University Library

MINERVA ACCESS

A gateway to Melbourne's research publications

Minerva Access is the Institutional Repository of The University of Melbourne

Author/s:
Cheung, MC;Hopcraft, MS;Darby, IB

Title:
Patient-reported oral hygiene and implant outcomes in general dental practice

Date:
2021-03-01

Citation:
Cheung, M. C., Hopcraft, M. S. & Darby, I. B. (2021). Patient-reported oral hygiene and implant outcomes in general dental practice. Australian Dental Journal, 66 (1), pp.49-60. https://doi.org/10.1111/adj.12806.

Persistent Link:
https://hdl.handle.net/11343/276705

Patient-reported oral hygiene and implant outcomes in general dental practice

Short title: Patient-reported oral hygiene and implant outcomes

Monique Charlene Cheung, Matthew S Hopcraft, Ivan B Darby

Author affiliations:

Monique Cheung: Melbourne Dental School, The University of Melbourne, VIC, Australia; Private practice, Sydney, NSW, Australia

Matthew Hopcraft, Ivan Darby: Melbourne Dental School, The University of Melbourne, VIC, Australia

Corresponding author:

Professor Ivan Darby

Head of Periodontics

Melbourne Dental School, The University of Melbourne

720 Swanston Street, Carlton, 3053 VIC Australia

T: +61 3 9341 1471 E: idarby@unimelb.edu.au

Ethics approval:

Ethics approval for this study (Ethics ID 1443625) was granted by the Health Sciences Human Ethics Sub-Committee of the University of Melbourne.

Acknowledgements:

The authors gratefully acknowledge support received from Dr Mehri Eshraghi and Dr Johnson Huang. This study was also supported by the Melbourne Dental School, The University of Melbourne, Victoria, Australia and the Australian Government Research Training Program Scholarship.

Conflict of interest:

Author Manuscript

This is the author manuscript accepted for publication and has undergone full peer review but has not been through the copyediting, typesetting, pagination and proofreading process, which may lead to differences between this version and the Version of Record. Please cite this article as doi: 10.1111/ADJ.12806

This article is protected by copyright. All rights reserved

Monique Cheung and Ivan Darby have no conflicts of interest to disclose. Matthew Hopcraft is the Chief Executive Officer of the Australian Dental Association Victorian Branch, the professional association for dentists in Victoria, Australia.

Author Manuscript

This article is protected by copyright. All rights reserved

DR. MONIQUE CHARLENE CHEUNG (Orcid ID : 0000-0001-5326-3048)

PROF. IVAN DARBY (Orcid ID : 0000-0002-6457-5327)

Author Manuscript

Article type : Scientific Article

Patient-reported oral hygiene and implant outcomes in general dental practice

Abstract

Background: This study investigated possible correlations between patient-performed implant hygiene and peri-implant success and disease, as well as patient-reported outcomes, in a community-based cohort.

Methods: Fifty-one patients (78 implants) from two private general practices were surveyed on their dental implant treatment history, oral hygiene instructions (OHI) received, home hygiene habits and current implant concerns. Their dentition, plaque/calculus scores, and clinical implant parameters were examined. Correlations between hygiene habits, risk factors, implant success and peri-implant disease rates were assessed.

Results: Implants had a patient-reported mean time in function of 6.7 years. Floss (74.4%), interdental brushes (44.9%) and mouthwash (39.7%) were commonly used, while 7.7% of implants were only cleaned by brushing. Over half (56.4%) of implants fulfilled the success criteria, 61.5% had peri-implant health, 24.4% mucositis and 7.7% peri-implantitis. Only brushing ($p<0.001$) and detectable plaque/calculus ($p<0.001$) were significantly associated with more peri-implant disease. Local prosthetic factors affecting cleaning accessibility significantly reduced implant success ($p<0.001$). Patients reported mixed recall of implant OHI, 7.7% of implants were aesthetically unsatisfactory and 9.0% had peri-implant symptoms.

Conclusions: Lack of interproximal cleaning and the presence of plaque/calculus were significantly associated with peri-implant disease in a community-based general practice setting, and patients reported mixed recall of OHI.

Keywords: Dental implants; patient satisfaction, peri-implantitis; oral hygiene; survey

This article is protected by copyright. All rights reserved

Introduction:

Plaque-induced peri-implant disease is a biological complication that can occur around dental implants and includes peri-implant mucositis, marginal inflammation of the adjacent soft tissues without significant bone loss, and peri-implantitis, which also involves alveolar bone loss after initial healing.[1] These conditions have been reported in recent meta-analyses to have weighted mean prevalence at the patient level of about 45% for peri-implant mucositis, and about 20% for peri-implantitis.[2, 3] Studies of peri-implant disease prevalence have mostly been conducted in university or specialist-based clinics,[4] with only a few studies examining disease prevalence in community-based cohorts.[4-7]

Plaque is considered a primary aetiological factor in the development of peri-implant disease, with higher plaque levels at the implant[8-11] or lack of accessibility for cleaning the implant[12] significantly associated with peri-implantitis. Patient-performed home hygiene is therefore a key component of peri-implant disease prevention[13, 14] but the efficacy of specific hygiene methods and their impact on peri-implant outcomes is not established.[15] The implant-specific oral hygiene instructions (OHI) given to patients in otherwise controlled studies of peri-implant disease management[16, 17] is also rarely described. While some studies have compared clinical outcomes of powered and manual toothbrushes around implants,[18-20] interproximal cleaning methods have been inconsistent in these studies, and whether hygiene methods additional to toothbrushing have any impact has not been shown. Interdental brush (IDB) cleaning efficacy has been studied in a comparison of brush designs when applied by a hygienist[21] but there are very few studies of patient use. In a study where individualised implant OHI were given for full-arch implant-retained prostheses, IDB were taken up by patients at the highest rate compared to other hygiene methods, although clinical parameters did not improve overall.[22] Whether IDB, floss or variations on flossing e.g. thick floss with threader, circumferential flossing method[23] are more effective in maintaining peri-implant health or managing peri-implant disease is not known.

Of the studies examining peri-implant outcomes in community-based cohorts,[4-7] only one reported patients' home hygiene habits[7] and did not investigate any subsequent correlation to disease. Whether having a dental implant affects patients' oral hygiene behaviour is also unclear, as hygiene habits were reported to be largely unchanged in one study,[24] although having an implant has been shown to increase patient compliance to attendance at supportive periodontal therapy.[25]

Prosthetic design and clinical execution can also affect peri-implant health, such as cemented prostheses showing greater rates of biological complications[26, 27] and peri-implant disease,[28-30] particularly when incompletely seated.[31] Oral hygiene accessibility is an important factor in peri-implant disease prevention[12] and interproximal food impaction around implants has been documented in recent studies.[32-34]

This article is protected by copyright. All rights reserved

Author Manuscript

Surveys of patients' implant experiences have previously investigated patient satisfaction with function and aesthetics,[4, 5, 7, 24, 35-38] and less commonly, self-rated ease of oral hygiene.[7, 24, 37] Again, only a few have surveyed community-based cohorts.

