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Short title: Dentists' implant maintenance preferences

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ABSTRACT

Background: This study investigated the preferences of dentists in Australia in providing professional implant maintenance and implant-specific oral hygiene instructions (OHI).

Methods: General dentists were surveyed online about their preferences in peri-implant diagnostics, maintenance provision, armamentarium used, and implant OHI techniques and frequency.

Results: Most of the 303 respondents (96%) provided maintenance services; 87.6% reviewed implants regularly while 10.7% only performed diagnostics after detecting clinical signs/symptoms. Supragingival prosthesis cleaning was performed by 77.9% of respondents, 35.0% performed subgingival debridement, 41.9% treated peri-implant mucositis and 18.2% treated peri-implantitis. About 15% did not treat nor refer peri-implant disease, including significantly more non-implant providers and dentists without implant training. Maintenance armamentarium commonly included floss (76.3%), prophylaxis (73.9%), plastic curettes (43.3%) and stainless-steel ultrasonics (38.0%). Brushing (86.5%), flossing (73.9%) and interdental brush use (68.3%) were most commonly recommended. Implant OHI was repeated routinely by 57.4% of dentists who provided it. Dentists

with greater implant training and experience were more likely to perform reviews and complex maintenance procedures.

Conclusions: Peri-implant diagnostics performed, treatments provided and armamentarium varied among dentists. Implant providers and those with higher levels of training had more preventative approaches to implant OHI. Possible shortcomings in disease management and OHI reinforcement were identified.

Key words: Continuing education; dental implants; dentists' practice patterns; implant maintenance; oral hygiene; survey.

INTRODUCTION

Dental implants are a treatment modality for the replacement of missing or lost teeth, with success[1] and survival rates[2, 3] above 90%, placed in the millions annually around the world.[4] Systematic reviews also demonstrate significant rates of plaque-induced peri-implant pathology, namely peri-implant mucositis (weighted mean prevalence of 43-46.83% at a patient level) and peri-implantitis (weighted mean prevalence of 19.83-22% at a patient level),[5, 6] while healthy peri-implant status has rarely been reported upon.[6]

With a reported rate of 33.6% of mechanical and/or biological complications in the first 5 years occurring in implant-supported fixed partial dentures reported in a systematic review,[3] a lifelong professional recall and maintenance regimen has been strongly recommended.[3, 7, 8] Maintenance consists of clinical evaluation of the peri-implant tissues to diagnose peri-implant health, mucositis or peri-implantitis, subsequent management and ongoing prevention. Diagnostic procedures should include, at a minimum, visual inspection, pocket probing and assessment of bleeding on probing and radiographic bone level.[9] Whether these procedures are performed by clinicians in the general community as recommended has not been studied.

Professional treatment protocols to prevent peri-implant mucositis have not been studied or standardised.[10] Mechanical plaque control alone is the cornerstone of mucositis management,[11] and professional removal using ultrasonic or hand instruments of various materials[12-18] and/or glycine powder air polishing[16-19] has been studied. Non-surgical treatment alone is likely ineffective

in treating peri-implantitis.[20-22] Surgical treatment of peri-implantitis has encompassed a large variety of protocols and combinations of debridement instruments, decontamination solutions, antibiotics, resective or regenerative techniques.[23-26] The types of peri-implant conditions treated by dentists in the general community and their technique preferences are unknown and may vary widely given the lack of consensus.

Similarly, there is a lack of evidence for optimal self-performed implant hygiene methods[27, 28] with some mixed results in plaque and bleeding scores for powered toothbrushes compared to manual toothbrushes and a lack of standardisation or even the exclusion of interdental cleaning (and therefore plaque control at the implant site) in the few clinical studies available.[29-31] Flossing circumferentially around implants has been recommended previously in some literature reviews[32, 33] and in dental hygiene articles[34] but floss remnants at exposed rough implant surfaces have more recently been found upon surgical exploration of refractive peri-implantitis cases.[35] Published studies on the use of interdental brushes for implants[36] are limited, with little information on clinical parameters and peri-implant health or disease outcomes when used by patients. When subjects in published peri-implant outcome studies are described as receiving oral hygiene instructions (OHI), if at all, the OHI is usually not described in full.

The evidence base for implant-specific hygiene techniques for at-home use by patients is therefore relatively weak, and without specific clinical guidelines, the implant OHI dentists are providing to their patients may vary widely. While specialist groups have previously been surveyed on their preferences,[37, 38] general dentists in the community have not been investigated.

The aims of this study were therefore to investigate the implant diagnostic procedures and frequency preferred by dentists in Australia, the maintenance types and treatment techniques they provide to manage biological complications, as well as their preferred implant-related oral hygiene instructions. It was hypothesised that these preferences were influenced by factors such as implant training and clinical experience.

METHODS

Using an online questionnaire on SurveyMonkey™ (San Mateo, CA, USA), dentists were surveyed about their provision of implant diagnostic review procedures, their preferred frequency for implant review generally as well as in the presence of pathological signs and symptoms, and patient factors influencing their preferred review frequency (available as Supplementary File). They also indicated their role in implant maintenance, their provision of types of professional implant maintenance treatments and the instruments or techniques used. Respondents were asked to report on which techniques they recommend when giving implant-specific OHI and their preferred OHI repetition frequency. Their background demographics, attendance at implant training programs, and implant treatment provision have been reported previously.[39]

Dentists registered in Australia were eligible to participate in the survey, which was distributed electronically by the Australian Dental Association state branches, the Australian Society of Periodontology and the Royal Australasian College of Dental Surgeons to their members, as access to the national register was unavailable. A prize draw was held to encourage participation.

This study was approved by the Health Sciences Human Ethics Sub-Committee of the University of Melbourne (Ethics ID 1443625) and data collected between March and September 2016.

