral and maxillofacial team for any of the following? (please tick all that apply)

Sinus lift ☐

Bone graft ☐

Zygomatic implants ☐
Comments …..

8b. Do you perform any of the following procedures yourself?
Sinus lift ☐
Bone graft ☐
Zygomatic implants ☐
Comments …..

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9. What medical factors do you consider as important in patient selection?

	Very important	Quite important	Not important
Smoking	☐	☐	☐
Irradiation	☐	☐	☐
Endocarditis	☐	☐	☐
Diabetes	☐	☐	☐
Osteoporosis	☐	☐	☐
Stress	☐	☐	☐
Age	☐	☐	☐
Immunosuppression	☐	☐	☐
Bisphosphonates	☐	☐	☐
Other			

---

10. What oral factors would you consider as important in patient selection?

	Very important	Quite important	Not important
Untreated periodontitis	☐	☐	☐
Poor oral hygiene	☐	☐	☐
Uncontrolled caries	☐	☐	☐
Parafunction	☐	☐	☐
Mucosal disease	☐	☐	☐
Immunodeficiency	☐	☐	☐
Occlusal relationship	☐	☐	☐
Intraocclusal space	☐	☐	☐
Other			

This is the end of the questionnaire. Please click finish to submit your results

Thank you for taking the time to complete this questionnaire.