This cross-sectional study therefore aimed to investigate patients' oral and implant hygiene habits, their implant treatment and OHI histories, and evaluate the implant outcomes (clinical parameters, implant success, peri-implant disease prevalence, patient-reported concerns) of a community-based patient cohort. The study aimed to identify possible specific oral hygiene risk factors and further research areas in the clinical practice of implant maintenance.

Material and methods:

This cross-sectional study involved patients from two private general practice clinics in Sydney, Australia who were known to have pre-existing completely restored dental implants. They were recruited via mail invitation, waiting room advertisement, or on attending a routine recall appointment with one of the investigators (MC). Any patient who had previously had their implant treatment completed by the examiner was not eligible for inclusion, to remove observer bias, and pregnant women for whom radiographic examination might be needed were also excluded. Patients who fit the inclusion criteria and attended an appointment with investigator MC between November 2015 and May 2017 were enrolled consecutively in the study, upon their consent. Participants agreed to complete a questionnaire and undergo a clinical examination. A prize draw to encourage participation was conducted. Ethics approval for this study was granted by the Health Sciences Human Ethics Sub-Committee of the University of Melbourne (Ethics ID 1443625), and was performed in accordance with the principles established in the Declaration of Helsinki. All patients provided informed consent.

All questionnaires and clinical examinations were administered by one examiner (MC). The subjects completed a paper questionnaire (Supplementary information available online), providing information about their background demographics, medical and dental history, oral hygiene habits in general, implant treatment history and any subsequent problems, recollection of implant-specific OHI received, and their ongoing maintenance routine. Any necessary clarifications were made immediately by the examiner.

Clinical assessment:

Clinical examination of the patients' dentition in general consisted of: teeth present, periodontal disease status (intact periodontium, reduced periodontium in non-periodontitis patient, successfully treated stable periodontitis patient or periodontitis patient with active disease), O'Leary plaque control index (the percentage of tooth surfaces with plaque detected using disclosing solution, six surfaces per tooth[39]).

This article is protected by copyright. All rights reserved

Author Manuscript

Clinical examination of each implant consisted of: visual assessment of soft tissues, bleeding on probing, pocket depths, percentage of surfaces with plaque or calculus detected using disclosing solution (six surfaces per tooth), Mombelli modified gingival index,[40] suppuration, keratinised mucosa presence or absence around the implant, mucosal recession, any local factors affecting accessibility for cleaning (gap between abutment and crown, ridge lap prosthesis [bucco-lingually], overcontoured or cantilevered pontic [mesio-distally], splinted crowns or implant bridge and/or open contact point). Clinical examination record forms are available as Supplementary information online.

Radiographic assessment:

A periapical radiograph of each implant was taken using a parallel technique, unless a radiograph from within the previous 12 month was available in the patient's records. This strategy aimed to minimise excessive radiation exposure to patients, as review radiographs of implants may be taken in the private practice environment on a two-yearly basis.[41] Only four patients in the cohort had radiographs from up to 7 months prior to the date of their participation included for assessment in the study. The vertical distance from the implant platform to the level of bone-implant contact was measured, and fixture depth (compared to adjacent or contralateral teeth), prosthetic fit and interproximal embrasure shapes (between the contact point and crestal bone, mesially and distally) were assessed on the radiographs.

During the examination patients were also asked to describe their implant-specific hygiene habits and any current symptoms or concerns, including aesthetic concerns.

Implant success was determined according to criteria described by Karoussis et al. (2004):[42]

- Absence of mobility.
- Absence of persistent subjective complaints (pain, foreign body sensation, and/or dysaesthesia).
- No PPD > 5 mm.
- No PPD = 5 mm and bleeding on probing (BOP).
- Absence of a continuous radiolucency around the implant.[43]
- After the first year of service, the annual vertical bone loss should not exceed 0.2 mm.

The presence of any of these findings deemed an implant to be unsuccessful.

Diagnosis of peri-implant health, mucositis or peri-implantitis was determined according to the latest recommendations for standardised criteria in implant research by Renvert et al. (2018):[1]

- Peri-implant health – absence of visual inflammation; lack of profuse (line or drop) bleeding on probing; and absence of further bone loss following initial healing, which should not be ≥2mm
- Peri-implant mucositis – visual inflammatory signs; profuse bleeding and/or suppuration on probing; and absence of bone loss beyond initial crestal bone remodelling
- Peri-implantitis – visual inflammatory signs; profuse bleeding and/or suppuration on probing; and bone level ≥3mm from the implant platform, or bone loss ≥2mm after initial crestal bone remodelling and/or probing depth ≥6mm

This article is protected by copyright. All rights reserved

Author Manuscript

Implants which lacked inflammation at the time of examination but showed bone loss ≥2mm after initial remodelling were excluded from analysis between healthy, mucositis and peri-implantitis groups.

Statistical analysis:

Data were described and correlations between implant outcomes and variables were assessed. At the patient level, medical history (age, smoking), dental history (periodontal disease status, regularity of dental attendance, whether patients recalled having their implant(s) checked during recall appointments, history of failed implant, history of peri-implant soft tissue complication, number of implants, O'Leary plaque control index) and implant hygiene (brushing only, presence of plaque/calculus at the implant, percentage of surfaces with plaque) risk factors were compared with each patient's most severe peri-implant health/disease and success finding, to assess the influence of known risk factors.

At the implant level, these same factors, as well as implant history (reported years in function, whether implant OHI was received on implant completion or any time subsequently) and local implant factors (presence of keratinised mucosal margin, screw or cement retention of prosthesis, single crown or multi-unit prosthesis, any local factor affecting cleaning accessibility, deep fixture position, presence of natural mesial/distal embrasure shape) were compared to implant outcomes to assess their influence.

Possible associations between known risk factors and variables found to be positively correlated to implant outcomes, were also examined at the implant level. The statistical software SPSS version 23.0 (SPSS, Chicago IL, USA) was used for data analysis, using Pearson's Chi-squared tests, Pearson correlation, one-way ANOVA and independent sample t-tests ($p<0.05$). This study was conducted in compliance with the STROBE guidelines for cross-sectional studies.

Results:

Patient-reported history and outcomes:

Fifty-one eligible subjects with 78 pre-existing dental implants with completed prostheses gave their consent to be enrolled in the study. The demographics of the cohort (gender, age, smoking history and dosage, dental attendance pattern) are shown in Table 1.

Using patient-reported estimates, the implants in this study had a mean of 6.7±4.3 years in function (range 7 months to 20 years, Figure 1), which was positively correlated to patient age ($p=0.032$, r=0.243). Subject recall of implant check timing, OHI timing, and history of complications (biological and prosthetic) are shown in Table 1.