Data were described as overall results from the cohort for each question. Comparisons were made between dentists who provided implant treatment or not, the highest level of implant training they had attended after completing their undergraduate/graduate dental degree (formal postgraduate training [non-specialist university qualification], continuing professional development [CPD] or neither), whether they graduated from an Australian university or not and their sector of practice (metropolitan areas only or any work in rural/regional areas). Dentists who had performed implant treatment previously were compared by their self-estimated annual implant case volume (<20, 21-50, >50 cases) and whether they provided restorative treatment only or also performed surgical implant placement. These factors were hypothesized to influence implant diagnostic review, professional maintenance and implant OHI preferences. Data were described and analysed using the statistical software SPSS version 23.0 (SPSS, Chicago IL, USA) to perform Fisher exact tests ($p<0.05$).

RESULTS

Responses were received from 303 general dental practitioners (GDPs). While some specialists responded to the survey, the numbers in each specialty group were too small to adequately compare, with variability in their involvement in implant maintenance, and thus they were excluded from the results and analysis. The demographic characteristics of the GDPs in this study are shown in Table 1, grouped according to whether they provide implant treatments (74.9%) or not (25.1%).

Almost all GDPs (99.7%) believed GDPs have a role to play in implant maintenance, while 97.0% believed they themselves have a role in implant maintenance (Table 2). GDPs not providing implants and those with no implant training were significantly less likely to see themselves as having a role in implant maintenance.

Implant diagnostic procedures

Implant checks (i.e. implant-specific diagnostic procedures) were not performed by 4.0% of the respondents, including significantly more of the GDPs not providing implants (14.5%) and those with no implant training (17.9%) (Table 2, $p<0.001$). Of the 291 GDPs who performed implant diagnostics, 87.6% did so at every recall or implant review appointment, but 10.7% only did so if peri-implant signs/symptoms were present, including 16.9% of the GDPs not providing implants.

During a routine implant check, GDPs most commonly assessed oral hygiene around the implant (97.3%) and the visual appearance of soft tissues (94.5%), followed by bleeding on probing (88.7%) and pocket depth probing (82.1%) (Figure 1). Recession measurement (56.0%) was performed least out of the available answer choices. Implant providers (96.9%) were significantly more likely to visually assess the soft tissues than non-providers (86.2%) ($p=0.003$). Otherwise, the highest level of implant training or annual case volume did not significantly affect the frequency of implant checks or types of diagnostic procedures performed.

Radiographs to assess the bone level or bony defects around an implant may not be taken at every implant check. When GDPs who performed implant diagnostics were asked when they would prefer to take "a routine radiograph of an established implant", 40.2% preferred every 24 months, 19.9%

every 12 months and 32.6% did so only in the presence of pathological signs or symptoms. No significant differences in overall preference distributions were found when comparing implant provision status, highest level of implant training or annual case volume.

Provision of implant maintenance and peri-implant disease treatment

Of the 303 respondents, 77.9% provided "supragingival/superficial implant prosthesis cleaning", 35.0% performed "subgingival debridement of implants/implant surface", 41.9% treated peri-implant mucositis and 18.2% treated peri-implantitis (Table 4). Respondents were asked to indicate if they treated or referred patients with peri-implant disease, and 14.5% did not treat mucositis nor provide referral to another practitioner, and 16.5% did not treat peri-implantitis nor provide referral to another practitioner. GDPs not providing implants and those with lower implant training provided significantly less treatment in almost all categories than their counterparts (Table 4), and were also more likely not to treat nor refer mucositis (p=0.004). Over a quarter (26.8%) of those with no training did not treat nor refer peri-implantitis although it did not reach significance when compared with the other higher training groups. Significantly, GDPs who trained outside of Australia were twice as likely not to treat nor refer mucositis (25.0% vs 12.5% of Australian graduates, p=0.041) and peri-implantitis (29.2% vs 14.1% Australian graduates, p=0.018). Among GDPs with implant experience, those who had higher annual case volumes or performed implant surgery in addition to restoration were much more likely to treat mucositis and peri-implantitis (both p<0.001).

Implant maintenance armamentarium

Among those GDPs who used any implant-specific instruments/techniques during professional maintenance or peri-implant treatment (n=245), flossing (76.3%) and rubber cup/brush with prophylaxis paste (73.9%) were the most popular (Table 5). Higher levels of implant provision and training significantly correlated to greater use of surgical interventions and antimicrobials. GDPs working in rural/regional areas were significantly more likely to perform surgical debridement/recontouring (28.3%) than their metropolitan counterparts (11.0%) (p=0.004), the

only significant difference between these two groups in this study. Australian graduates were more likely to use stainless steel ultrasonic scalers (40.7%, p=0.041) than dentists who graduated in other countries (22.2%).

Implant-specific maintenance instruments/techniques were not used at all by 19.1% of the respondents, including significantly more of the GDPs not providing implants (35.5%) and those with less implant training (Table 2, all p<0.001).

Implant hygiene preferences

Most GDP respondents rated the correlation between implant home hygiene and the health of the peri-implant tissues to be strong (46.5%) or very strong (41.9%), 10.2% considered it to be neutral, 1.3% weak, and none considered it to be very weak. There were no differences according to implant provision status or highest training level.

Given the example of a single implant crown, the most common implant hygiene techniques that GDPs included in their instructions to their patients were brushing, flossing and interdental brush use (Table 6). Non-providers and dentists with no implant training were significantly less likely to recommend several of the techniques, and were significantly more likely to recommend none of the OHI techniques at all (p<0.001).

Regarding the highest preferred frequency of OHI repetition, over half (57.4%) of the 289 GDPs who reported giving implant OHI then repeated it at every general/periodontal recall or implant review appointment (Table 7), including 70.8% of formal postgraduate-trained dentists. Over a quarter (27.0%) of the 289 GDPs only repeated OHI only in the presence of pathological signs or symptoms, including a high proportion of non-providers (41.9%) and those with no training (39.1%). Overall, 42.6% of GDPs who reported giving implant OHI did not repeat it routinely, implant provision status significantly affected OHI repetition preferences (p<0.001), and higher levels of training significantly correlated to a more preventive approach (p=0.002).