Regarding practitioner type, subjects recalled that dental specialists performed implant surgery for 60.3% of the implants while general dental practitioners (GDPs) restored 53.8% of the implants. The 39.7% of implants in the

This article is protected by copyright. All rights reserved

Author Manuscript

sample which were placed and restored by GDPs consisted of 19.2% provided by the patient's regular GDP and 20.5% provided by another GDP with a special interest in implant treatment.

At the time of examination, three subjects (5.9%) expressed general dissatisfaction with soft tissue aesthetics involving 6 implants (7.7%). Seven subjects (13.7%) reported peri-implant symptoms involving 7 implants (9.0%), including "tenderness" or "sensation" in the gum, food impaction and the implant feeling "too forward". Two subjects (3.9%) reported pain or discomfort when cleaning two implants (2.6%).

Patient-reported home hygiene:

The oral hygiene habits performed by the subjects at home, the average reported frequency, and methods specifically used to clean their implant(s) are shown in Table 2. At the implant level, 7.7% of implants were reported by subjects to be brushed only, while regular flossing (77.4%), interdental brush (IDB) (44.9%) and mouthwash (39.7%) were the most common additional techniques.

Dental examination findings and peri-implant outcomes:

The subject group had a mean O'Leary plaque control index of 63.4±17.6% (range 28.0-100.0%). The majority of subjects had an intact periodontium (74.5%), while 15.7% had successfully treated stable periodontitis (with healthy gingiva or gingivitis) and 9.8% were periodontitis patients with current active disease. Number of implants per patient, implant prosthesis type and retention type, and prevalence of some common clinical parameters are shown in Table 3.

Of the implants with inflammatory bleeding on probing (29.5%), this included a Mombelli modified gingival index (mGI) of grade 1 (17.9%), grade 2 (10.3%) and grade 3 (1.3%), with a mean mGI of 0.4±0.7 (range 0-3). While 56.4% of implants had plaque/calculus present, the mean percentage of surfaces (out of 6 surfaces per implant) with plaque/calculus was 23.5% (range 0-100%).

Radiographic bone loss was defined as any loss greater than the expected initial crestal bone remodelling appropriate for each implant system/type and was found in 41.0% of implants. Bone loss of ≥2mm after initial crestal bone remodelling was found in 13.0% of implants. The implants had a mean estimated bone loss of 0.8±1.2mm ranging from 0-4.5mm; among the 41.0% of implants with bone loss, the mean estimated bone loss was 1.9±1.1mm.

The mean probing pocket depth (PPD) of each implant (6 sites per implant) ranged from 0.5-4.7mm, at an average of 2.2±0.7mm across the sample. When considering the deepest PPD of each implant, the mean deepest PPD across the sample was 3.2±1.1mm (range 1-6mm). Only one implant demonstrated recession (2mm), while 6 implants (7.7%) had a more apical mucosal margin compared to the contralateral or adjacent teeth, ranging from 1-5mm (mean 3.2±1.7mm).

This article is protected by copyright. All rights reserved

Author Manuscript

The prevalence of local prosthetic factors that may affect plaque retention, ease of cleaning or accessibility are shown in Table 4. At least one of these factors was found in 64.1% of implants. One-third of implants (30.8%) were classified from radiographs as having interproximal embrasure shapes similar to natural teeth while the remainder had at least one embrasure that was not naturally shaped.

Subject-level (the worst diagnosis per patient) and implant-level success according to the criteria outlined by Karoussis et al. (2004),[42] and peri-implant health/disease status according to the criteria outlined by Renvert et al. (2018)[1] are shown in Table 5. A small number of implants (6.4% of implants in 5.9% of patients) demonstrated no signs of inflammation yet had ≥2mm bone loss and could not be included in the above peri-implant status groups or subsequent analysis between groups.

Risk factors for peri-implant disease status and implant success:

The distribution of implants with healthy, mucositis and peri-implantitis status among risk factor characteristic groups is shown in Table 6, with statistical analysis across the 3 status groups shown. Significant differences found when comparing two implant status groups, and in analysing implant success among all implants, are shown in Table 7.

Oral hygiene

Whether an implant was reportedly only brushed (*p=0.001*) significantly affected peri-implant health status at the implant level, especially between health and peri-implantitis (Tables 6, 7). Being cleaned by brushing alone was also significantly associated with peri-implantitis over mucositis (*p=0.009*).

Peri-implant health was significantly correlated to the absence of plaque/calculus at the implant level (*p<0.001*) as well as lower plaque surface percentage (*p<0.001*), which was also associated with higher implant success (*p=0.005* [95% CI: 6.0-32.3%], 15.2% for successful vs 34.3% for not successful) (Table 7).

At the patient level, those with more severe peri-implant pathology tended to have higher average O'Leary plaque control scores and were of older age, but these findings were not statistically significant.

Periodontal factors

Periodontal disease status did not significantly correlate to either implant success or peri-implant disease. Implants in patients with active periodontal disease had higher rates of mucositis while implants in patients with a stable treated periodontium had higher rates of peri-implantitis, but these differences were not statistically significant (Table 6). Whether the patient smoked, and the presence of a keratinised mucosal margin did not show any correlation to implant success or peri-implant disease status.

Author Manuscript

This article is protected by copyright. All rights reserved

Prosthetic factors

The presence of any local prosthetic factor affecting cleaning accessibility significantly reduced implant success (58.0% unsuccessful vs 17.9% without any of these factors; *p<0.001*) (Table 7) and trended towards more severe pathology, but only reached significance between the healthy and peri-implantitis groups (*p=0.038*).

At the implant level, prosthesis retention by cement or screw, and whether an implant was associated with a single crown or multi-unit prosthesis, did not correlate significantly to implant success or peri-implant disease status. Implants with a close to natural embrasure shape mesially and distally had a higher success rate (66.7% vs 51.9% with any irregular embrasure shape) which was not statistically significant, and showed no correlation to peri-implant disease status.

Implant treatment history

At the implant level, a history of a failed implant (*p<0.001*) or a history of a soft-tissue complication (*p=0.005*) significantly affected peri-implant health status overall and were significantly associated with peri-implantitis (Tables 6, 7).

In this cohort, lower reported years in function at the implant level was significantly associated with lower implant success (*p=0.007* [95% CI: 0.7-4.2], 5.4 years not successful vs 7.8 years successful) (Table 7), but did not correlate to peri-implant disease status. While higher reported years in function was correlated to older patient age, the latter did not show significant correlations to implant success or peri-implant disease status.

Generally, age at the time of examination, gender, and patient recall of whether OHI was given at the time of implant completion or any time subsequently did not show any correlation to implant success or peri-implant disease status.