DISCUSSION

General dentists are mainly responsible for routine preventive dentistry in Australia, and respondents' perception of dental implant maintenance seems to be similar in this study. Compared to 66% in a small survey of dentists in the UK,[40] almost all GDPs in this study (97.0%) believe they have a role to play in implant maintenance, but this did not appear to translate completely into clinical practice.

Implant diagnostics

Diagnostic tests are a critical part of ongoing monitoring, whereby peri-implant parameters are compared with baseline or previous records over time to detect any development of pathology. Overall, one in ten of the GDPs who perform implant checks in this study only did so in the presence of pathological signs/symptoms, rather than routinely, which is not in line with preventive monitoring. While almost all of this group assessed local oral hygiene and soft tissue condition, as recommended in the literature,[9] decreasing proportions performed pocket depth probing, assessed suppuration and measured recession. Recession measurement should form part of probing depth assessment.[41] It is a concern that at least one in five of the GDPs surveyed did not perform these assessments and may have a less than preventive approach. Clinical signs may only be detected upon performing diagnostic procedures, and changes in probing depth or radiographic bone levels may be the only sign of disease development or progression.[9, 42]

The most recent peri-implant health and disease diagnostic criteria[9] outlined that inflammatory changes should be present in addition to bleeding on probing to confirm a disease state. However, whether peri-implant disease can develop in the absence of signs (assessed only at the time of clinical examination) has not been established or excluded and requires further investigation, although considered to be rare in a recent review.[43] In this study, GDPs not providing implants were particularly less likely to assess the soft tissues visually, whereupon even inflammatory changes present at the time of examination might be missed. Otherwise, no differences were found in implant check procedures between GDPs in this study with different levels of training and treatment experience, indicating the need to promote a preventative attitude across the entire profession.

Radiographs assessing peri-implant bone levels should be taken when signs of clinical inflammation are detected, for comparison with baseline radiographs with the prosthesis in place,[9] ideally after remodelling.[44] Otherwise there are no standardised recommendations for radiograph frequency in the literature,[45] although previous recommendations for longitudinal clinical research (not further elaborated upon in the literature) specified two-yearly reviews until 5 years and 5-yearly thereafter if bone levels are stable.[46] It is not surprising to find a range of preferences in this study with 24-monthly and in the presence of pathological sign/symptoms the most popular, in general agreement with the available literature. Formal postgraduate-trained GDPs and those with the highest case volume may have demonstrated higher preference for 12-monthly radiographs if they were more concerned about the success of implants they had placed.

Professional maintenance and armamentarium

While surveys of periodontists in the USA,[37] Australia and the UK[38] have outlined their preferences in armamentarium and surgical procedures, similar literature is not available on the relative provision of implant maintenance services by general dentists or their preferred instruments/techniques. As expected, GDPs with higher levels of training, implant providers and those performing surgical implant placement were highly significantly more likely to treat mucositis and implantitis in this study, while non-providers were also less likely to perform superficial or subgingival cleaning. Intriguingly, more GDPs in this study provided mucositis treatment than performed subgingival debridement, raising the question of how they are doing the former without the latter. However, perhaps the use of the phrase "subgingival debridement" rather than "submucosal" in the survey was confusing for respondents (it was chosen to minimise confusion for dentists with no implant training as "submucosal" has an alternative histological definition).

A lack of standardised control procedures in the literature has meant that the efficacy of individual instrumentation techniques is generally unknown, and there are as yet no standardised protocols for practitioners in maintaining peri-implant health,[10, 44] managing peri-implant mucositis[47] or peri-implantitis.[48] It is therefore not surprising that GDPs had mixed preferences in this study, including in their use of some techniques shown to have disadvantages or detrimental effects. Metal instruments cause surface scratching[49-53] and plastic curettes may be too large for effective use in the sulcus or implant threads,[12] but both were popular in this study; conversely, there is some evidence for safe and effective use of air-powder prophylaxis[17, 19] and plastic ultrasonics[54, 55] (although recent *in vitro* research has reported possible residual plastic debris[52, 56]), which were

preferred by a few GDPs. Meanwhile, almost 40% of respondents may be assuming incorrectly that stainless steel ultrasonics can be used around implants as part of routine scaling and periodontal maintenance.

Topical antimicrobials do not appear to enhance mucositis management outcomes[13-15] but were recommended in the recent AACP Clinical Practice Guidelines[57] and in this study were reportedly used widely, especially by those with more implant training.

Systemic antibiotics are not recommended for mucositis treatment,[11] and while they are commonly used in surgical peri-implantitis management research, the evidence for any particular regimen is not established.[58] In this study, GDPs with more training or implant treatment experience were more likely to prescribe systemic antibiotics and perform surgical procedures, as expected, presumably in managing more complex peri-implant pathology. Rural/regional-based dentists surveyed were also more likely to report performing surgical peri-implant procedures, perhaps compensating for the low distribution of specialists outside of major cities.[59]

It is a striking finding that almost one-fifth of GDPs in this study reported not using any implant-specific instruments/techniques for professional maintenance. Additionally, the finding that a significant proportion of respondents reported not treating or referring mucositis/peri-implantitis to another practitioner (including up to 30% of those who did not attain their dental degree in Australia) may indicate a less than pro-active attitude in managing peri-implant disease, although these figures did not specify or exclude respondents who may not see any implant patients.

Implant OHI

The vast majority of dentists in this study considered the correlation between implant home hygiene and the condition of the peri-implant tissues to be strong or very strong, corresponding to the current evidence in the literature showing greater peri-implant pathology in patients with poor general oral hygiene[60-62] or plaque at the implant site.[63, 64] However, translating this knowledge to teaching their patients to perform implant oral hygiene did not appear to be as straightforward.