Discussion:

Patient cohorts surveyed on their implant treatment experiences and outcomes have mostly been drawn from "convenience samples" in university or specialty clinics,[4] while cohorts from the general community have only rarely been surveyed.[4, 5, 7] This study investigated a community-based private practice patient cohort in Australia, which is a rarity in the literature.

Patient-reported findings

Surveyed aspects of the patient experience vary widely in the literature, and in this study, patient reports of peri-implant history, OHI history and current peri-implant status were emphasized.

This article is protected by copyright. All rights reserved

Author Manuscript

The 5.9% of patients in this study who were less than satisfied with the aesthetics of their implant treatment was similar to the 4.4-7% found in community or general practice cohorts[4, 5] and 3-8.7% in university/specialist-based cohorts[7, 24, 37, 38] in the literature. Patient-reported discomfort around the implant or on performing implant hygiene is rarely reported in the literature, with 13.7% reporting discomfort in this study, a small but notable proportion.

The oral hygiene habits of patients with implants is rarely reported in the literature. Reported regular flossing (76.5% of patients) was higher in this study than the 45% found in a study of 40 private practice patients with implants ,[7] while reported IDB use was similar at about 40%.

Patient recall of implant OHI received is rarely reported, and it appeared to be less than ideal in this study, with only half of the cohort recalling OHI at the time of implant completion. Whether patients did not remember or OHI was not provided cannot be estimated, and instructions given may not translate to hygiene methods performed in any case. This was apparent in this study's results, as peri-implant disease outcomes correlated to reported hygiene habits but not to whether any implant OHI was received. Patients' oral hygiene habits and levels prior to implant treatment, which may not change after implant therapy,[24] may therefore have an impact not just on implant failure rates[44] but possibly peri-implant pathology. This study's findings support the need for careful hygiene assessment by clinicians when considering implant therapy. Otherwise, hygiene compliance in periodontal disease patients is improved with better understanding of possible benefits and disease sequelae, while clinical hygiene parameters are improved when goal-setting, hygiene diary, self-assessment or feedback discussion methods are used.[45] These strategies may also be applicable to peri-implant disease prevention and warrant further research. The challenges of long-term OHI communication and current best practices for behaviour change should be emphasised in implant education programs especially as teaching of implant home hygiene has been reported to be mixed in a survey of implant educators in Australia.[46]

Implant success and peri-implant disease rates

Implant success rates in the literature depend greatly upon the criteria used in each study.[47] This study's implant-level success rate of 56.4% after a mean 6.7 patient-reported years in function is similar to other studies using the same criteria (59.4% to 79.1% after 10 years depending on periodontal disease history and implant design),[42, 48] while other recent studies reported success rates of 51-90%.[49, 50] One study of patients in a private general practice research network reported a success rate of 81.3% after a mean 4.2 years[6] when using the criteria by Albrektsson et al. (1986),[51] concluding it to be lower than studies in specialist/university settings. In the current study, implant success was significantly correlated to a longer mean time in function, perhaps an unexpected result compared to the positive correlation found in meta-analysis between years in function and peri-implantitis prevalence.[3] However, success considers patient-reported symptoms where the disease criteria do not, and symptomatic implants having a shorter mean time in function in this study (although not statistically significant) may explain the finding. Comparisons of implant success to time in function are rarely reported.

The diagnostic criteria for reports of peri-implant health and disease prevalence have also varied widely in the literature.[1] The recent consensus criteria outlined by Renvert et al (2018)[1] was used in this study to allow future

This article is protected by copyright. All rights reserved

Author Manuscript

standardised comparison. This study's findings of mucositis (24.4%) and peri-implantitis (7.7%) prevalence at the implant level were similar to weighted mean prevalence (30% and about 9% respectively) calculated in recent meta-analyses.[2, 52] At the patient level, this study's findings (33.3% for mucositis and 7.8% for peri-implantitis) were lower than the weighted mean prevalence of 43-63% and 18-22% respectively calculated in recent meta-analyses.[2, 3] Peri-implant health prevalence (52.9% at patient-level, 61.5% at implant-level) was higher, mucositis prevalence was similar and peri-implantitis prevalence was lower in this study compared to the Swedish implant registry study,[53] which reported 23.0% patient-level and 39.3% implant-level health, 32.0% patient-level and 35.1% implant-level mucositis, 45.0% patient-level and 24.9% implant-level peri-implantitis in 588 patients. These differences may be due to the smaller sample size or the demographics of the private practices in this study. Rates of peri-implant health have otherwise been seldom reported.

Some limitations in the consensus diagnostic criteria of peri-implant health and disease[1] were found in analysing the results of this study, where 5 implants without signs of inflammation but which demonstrated bone loss could not be categorised and were therefore excluded from analysis. More research with long-term follow-up is needed to determine if progressive bone loss can occur in the absence of inflammatory signs, although it was suggested to be rare in a recent systematic review.[54]

Peri-implant disease risk factors

This study's results are in agreement with the established literature on poorer oral hygiene as a significant risk factor for peri-implant disease,[8-12] with the lower plaque/calculus presence at the implant strongly correlating to peri-implant health, and patient reports of only brushing strongly correlated to peri-implantitis. The overall plaque levels exhibited by patients in this study appeared to be high, with all patients exhibiting O'Leary plaque control scores >20%, considered to be a threshold for "good" oral hygiene in a multicentre study in Sweden, met by 88.3% of peri-implantitis patients in that study.[55] At the implant level, 43.6% of implants in this study demonstrated no plaque present, similar to 32.6% in a private practice-based study,[7] while findings in specialist/university settings ranged from 47.5%[38] and 56%[56] up to over 87%.[43, 57, 58]

The efficacy of patient-performed interdental cleaning methods for peri-implant health is not established[15] and usually is not explicitly described in mucositis intervention studies. One study of patient-performed hygiene around full-arch implant-retained prostheses after instruction found it to be generally poor[22] but there are no similar studies for fixed partial denture or single crown prostheses. This study showed that brushing alone is unlikely to be adequate in preventing peri-implant disease, but subjects often performed more than one interproximal cleaning method, and further research into the efficacy of different interproximal cleaning methods is warranted. In the periodontal literature, IDB use is recommended as the most efficacious[59] and patient-preferred method.[60] For peri-implant use, only one study has compared IDB design efficacy when applied by a hygienist,[21] and Kreve et al. (2016) found it to be significantly taken up by patients after instruction, compared to other hygiene methods.[22] One encouraging finding in this study was that implants that were cleaned more interproximally, especially with IDB, had

This article is protected by copyright. All rights reserved

Author Manuscript

fewer reported years in function (i.e. were completed more recently), perhaps reflecting a greater emphasis on thorough implant hygiene by practitioners in recent years.

There are risk factors for peri-implant disease which have been established or investigated in the literature, which were not statistically significant or had no apparent no effect in this study. The small number of smokers in this study may have hidden its strong effect on peri-implantitis.[10, 61] Active periodontal disease[8, 9, 11, 53, 62] or residual pockets[63, 64] and lack of compliance to supportive periodontal therapy are also risk factors for peri-implant disease, and this study showed non-significant trends for peri-implantitis in patients with a stable treated periodontium, and peri-implant mucositis in patients with active periodontal disease. The effects of the periodontal status variables compared to the three peri-implant statuses are likely unclear due to the sample size. The effect of a higher implant to subject ratio[2] (i.e. the extent of peri-implant disease) may have been limited by the low number of patients with multiple implants in this study. Absence of keratinised mucosa as a risk factor has been studied using variable criteria[65] and recently reviewed to have limited evidence of impact upon self-performed hygiene,[54] and this study found no direct correlation to detectable plaque/calculus or peri-implant disease status. The amount of attached mucosa as a component of keratinised mucosa was not measured in this study but was found in a recent study to be significantly associated with >2mm width of keratinised mucosa, below which threshold there were significantly poorer peri-implant parameters.[66] Previously, the literature had primarily considered only keratinised attached mucosa.[67]

The design of implant prostheses to facilitate oral hygiene accessibility is recommended[14] given its high negative predictive value for peri-implantitis,[12] but prosthetic design guidelines are not available. In this study, implant outcomes were analysed according to whether the radiographic embrasure shapes between proximal contact to crestal bone were close to natural (i.e. as expected between teeth) or not, and while no significant correlations to peri-implant health/disease were found, there was a non-significant trend towards greater implant success with more naturally shaped embrasures, which warrants further research in a larger cohort. The possibility of placement in non-ideal sites is one of the advantages of implant therapy, but with the additional concerns of proximal contacts loosening over time and food impaction,[32-34, 68, 69] further research is warranted into interproximal implant hygiene, prosthetic design and optimal cleaning methods in non-anatomical situations.

In this study, 84.3% of patients recalled their implants being checked during their routine recall appointments, similar to the 80% of patients who had implant maintenance performed by general practitioners in the Swedish registry study.[53] Maintenance provision by which practitioner types has otherwise rarely been outlined in the literature dominated by specialist/university-based samples.

This study was cross-sectional and established a descriptive snapshot of implant patients in private general practice. Comprehensive treatment records or baseline data were lacking in many cases due to patients having moved between dental practices, or having seen specialists for part of the treatment, whose records were not available. Several possible impacting variables such as time in function, OHI history or a previous soft-tissue complication were therefore reliant on patient recall where records were not available, and this is a limitation of this study which

This article is protected by copyright. All rights reserved

Author Manuscript

reflects challenges in implant record-keeping in clinical practice. Patient compliance to recommended implant review frequency, which is recommended to improve implant treatment success[70] also could not be assessed as this data was often not available or not recorded. Patients' reports of oral hygiene performed might also be different from their actual habits, which is a limitation of survey-based research. While patient satisfaction and symptoms were recorded descriptively in this study rather than using a scale, scales used in other studies vary widely and cannot be compared easily.[7, 24, 37, 38] Many risk factors were statistically assessed in this study with an increased risk of type I error as a consequence, which should be considered when interpreting the results. As this community-based general practice setting of study is relatively rare, it is hoped that the findings in this study will engender further research in similar settings which may provide greater clarity.

While peri-implant outcomes were reported at both the implant and patient level in this study, risk factors such as oral hygiene habits and periodontal disease history have a patient-level effect. However, the number of patients with multiple implants was too small to calculate the relative impact of patient-level factors, and patient-level effects should be considered when interpreting the results. The sample size was small as it was restricted to the patients seen by one practitioner in general private practice over an 18 month period, such that multiple logistic regression analysis was not appropriate. However, the sample size was similar to other studies with general practitioner and community-based cohorts, such as 40 patients with 43 implant crowns examined after implant placement by periodontists and restoration by general dentists,[7] and 54 patients with implants in a sample of 1000 Austrian adults.[5] The study by Derks et al. sampled the Swedish data registry to survey 3827 implant patients with 588 examined.[4, 53] It is hoped future implant registries will allow similar large-scale evaluation of implant outcomes in community settings.

Conclusions:

In this study, conducted in a community-based general practice setting, implants being cleaned by brushing alone had significantly more peri-implantitis, while lower presence of plaque/calculus was significantly correlated to peri-implant health. This study recorded the oral and implant hygiene habits and peri-implant symptoms reported by patients in the community, and implant OHI was poorly recalled. Further research should continue into interproximal implant hygiene, practitioners' OHI strategies and peri-implant outcomes in community cohorts. The challenges of long-term record-keeping for implant review and maintenance should also be addressed.

Author Manuscript

This article is protected by copyright. All rights reserved

References

1. 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.
2. 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.
3. 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.
4. Derks J, Håkansson J, Wennström JL, Klinge B, Berglundh T. Patient-reported outcomes of dental implant therapy in a large randomly selected sample. Clinical oral implants research 2015;26:586-591.
5. Pommer B, Zechner W, Watzak G, Ulm C, Watzek G, Tepper G. Progress and trends in patients' mindset on dental implants. II: implant acceptance, patient-perceived costs and patient satisfaction. Clinical oral implants research 2011;22:106-112.
6. Da Silva JD, Kazimiroff J, Papas A*, et al.* Outcomes of implants and restorations placed in general dental practices: a retrospective study by the Practitioners Engaged in Applied Research and Learning (PEARL) Network. Journal of the American Dental Association 2014;145:704-713.
7. Vermylen K, Collaert B, Linden U, Bjorn AL, De Bruyn H. Patient satisfaction and quality of single-tooth restorations. Clinical oral implants research 2003;14:119-124.
8. 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.
9. 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.
10. Roos-Jansåker AM, Renvert H, Lindahl C, Renvert S. Nine- to fourteen-year follow-up of implant treatment. Part III: factors associated with peri-implant lesions. Journal of clinical periodontology 2006;33:296-301.
11. 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.
12. Serino G, Ström C. Peri-implantitis in partially edentulous patients: association with inadequate plaque control. Clinical oral implants research 2009;20:169-174.
13. 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.
14. Heitz-Mayfield LJ, Salvi GE. Peri-implant mucositis. Journal of periodontology 2018;89 Suppl 1:S257-S266.
15. 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.
16. Heitz-Mayfield LJ, Salvi GE, Mombelli A, Faddy M, Lang NP. Anti-infective surgical therapy of peri-implantitis. A 12-month prospective clinical study. Clinical oral implants research 2012;23:205-210.

This article is protected by copyright. All rights reserved

Author Manuscript

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. 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.

19. 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.

20. 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.

21. 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.

22. Kreve S, Pinheiro De Carvalho G, Ramos E, Dias S. Clinical Evaluation of Hygiene Maintenance of Full-arch Implant-supported Prostheses. Journal of International Oral Health 2016;8:903-910.