The quantity and quality of evidence to support optimal self-performed oral hygiene methods (including interdental cleaning) in patients with implants to prevent peri-implant disease is limited. Minimum implant oral hygiene measures for preserving peri-implant health as a standard control in clinical research[44] and clinical trials with long-term follow-up are needed.[27, 28] Otherwise it appears that oral hygiene methods in research are assumed from the periodontal literature, and it was not

surprising to find a mixed pattern of implant OHI preferences among the dentists surveyed, who may also be extrapolating from their clinical experience. This may not be appropriate as peri-implant tissues demonstrate greater inflammation and recover more slowly than do gingivae/teeth subjected to experimental plaque accumulation.[65]

Small but significant proportions (11-15%) of non-providers and GDPs with no post-graduation implant training in this study do not give any implant-specific OHI, despite equally understanding the strong relationship between home hygiene and peri-implant health. These practitioners may be assuming that others have responsibility for OHI, or they may not want to contradict others with greater knowledge. Alternatively, implant training attendance, personal involvement in treatment and the patient's prior investment may instil greater preventative motivation.

The literature strongly recommends ongoing monitoring of oral hygiene around implants as part of regular maintenance.[66] Repeated and individualised OHI is recommended as the key to periodontal disease prevention[67, 68] and although specific peri-implant recommendations are not available, it is a concern that over 40% of GDPs in this study reported not repeating implant OHI routinely, with 27.0% only repeating it when signs or symptoms of pathology are present. This group included 41.9% of non-providers and 39.1% of GDPs with no training. As the signs and symptoms of pathology can be prevented by hygiene methods, a large group clearly did not maintain a precautionary approach. A more preventative attitude correlated strongly in this study to higher-level implant training.

There are implications for implant dentistry education in Australia stemming from the results of this study. A more preventative approach should be promoted to all dentists, to compensate for variable teaching from their initial dental degrees (depending on when/where attained), differing interest in implant training and lack of academic standardisation in CPD programs,[69] which was the most popular training type attended. All GDPs are certain to encounter patients with implants and should be able to provide preventative advice and long-term implant maintenance, regardless of any perception of responsibility being held by other practitioners. As an example, informative newsletter literature or webinars could be developed by dental associations, to reach dentists who may not attend any implant training. Given the evolving literature on disease process, speed of

progression, standardised management and instrument protocols, practitioners must be encouraged to stay in touch with current research.

This study was limited by lack of access to the national dentist register, but nevertheless the characteristics of this study's respondents were similar to the latest available workforce reports,[70] albeit with a slightly higher proportions of females and Australian graduates. The response rate of 2.1% of the registered GDP workforce in Australia at the time[71] was lower than 7.6% in a similar implant-related survey of Australian dentists.[72] Mailed surveys of dentists receive better response rates than web-based surveys (26% vs 11%)[73] and randomly selected samples from national dentist registers resulted in response rates of 43-54% in other countries.[74-76] Dentists with lower interest in implant dentistry may be underrepresented if they were less likely to participate in the study, and the differences found in this group may even have been underestimated. The nature of the survey instrument also gathers participants' reported beliefs and recalled estimates rather than strictly their clinical practices, and younger respondents may have been more likely to complete an online survey. The results of this survey should be interpreted in light of the limitations present but are unable to be compared to others due to the absence of similar research into the clinical preferences of dentists working in the general community. It is hoped further investigations will continue to track clinical practice and professional maintenance practices in the community in Australia and globally, given the high numbers of implants being placed and the prevalence of peri-implant disease, as evidence for best practices continues to be developed and implant education also evolves.

CONCLUSION

This study established the implant diagnostic and maintenance practice patterns of general dentist respondents in Australia, a large majority of whom were aware of the importance of oral hygiene and short-term review of peri-implant disease. Implant training and experience significantly increased respondents' performance of diagnostic checks and more complex maintenance/treatment procedures. Over 10% of the respondents who perform diagnostic procedures only did so when clinical signs/symptoms were present, while about 15% did not treat nor refer cases of peri-implant mucositis or peri-implantitis for management, and over 40% of

respondents did not repeat OHI routinely. Greater promotion of implant OHI in the dental profession is indicated, particularly to reach GDPs with lower interest in implant dentistry, but also within all implant training programs. Dentists must ensure a preventative attitude in performing peri-implant diagnostics, considering patient risk factors, making appropriate referrals and staying abreast of current evidence.

REFERENCES

1. Moraschini V, Poubel LA, Ferreira VF, Barboza Edos S. Evaluation of survival and success rates of dental implants reported in longitudinal studies with a follow-up period of at least 10 years: a systematic review. International journal of oral and maxillofacial surgery 2015;44:377-388.

2. Jung RE, Zembic A, Pjetursson BE, Zwahlen M, Thoma DS. Systematic review of the survival rate and the incidence of biological, technical, and aesthetic complications of single crowns on implants reported in longitudinal studies with a mean follow-up of 5 years. Clinical oral implants research 2012;23 Suppl 6:2-21.

3. Pjetursson BE, Thoma D, Jung R, Zwahlen M, Zembic A. A systematic review of the survival and complication rates of implant-supported fixed dental prostheses (FDPs) after a mean observation period of at least 5 years. Clinical oral implants research 2012;23 Suppl 6:22-38.

4. American Dental Association. 2005-06 Survey of Dental Services Rendered. Chicago, IL: American Dental Association, 2007.

5. Lee CT, Huang YW, Zhu L, Weltman R. Prevalences of peri-implantitis and peri-implant mucositis: systematic review and meta-analysis. J Dent 2017;62:1-12.

6. Derks J, Tomasi C. Peri-implant health and disease. A systematic review of current epidemiology. Journal of clinical periodontology 2015;42 Suppl 16:S158-171.

7. Wilson TG, Jr., Valderrama P, Rodrigues DB. The case for routine maintenance of dental implants. Journal of periodontology 2014;85:657-660.

8. Bidra AS, Daubert DM, Garcia LT*, et al.* A Systematic Review of Recall Regimen and Maintenance Regimen of Patients with Dental Restorations. Part 2: Implant-Borne Restorations. Journal of prosthodontics : official journal of the American College of Prosthodontists 2016;25 Suppl 1:S16-31.