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

24. Pjetursson BE, Karoussis I, Burgin W, Bragger U, Lang NP. Patients' satisfaction following implant therapy. A 10-year prospective cohort study. Clinical oral implants research 2005;16:185-193.

25. Cardaropoli D, Gaveglio L. Supportive periodontal therapy and dental implants: an analysis of patients' compliance. Clinical oral implants research 2012;23:1385-1388.

26. Sailer I, Muhlemann S, Zwahlen M, Hammerle CH, Schneider D. Cemented and screw-retained implant reconstructions: a systematic review of the survival and complication rates. Clinical oral implants research 2012;23 Suppl 6:163-201.

27. 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.

28. Wilson TG, Jr. The positive relationship between excess cement and peri-implant disease: a prospective clinical endoscopic study. Journal of periodontology 2009;80:1388-1392.

29. Korsch M, Obst U, Walther W. Cement-associated peri-implantitis: a retrospective clinical observational study of fixed implant-supported restorations using a methacrylate cement. Clinical oral implants research 2014;25:797-802.

30. Linkevicius T, Puisys A, Vindasiute E, Linkeviciene L, Apse P. Does residual cement around implant-supported restorations cause peri-implant disease? A retrospective case analysis. Clinical oral implants research 2013;24:1179-1184.

31. Chen CJ, Papaspyridakos P, Guze K, Singh M, Weber HP, Gallucci GO. Effect of misfit of cement-retained implant single crowns on crestal bone changes. The International journal of prosthodontics 2013;26:135-137.

This article is protected by copyright. All rights reserved

Author Manuscript

32. Wang JH, Judge R, Bailey D. A 5-Year Retrospective Assay of Implant Treatments and Complications in Private Practice: The Restorative Complications of Single and Short-Span Implant-Supported Fixed Prostheses. The International journal of prosthodontics 2016;29:435-444.
33. Koori H, Morimoto K, Tsukiyama Y, Koyano K. Statistical analysis of the diachronic loss of interproximal contact between fixed implant prostheses and adjacent teeth. The International journal of prosthodontics 2010;23:535-540.
34. Wong AT, Wat PY, Pow EH, Leung KC. Proximal contact loss between implant-supported prostheses and adjacent natural teeth: a retrospective study. Clinical oral implants research 2015;26:e68-71.
35. Baracat LF, Teixeira AM, dos Santos MB, da Cunha Vde P, Marchini L. Patients' expectations before and evaluation after dental implant therapy. Clinical implant dentistry and related research 2011;13:141-145.
36. Zitzmann NU, Marinello CP. Treatment outcomes of fixed or removable implant-supported prostheses in the edentulous maxilla. Part I: patients' assessments. The Journal of prosthetic dentistry 2000;83:424-433.
37. Tey VH, Phillips R, Tan K. Patient-related outcome measures with implant therapy after 5 years. Clinical oral implants research 2016.
38. Simonis P, Dufour T, Tenenbaum H. Long-term implant survival and success: a 10-16-year follow-up of non-submerged dental implants. Clinical oral implants research 2010;21:772-777.
39. O'Leary TJ, Drake RB, Naylor JE. The plaque control record. Journal of periodontology 1972;43:38.
40. Mombelli A, van Oosten MA, Schürch E, Jr., Lang NP. The microbiota associated with successful or failing osseointegrated titanium implants. Oral Microbiol Immunol 1987;2:145-151.
41. Salvi GE, Lang NP. Diagnostic parameters for monitoring peri-implant conditions. The International journal of oral & maxillofacial implants 2004;19 Suppl:116-127.
42. Karoussis IK, Bragger U, Salvi GE, Burgin W, Lang NP. Effect of implant design on survival and success rates of titanium oral implants: a 10-year prospective cohort study of the ITI Dental Implant System. Clinical oral implants research 2004;15:8-17.
43. Buser D, Weber HP, Lang NP. Tissue integration of non-submerged implants. 1-year results of a prospective study with 100 ITI hollow-cylinder and hollow-screw implants. Clinical oral implants research 1990;1:33-40.
44. van Steenberghe D, Klinge B, Linden U, Quirynen M, Herrmann I, Garpland C. Periodontal indices around natural and titanium abutments: a longitudinal multicenter study. Journal of periodontology 1993;64:538-541.
45. Newton JT, Asimakopoulou K. Managing oral hygiene as a risk factor for periodontal disease: a systematic review of psychological approaches to behaviour change for improved plaque control in periodontal management. Journal of clinical periodontology 2015;42 Suppl 16:S36-46.
46. Cheung MC, Hopcraft MS, Darby IB. Dental implant maintenance teaching in Australia—A survey of education providers. European Journal of Dental Education 2020;24:310-319.
47. Papaspyridakos P, Chen CJ, Singh M, Weber HP, Gallucci GO. Success criteria in implant dentistry: a systematic review. Journal of dental research 2012;91:242-248.

This article is protected by copyright. All rights reserved

Author Manuscript

48. Karoussis IK, Salvi GE, Heitz-Mayfield LJ, Bragger U, Hammerle CH, Lang NP. Long-term implant prognosis in patients with and without a history of chronic periodontitis: a 10-year prospective cohort study of the ITI Dental Implant System. Clinical oral implants research 2003;14:329-339.

49. Apostolopoulos P, Darby I. Retrospective success and survival rates of dental implants placed after a ridge preservation procedure. Clinical oral implants research 2016.

50. Bazrafshan N, Darby I. Retrospective success and survival rates of dental implants placed with simultaneous bone augmentation in partially edentulous patients. Clinical oral implants research 2014;25:768-773.

51. Albrektsson T, Zarb G, Worthington P, Eriksson AR. The long-term efficacy of currently used dental implants: a review and proposed criteria of success. The International journal of oral & maxillofacial implants 1986;1:11-25.

52. Atieh MA, Alsabeeha NH, Faggion CM, Jr., Duncan WJ. The frequency of peri-implant diseases: a systematic review and meta-analysis. Journal of periodontology 2013;84:1586-1598.

53. Derks J, Schaller D, Håkansson J, Wennström JL, Tomasi C, Berglundh T. Effectiveness of Implant Therapy Analyzed in a Swedish Population: Prevalence of Peri-implantitis. Journal of dental research 2016;95:43-49.

54. Schwarz F, Derks J, Monje A, Wang HL. Peri-implantitis. Journal of periodontology 2018;89 Suppl 1:S267-S290.

55. Charalampakis G, Leonhardt A, Rabe P, Dahlen G. Clinical and microbiological characteristics of peri-implantitis cases: a retrospective multicentre study. Clinical oral implants research 2012;23:1045-1054.

56. Lambrecht JT, Filippi A, Kunzel AR, Schiel HJ. Long-term evaluation of submerged and nonsubmerged ITI solid-screw titanium implants: a 10-year life table analysis of 468 implants. The International journal of oral & maxillofacial implants 2003;18:826-834.