9. Renvert S, Persson GR, Pirih FQ, Camargo PM. Peri-implant health, peri-implant mucositis, and peri-implantitis: Case definitions and diagnostic considerations. Journal of periodontology 2018;89 Suppl 1:S304-S312.

10. Jepsen S, Berglundh T, Genco R, *et al.* Primary prevention of peri-implantitis: managing peri-implant mucositis. Journal of clinical periodontology 2015;42 Suppl 16:S152-157.
11. Salvi GE, Ramseier CA. Efficacy of patient-administered mechanical and/or chemical plaque control protocols in the management of peri-implant mucositis. A systematic review. Journal of clinical periodontology 2015;42 Suppl 16:S187-201.
12. Maximo MB, de Mendonca AC, Renata Santos V, Figueiredo LC, Feres M, Duarte PM. Short-term clinical and microbiological evaluations of peri-implant diseases before and after mechanical anti-infective therapies. Clinical oral implants research 2009;20:99-108.
13. Thöne-Mühling M, Swierkot K, Nonnenmacher C, Mutters R, Flores-de-Jacoby L, Mengel R. Comparison of two full-mouth approaches in the treatment of peri-implant mucositis: a pilot study. Clinical oral implants research 2010;21:504-512.
14. Porras R, Anderson GB, Caffesse R, Narendran S, Trejo PM. Clinical response to 2 different therapeutic regimens to treat peri-implant mucositis. Journal of periodontology 2002;73:1118-1125.
15. Heitz-Mayfield LJ, Salvi GE, Botticelli D, *et al.* Anti-infective treatment of peri-implant mucositis: a randomised controlled clinical trial. Clinical oral implants research 2011;22:237-241.
16. Ji YJ, Tang ZH, Wang R, Cao J, Cao CF, Jin LJ. Effect of glycine powder air-polishing as an adjunct in the treatment of peri-implant mucositis: a pilot clinical trial. Clinical oral implants research 2014;25:683-689.
17. Riben-Grundstrom C, Norderyd O, Andre U, Renvert S. Treatment of peri-implant mucositis using a glycine powder air-polishing or ultrasonic device: a randomized clinical trial. Journal of clinical periodontology 2015;42:462-469.
18. Blasi A, Iorio-Siciliano V, Pacenza C, Pomingi F, Matarasso S, Rasperini G. Biofilm removal from implants supported restoration using different instruments: a 6-month comparative multicenter clinical study. Clinical oral implants research 2016;27:e68-73.
19. Mussano F, Rovasio S, Schierano G, Baldi I, Carossa S. The effect of glycine-powder airflow and hand instrumentation on peri-implant soft tissues: a split-mouth pilot study. The International journal of prosthodontics 2013;26:42-44.
20. Romanos GE, Weitz D. Therapy of peri-implant diseases. Where is the evidence? The journal of evidence-based dental practice 2012;12:204-208.
21. Renvert S, Roos-Jansåker AM, Claffey N. Non-surgical treatment of peri-implant mucositis and peri-implantitis: a literature review. Journal of clinical periodontology 2008;35:305-315.
22. Muthukuru M, Zainvi A, Esplugues EO, Flemmig TF. Non-surgical therapy for the management of peri-implantitis: a systematic review. Clinical oral implants research 2012;23 Suppl 6:77-83.
23. Renvert S, Polyzois I, Claffey N. Surgical therapy for the control of peri-implantitis. Clinical oral implants research 2012;23 Suppl 6:84-94.

24. Mombelli A, Moene R, Decaillet F. Surgical treatments of peri-implantitis. Eur J Oral Implantol 2012;5 Suppl:S61-70.

25. Heitz-Mayfield LJ, Mombelli A. The therapy of peri-implantitis: a systematic review. The International journal of oral & maxillofacial implants 2014;29 Suppl:325-345.

26. Chan HL, Lin GH, Suarez F, MacEachern M, Wang HL. Surgical management of peri-implantitis: a systematic review and meta-analysis of treatment outcomes. Journal of periodontology 2014;85:1027-1041.

27. Louropoulou A, Slot DE, Van der Weijden F. Mechanical self-performed oral hygiene of implant supported restorations: a systematic review. The journal of evidence-based dental practice 2014;14 Suppl:60-69 e61.

28. Grusovin MG, Coulthard P, Worthington HV, George P, Esposito M. Interventions for replacing missing teeth: maintaining and recovering soft tissue health around dental implants. The Cochrane database of systematic reviews 2010:CD003069.

29. Wolff L, Kim A, Nunn M, Bakdash B, Hinrichs J. Effectiveness of a sonic toothbrush in maintenance of dental implants. A prospective study. Journal of clinical periodontology 1998;25:821-828.

30. Truhlar RS, Morris HF, Ochi S. The efficacy of a counter-rotational powered toothbrush in the maintenance of endosseous dental implants. Journal of the American Dental Association 2000;131:101-107.

31. Swierkot K, Brusius M, Leismann D, *et al.* Manual versus sonic-powered toothbrushing for plaque reduction in patients with dental implants: an explanatory randomised controlled trial. Eur J Oral Implantol 2013;6:133-144.

32. Chen S, Darby I. Dental implants: maintenance, care and treatment of peri-implant infection. Australian dental journal 2003;48:212-220.

33. Kracher CM, Smith WS. Oral health maintenance dental implants. Dental assistant 2010;79:27-35; quiz 36.

34. Wingrove SS. Dental implants - home-care is key! Dental Health, 2011:10-13.

35. van Velzen FJ, Lang NP, Schulten EA, Ten Bruggenkate CM. Dental floss as a possible risk for the development of peri-implant disease: an observational study of 10 cases. Clinical oral implants research 2016;27:618-621.

36. Chongcharoen N, Lulic M, Lang NP. Effectiveness of different interdental brushes on cleaning the interproximal surfaces of teeth and implants: a randomized controlled, double-blind cross-over study. Clinical oral implants research 2012;23:635-640.