57. Krennmair G, Schmidinger S, Waldenberger O. Single-tooth replacement with the Frialit-2 system: a retrospective clinical analysis of 146 implants. The International journal of oral & maxillofacial implants 2002;17:78-85.

58. Blanes RJ, Bernard JP, Blanes ZM, Belser UC. A 10-year prospective study of ITI dental implants placed in the posterior region. I: Clinical and radiographic results. Clinical oral implants research 2007;18:699-706.

59. Sälzer S, Slot DE, Van der Weijden FA, Dorfer CE. Efficacy of inter-dental mechanical plaque control in managing gingivitis--a meta-review. Journal of clinical periodontology 2015;42 Suppl 16:S92-105.

60. Noorlin I, Watts TL. A comparison of the efficacy and ease of use of dental floss and interproximal brushes in a randomised split mouth trial incorporating an assessment of subgingival plaque. Oral Health Prev Dent 2007;5:13-18.

61. Rinke S, Ohl S, Ziebolz D, Lange K, Eickholz P. Prevalence of periimplant disease in partially edentulous patients: a practice-based cross-sectional study. Clinical oral implants research 2011;22:826-833.

62. Marrone A, Lasserre J, Bercy P, Brecx MC. Prevalence and risk factors for peri-implant disease in Belgian adults. Clinical oral implants research 2013;24:934-940.

63. Cho-Yan Lee J, Mattheos N, Nixon KC, Ivanovski S. Residual periodontal pockets are a risk indicator for peri-implantitis in patients treated for periodontitis. Clinical oral implants research 2012;23:325-333.

This article is protected by copyright. All rights reserved

Author Manuscript

64. Pjetursson BE, Helbling C, Weber HP*, et al.* Peri-implantitis susceptibility as it relates to periodontal therapy and supportive care. Clinical oral implants research 2012;23:888-894.

65. Brito C, Tenenbaum HC, Wong BK, Schmitt C, Nogueira-Filho G. Is keratinized mucosa indispensable to maintain peri-implant health? A systematic review of the literature. J Biomed Mater Res B Appl Biomater 2014;102:643-650.

66. Monje A, Blasi G. Significance of keratinized mucosa/gingiva on peri‐implant and adjacent periodontal conditions in erratic maintenance compliers. Journal of periodontology 2019;90:445-453.

67. Sculean A, Romanos G, Schwarz F*, et al.* Soft-Tissue Management as Part of the Surgical Treatment of Periimplantitis: A Narrative Review. Implant dentistry 2019;28:210-216.

68. Byun SJ, Heo SM, Ahn SG, Chang M. Analysis of proximal contact loss between implant-supported fixed dental prostheses and adjacent teeth in relation to influential factors and effects. A cross-sectional study. Clinical oral implants research 2015;26:709-714.

69. Abduo J, Gade L, Gill H, Judge R, Darby I. A comparative study of encode protocol versus conventional protocol for restoring single implants: One-year prospective randomized controlled clinical trial. Clinical implant dentistry and related research 2017;19:1061-1067.

70. Monje A, Aranda L, Diaz KT*, et al.* Impact of Maintenance Therapy for the Prevention of Peri-implant Diseases: A Systematic Review and Meta-analysis. Journal of dental research 2016;95:372-379.

Author Manuscript

Tables:

Table 1. Patient-level and implant-level history, as reported by patients

Patient-level reported history	**n=51**
Gender:	
Female	51.0%
Male	49.0%
Age	56.6±14.2 years (range 25-84)
Smokers	7.8%, mean 9.0±4.6 cigarettes per day
Dental attendance pattern:	
Regular at least 12-monthly	92.2%
Regular 12-24 monthly	3.9%
Only when there is a problem	3.9%
Implant check timing:	
during regular recall appointments	84.3%
during specific implant review appointments	19.6%, 2.0% with a general dentist, 17.6% with a specialist
not checked to patient's recollection	13.7%
O'Leary plaque index	63.4±17.6% (range 28.0-100.0%)

This article is protected by copyright. All rights reserved

History of failed implant	5.9%
Previous complication with existing implant(s)	20.4%
- history of a soft-tissue (biological) complication	9.8%
- history of a prosthetic complication	13.7%
Implant-level reported history	**n=78**
OHI recalled at time of completion	53.8%
OHI recalled at any subsequent time	67.7%
No OHI recalled at any time	11.5%
History of a soft-tissue (biological) complication	10.3%
History of a prosthetic complication	9.0%

Table 2. Home dental hygiene habits and mean performance frequency at subject level (n=51) and implant-specific hygiene at implant level (n=78)

Home hygiene method	Performed in general at subject level (n=51)	Mean times performed per day by subjects using the method	Performed regularly for each implant (n=78)
Toothbrushing	100.0%	2.0±0.4	7.7% (only cleaned with brushing)
Regular flossing	76.5%	1.1±0.7	74.4%
Interdental brush (IDB)	43.1%	1.5±0.7	44.9%
Superfloss™	13.7%	0.6±0.4	9.0%
Circumferential floss	33.3%	0.7±0.5	24.4%
Mouthwash	35.3%	1.4±0.8	39.7%
Oral irrigator	5.9%	1.3±0.8	9.0%

Table 3. Patient-level and implant-level examination findings

Patient-level examination findings	**n=51**
Periodontal status:	
intact periodontium	74.5%
successfully treated stable periodontitis (with healthy gingiva or gingivitis)	15.7%
periodontitis patients with current active disease	9.8%
Number of implants:	
1	58.8%
2	31.4%
3	7.8%
4	2.0%
Implant-level examination findings	**n=78**
Prosthesis type:	

This article is protected by copyright. All rights reserved

Author Manuscript

Single crowns	66.7%
Part of a multi-unit fixed prosthesis	29.5%
Overdenture-retaining abutments	3.8%
Prosthesis retention type:	
Direct screw to fixture	53.8%
Cross-pin	2.6%
Cemented	39.7%
Clinical parameter present:	
Visual soft tissue inflammation	10.3%
Non-keratinised mucosal margin	16.7%
Inflammatory bleeding on probing (BOP)	29.5%
Suppuration	3.8%
Probeable fixture threads	15.4%
Visible fixture threads	11.5%
Any plaque/calculus present	56.4%
Mean percentage of surfaces (out of 6) with plaque/calculus	23.5% (range 0-100%)

Table 4. Frequency of local and radiographic-detected prosthetic factors at implant level (n=78)

Local prosthetic factor affecting cleaning	**Percentage**
Gap between abutment and crown	20.5%
Ridge lap prosthesis (bucco-lingually)	10.3%
Overcontoured or cantilevered pontic (mesio-distally)	24.4%
Splinted crowns or implant bridge	33.3%
Open contact point	7.7%
Radiographically-detected prosthetic factor	
Deep fixture position	14.1%
Gap between fixture and abutment	3.8%