37. Papathanasiou E, Finkelman M, Hanley J, Parashis AO. Prevalence, Etiology and Treatment of Peri-Implant Mucositis and Peri-Implantitis: A Survey of Periodontists in the United States. Journal of periodontology 2016;87:493-501.

38. Mattheos N, Collier S, Walmsley AD. Specialists' management decisions and attitudes towards mucositis and peri-implantitis. British dental journal 2012;212:E1.
39. Cheung MC, Hopcraft MS, Darby IB. Implant education patterns and clinical practice of general dentists in Australia. Australian dental journal 2019;64:273-281.
40. Gibson RL, Barclay CW. Dental implantology education: a survey of opinion and experience of 106 general dental practitioners. British dental journal 2006;201:367-370.
41. Berglundh T, Armitage G, Araujo MG*, et al.* Peri-implant diseases and conditions: Consensus report of workgroup 4 of the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions. Journal of periodontology 2018;89 Suppl 1:S313-S318.
42. Heitz-Mayfield LJ. Peri-implant diseases: diagnosis and risk indicators. Journal of clinical periodontology 2008;35:292-304.
43. Schwarz F, Derks J, Monje A, Wang HL. Peri-implantitis. Journal of periodontology 2018;89 Suppl 1:S267-S290.
44. Sanz M, Chapple IL. Clinical research on peri-implant diseases: consensus report of Working Group 4. Journal of clinical periodontology 2012;39 Suppl 12:202-206.
45. Armitage GC, Xenoudi P. Post-treatment supportive care for the natural dentition and dental implants. Periodontology 2000 2016;71:164-184.
46. Salvi GE, Lang NP. Diagnostic parameters for monitoring peri-implant conditions. The International journal of oral & maxillofacial implants 2004;19 Suppl:116-127.
47. Schwarz F, Becker K, Sager M. Efficacy of professionally administered plaque removal with or without adjunctive measures for the treatment of peri-implant mucositis. A systematic review and meta-analysis. Journal of clinical periodontology 2015;42 Suppl 16:S202-213.
48. Romanos GE, Javed F, Delgado-Ruiz RA, Calvo-Guirado JL. Peri-implant diseases: a review of treatment interventions. Dental clinics of North America 2015;59:157-178.
49. Matarasso S, Quaremba G, Coraggio F, Vaia E, Cafiero C, Lang NP. Maintenance of implants: an in vitro study of titanium implant surface modifications subsequent to the application of different prophylaxis procedures. Clinical oral implants research 1996;7:64-72.
50. Agar JR, Cameron SM, Hughbanks JC, Parker MH. Cement removal from restorations luted to titanium abutments with simulated subgingival margins. The Journal of prosthetic dentistry 1997;78:43-47.
51. Mengel R, Meer C, Flores-de-Jacoby L. The treatment of uncoated and titanium nitride-coated abutments with different instruments. The International journal of oral & maxillofacial implants 2004;19:232-238.
52. Mann M, Parmar D, Walmsley AD, Lea SC. Effect of plastic-covered ultrasonic scalers on titanium implant surfaces. Clinical oral implants research 2012;23:76-82.

53. Baek SH, Shon WJ, Bae KS, Kum KY, Lee WC, Park YS. Evaluation of the safety and efficiency of novel metallic ultrasonic scaler tip on titanium surfaces. Clinical oral implants research 2012;23:1269-1274.
54. Kawashima H, Sato S, Kishida M, Yagi H, Matsumoto K, Ito K. Treatment of titanium dental implants with three piezoelectric ultrasonic scalers: an in vivo study. Journal of periodontology 2007;78:1689-1694.
55. Schmage P, Thielemann J, Nergiz I, Scorziello TM, Pfeiffer P. Effects of 10 cleaning instruments on four different implant surfaces. The International journal of oral & maxillofacial implants 2012;27:308-317.
56. Bertoldi C, Lusuardi D, Battarra F, Sassatelli P, Spinato S, Zaffe D. The maintenance of inserted titanium implants: in-vitro evaluation of exposed surfaces cleaned with three different instruments. Clinical oral implants research 2017;28:57-63.
57. Bidra AS, Daubert DM, Garcia LT*, et al.* Clinical Practice Guidelines for Recall and Maintenance of Patients with Tooth-Borne and Implant-Borne Dental Restorations. Journal of prosthodontics : official journal of the American College of Prosthodontists 2016;25 Suppl 1:S32-40.
58. Javed F, Alghamdi AS, Ahmed A, Mikami T, Ahmed HB, Tenenbaum HC. Clinical efficacy of antibiotics in the treatment of peri-implantitis. Int Dent J 2013;63:169-176.
59. AIHW. Dental workforce 2012. National health workforce series no 7. Cat. no. HWL 53. Canberra: Australian Institute of Health and Welfare, https://www.aihw.gov.au/getmedia/cd0bd5ad-ecd9-40f9-8430-c2818b80e7dd/16428.pdf. Accessed August 7th 2018.
60. Ferreira SD, Silva GL, Cortelli JR, Costa JE, Costa FO. Prevalence and risk variables for peri-implant disease in Brazilian subjects. Journal of clinical periodontology 2006;33:929-935.
61. Lindquist LW, Carlsson GE, Jemt T. Association between marginal bone loss around osseointegrated mandibular implants and smoking habits: a 10-year follow-up study. Journal of dental research 1997;76:1667-1674.
62. Costa FO, Takenaka-Martinez S, Cota LO, Ferreira SD, Silva GL, Costa JE. Peri-implant disease in subjects with and without preventive maintenance: a 5-year follow-up. Journal of clinical periodontology 2012;39:173-181.
63. Roos-Jansåker AM, Lindahl C, Renvert H, Renvert S. Nine- to fourteen-year follow-up of implant treatment. Part II: presence of peri-implant lesions. Journal of clinical periodontology 2006;33:290-295.
64. Canullo L, Penarrocha-Oltra D, Covani U, Botticelli D, Serino G, Penarrocha M. Clinical and microbiological findings in patients with peri-implantitis: a cross-sectional study. Clinical oral implants research 2016;27:376-382.
65. Salvi GE, Aglietta M, Eick S, Sculean A, Lang NP, Ramseier CA. Reversibility of experimental peri-implant mucositis compared with experimental gingivitis in humans. Clinical oral implants research 2012;23:182-190.

66. Renvert S, Polyzois I. Risk indicators for peri-implant mucositis: a systematic literature review. Journal of clinical periodontology 2015;42 Suppl 16:S172-186.

67. Tonetti MS, Eickholz P, Loos BG, *et al.* Principles in prevention of periodontal diseases: Consensus report of group 1 of the 11th European Workshop on Periodontology on effective prevention of periodontal and peri-implant diseases. Journal of clinical periodontology 2015;42 Suppl 16:S5-11.

68. Worthington HV, Clarkson JE, Bryan G, Beirne PV. Routine scale and polish for periodontal health in adults. The Cochrane database of systematic reviews 2013:CD004625.

69. Ivanovski S, Mattheos N, Scholz S, Heitz-Mayfield L. University postgraduate training in implant dentistry for the general dental practitioner. Australian dental journal 2010;55:339-345.

70. AIHW, Chrisopoulos S, Harford JE, Ellershaw A. Oral health and dental care in Australia: key facts and figures 2015. Cat. no. DEN 229. Canberra: Australian Institute of Health and Welfare, Last updated 31/08/2017. https://www.aihw.gov.au/reports/dental-oral-health/oral-health-and-dental-care-in-australia-2015/contents/dental-workforce. Accessed 7th August 2018.

71. AHPRA. Dental Board of Australia Registrant Data Reporting period: March 2016. Australian Health Practitioner Regulation Agency, https://www.dentalboard.gov.au/documents/default.aspx?record=WD16%2f20764&dbid=AP&chksum=a%2bJHU26l%2bs7WJx8lCxFLMA%3d%3d. Accessed 19th January 2019.

72. Guo YN, Dudley JE, Logan RM, Richards LC. Implant dentistry in Australia: the present and future. A survey of Australian dentists and specialists. Australian dental journal 2017;62:500-509.

73. Hardigan PC, Succar CT, Fleisher JM. An analysis of response rate and economic costs between mail and web-based surveys among practicing dentists: a randomized trial. J Community Health 2012;37:383-394.

74. Murray CM, Thomson WM, Leichter JW. Dental implant use in New Zealand: A 10-year update. The New Zealand dental journal 2016;112:49-54.

75. Ng PC, Pow EH, Ching SH, Lo EC, Chow TW. Dental implant practice among Hong Kong general dental practitioners in 2004 and 2008. Implant dentistry 2011;20:95-105.

76. Patel PM, Lynch CD, Sloan AJ, Gilmour AS. Treatment planning for replacing missing teeth in UK general dental practice: current trends. Journal of oral rehabilitation 2010;37:509-517.

[Deleted reference list below – tracking function has issues with Endnote. Highlights above are additions]

TABLES

Table 1. Demographics of GDP respondents overall (n=303). p values <0.05 shown

GDPs overall (n=303)	Implant providers (n=227)	Non-providers (n=76)	p-value
Male (n=164)	86.6%	13.4%	<0.001
Female (n=139)	61.2%	38.8%	
Practice owner (n=120)	61.7%	38.3%	<0.001
Non-owner (n=183)	95.0%	5.0%	
Private practice only (n=253)	81.0%	19.0%	<0.001
Any work in public sector (n=50)	44.0%	56.0%	
Metropolitan practice only (n=214)	75.2%	24.8%	
Any rural/regional practice (n=68)	72.1%	27.9%	
Dental degree from Australian university (n=255)	74.9%	25.1%	
Dental degree from non-Australian university (n=48)	75.0%	25.0%	

Table 2. GDPs' self-reported role in and clinical performance of implant diagnostics and maintenance. p values <0.05 shown

	GDPs overall (n=303)	Implant provision			Highest level of implant training			
		Implant providers (n=227)	Non-providers (n=76)	p-value	Formal postgraduate (n=24)	CPD training (n=223)	Neither (n=56)	p-value
GDPs who believe they have a role to play in implant maintenance	97.0%	99.6%	89.5%	<0.001	100.0%	98.7%	89.3%	0.004
GDPs who do not perform any implant-specific diagnostic procedures	4.0%	0.4%	14.5%	<0.001	0.0%	0.9%	17.9%	<0.001
GDPs who do not use any implant-specific maintenance instruments/techniques	19.1%	13.7%	35.5%	<0.001	8.3%	15.2%	39.3%	<0.001

Table 3. Preferred implant review period in the presence of peri-implant signs or symptoms, among GDPs who perform implant diagnostics (n=291). p values <0.05 shown

	GDPs overall (n=291)	Implant provision			Highest level of implant training			
		Implant providers (n=226)	Non-providers (n=65)	p-value	Formal postgraduate (n=24)	CPD training (n=221)	Neither (n=46)	p-value
Do not do implant check	1.4%	0.4%	4.6%	0.005	0.0%	0.5%	8.7%	0.004
3 months or less	55.7%	58.8%	44.6%		58.3%	57.5%	43.5%	

6 months	27.8%	28.3%	26.2%		20.8%	30.3%	19.6%	
12 months	4.8%	3.5%	9.2%		4.2%	3.2%	13.0%	
Varies depending on factors	1.7%	2.2%	0.0%		0.0%	2.3%	0.0%	
Would refer	8.6%	6.6%	15.4%		16.7%	6.3%	15.2%	

Table 4. Types of peri-implant procedures and treatments provided by GDPs. p values <0.05 shown

	GDPs overall (n=303)	**Implant provision**			**Highest level of implant training**				**Providers with implant experience performing:**		
		Implant providers (n=227)	**Non-providers (n=76)**	**p-value**	**Formal postgraduate (n=24)**	**CPD training (n=223)**	**Neither (n=56)**	**p-value**	**Restoration only (n=139)**	**Surgery and restoration (n=73)**	**p-value**
Supragingival/superficial implant prosthesis cleaning during recall/periodontal maintenance	77.9%	81.1%	68.4%	0.026	87.5%	79.4%	67.9%		80.6%	86.3%	
Subgingival debridement of implants/implant surface during recall/periodontal maintenance	35.0%	41.0%	17.1%	<0.001	45.8%	39.0%	14.3%	0.001	41.7%	45.2%	
Treatment of peri-implant mucositis	41.9%	48.9%	21.1%	<0.001	75.0%	45.7%	12.5%	<0.001	41.7%	69.9%	<0.001
Do not treat nor refer for peri-implant mucositis	14.5%	11.0%	25.0%	0.004	4.2%	12.1%	28.6%	0.004	11.5%	11.0%	

Treatment of peri-implantitis	18.2%	23.3%	2.6%	<0.001	50.0%	18.4%	3.6%	<0.001	14.4%	45.2%	<0.001
Do not treat nor refer for peri-implantitis	16.5%	15.0%	21.1%		12.5%	14.3%	26.8%		15.1%	16.4%	

Table 5. Usage of implant-specific maintenance instruments/techniques by GDPs who perform them (n=245). p values <0.05 shown

	GDPs overall (n=245)	**Implant provision**			**Highest level of implant training**				**Providers with implant experience performing:**		
		Implant providers (n=196)	**Non-providers (n=49)**	**p-value**	**Formal postgraduate (n=22)**	**CPD training (n=189)**	**Neither (n=34)**	**p-value**	**Restoration only (n=121)**	**Surgery and restoration (n=67)**	**p-value**
Floss	76.3%	75.5%	79.6%		81.8%	76.2%	73.5%		77.7%	73.1%	
Rubber cup/brush with prophylaxis paste	73.9%	74.5%	71.4%		72.7%	74.6%	70.6%		77.7%	67.2%	
Air-powder polishing/prophylaxis	9.8%	12.2%	0.0%	0.006	13.6%	10.6%	2.9%		5.8%	25.4%	<0.001
Stainless steel ultrasonic scaler	38.0%	39.3%	32.7%		31.8%	39.7%	32.4%		39.7%	37.3%	
Plastic ultrasonic tips	26.5%	26.0%	28.6%		40.9%	25.9%	20.6%		22.3%	32.8%	
Stainless steel curettes	15.5%	15.3%	16.3%		27.3%	13.8%	17.6%		13.2%	17.9%	
Plastic/carbon curettes	43.3%	44.4%	38.8%		36.4%	47.6%	23.5%	0.024	43.0%	49.3%	
Titanium curettes	12.7%	14.8%	4.1%		27.3%	12.2%	5.9%		12.4%	20.9%	
Topical antimicrobials	32.2%	35.7%	18.4%	0.026	50.0%	34.4%	8.8%	0.001	31.4%	47.8%	0.029
Local antibiotics	9.8%	12.2%	0.0%	0.006	18.2%	10.1%	2.9%		8.3%	20.9%	0.021
Systemic antibiotics	18.4%	21.9%	4.1%	0.003	50.0%	17.5%	2.9%	<0.001	13.2%	40.3%	<0.001
Bone augmentation	6.1%	7.7%	0.0%	0.046	18.2%	5.8%	0.0%	0.023	0.8%	20.9%	<0.001

Open (surgical) debridement and/or recontouring	14.7%	17.9%	2.0%	0.003	50.0%	12.7%	2.9%	<0.001	3.3%	46.3%	<0.001

Table 6. Post-restoration implant-specific OHI techniques recommended by GDPs, for a single implant crown. p values <0.05 shown

	GDPs overall (n=303)	Implant provision			Highest level of implant training			
		Implant providers (n=227)	Non-providers (n=76)	p-value	Formal postgraduate (n=24)	CPD training (n=223)	Neither (n=56)	p-value
Brushing	86.5%	89.9%	76.3%	0.006	95.8%	87.9%	76.8%	0.046
Flossing	73.9%	78.0%	61.8%	0.007	79.2%	76.7%	60.7%	0.048
Superfloss™	41.9%	40.5%	46.1%		33.3%	40.4%	51.8%	
Interdental brush	68.3%	68.7%	67.1%		70.8%	69.1%	64.3%	
Circumferential flossing	41.3%	44.5%	31.6%		41.7%	45.3%	25.0%	0.019
Oral irrigation	17.8%	20.7%	9.2%	0.024	37.5%	17.9%	8.9%	0.012
Mouthwash	14.5%	15.9%	10.5%		12.5%	13.5%	19.6%	
Topical agent	1.0%	1.3%	0.0%		0.0%	1.3%	0.0%	
None of the above	3.0%	0.0%	11.8%	<0.001	0.0%	0.4%	14.3%	<0.001

Table 7. Greatest preferred frequency of implant OHI repetition by providers of implant OHI (n=289). p values <0.05 shown

	GDPs overall (n=289)	Implant provision			Highest level of implant training			
		Implant providers (n=227)	Non-providers (n=62)	p-value	Formal postgraduate (n=24)	CPD training (n=219)	Neither (n=46)	p-value
Repeat at every recall or review	57.4%	58.6%	53.2%	<0.001	70.8%	56.2%	56.5%	0.002
Repeat only once at next recall or review	13.5%	16.7%	1.6%		20.8%	15.5%	0.0%	
Repeat only if signs/symptoms present	27.0%	22.9%	41.9%		8.3%	26.5%	39.1%	
Do not repeat	2.1%	1.8%	3.2%		0.0%	1.8%	4.3%	

FIGURES

Figure 1. Implant-specific diagnostic procedures used by GDPs who perform them (n=291).

Conflict of interest statement:

All of the authors have no conflicts of interest to disclose.

Figure 1. Implant-specific diagnostic procedures used by GDPs who perform them (n=291).