Table 5. Subject-level and implant-level success rates and peri-implant health/disease status

	Subject level (worst diagnosis) (n=51)	**Implant level (n=78)**
Implant success	51.0%	56.4%
Peri-implant health	52.9%	61.5%
Peri-implant mucositis	33.3%	24.4%
Peri-implantitis	7.8%	7.7%
≥2mm bone loss, no signs of inflammation	5.9%	6.4%

Author Manuscript

This article is protected by copyright. All rights reserved

Table 6. Characteristics and risk factors present in healthy, peri-implant mucositis and peri-implantitis groups, at the implant level. P values <0.05 shown

	Healthy (n=48)	Peri-implant mucositis (n=19)	Peri-implantitis (n=6)	P value
Mean years in function	6.6	7.1	7.3	N.S.*
Mean patient age at time of exam (years)	57.6	58.3	71.8	N.S.*
Previous history of soft tissue complication (n=8)	3 (6.3%)	2 (10.5%)	3 (50.0%)	0.005
History of other failed implant (n=5)	1 (2.1%)	1 (5.3%)	3 (50.0%)	<0.001
Plaque/calculus present (n=44)	8 (16.7%)	15 (78.9%)	5 (83.3%)	<0.001
Mean percentage of surfaces (out of 6) with plaque/calculus	13.9%	31.6%	72.2%	<0.001*
Implant brushed only (n=6)	2 (4.2%)	1 (5.3%)	3 (50.0%)	0.001
Any local factor affecting cleaning difficulty (n=45)	27 (56.3%)	12 (63.2%)	6 (100%)	N.S.
Patient periodontal status:				
Intact periodontium (n=53)	36 (75.0%)	13 (68.4%)	4 (66.7%)	N.S.
Stable treated periodontium (n=12)	9 (18.8%)	1 (5.3%)	2 (33.3%)	
Active periodontitis (n=8)	3 (6.3%)	5 (26.3%)	0 (0%)	

*One-way ANOVA performed to compare 3 peri-implant status groups for linear data; Pearson's chi-squared tests performed otherwise

N.S. – not significant

Table 7. Significant factors impacting implant success (n=78); two-group comparisons between healthy/mucositis/peri-implantitis status (n=73) at the implant level. P values <0.05 shown

	Implant success	Healthy vs mucositis	Healthy vs peri-implantitis	Mucositis vs peri-implantitis
Years in function	0.007#			
Previous history of soft tissue complication (n=8)			0.001	0.035
History of other failed implant (n=5)			<0.001	0.009
Plaque/calculus present (n=44)		<0.001	0.042	
Mean percentage of surfaces (out of 6) with plaque/calculus	0.005#	0.003#	0.023#	
Implant brushed only (n=6)			<0.001	0.009
Any local factor affecting cleaning difficulty (n=50)	<0.001		0.038	

Independent sample t-test performed for linear data; Pearson's chi-squared tests performed otherwise

Author Manuscript

This article is protected by copyright. All rights reserved

Figure caption:

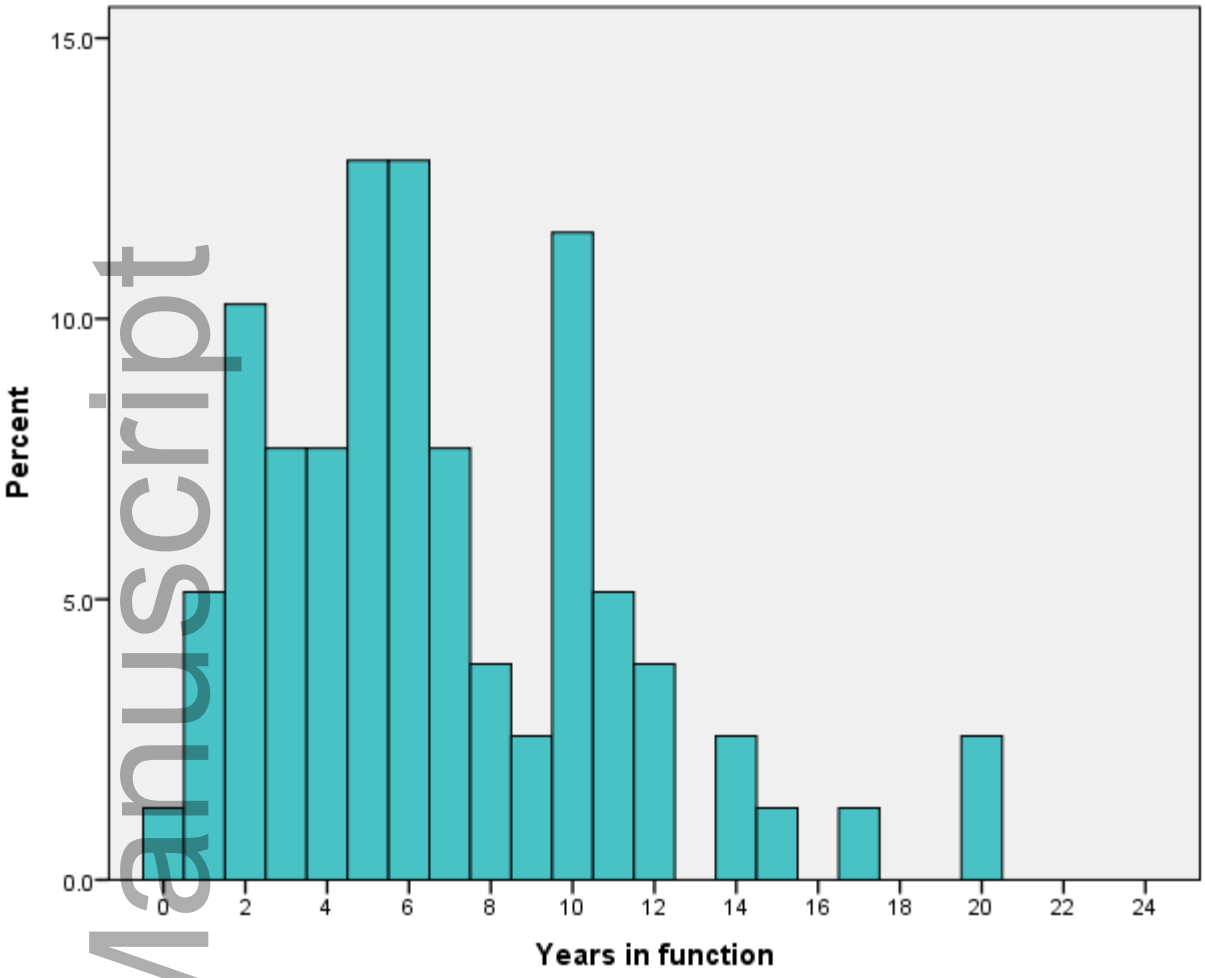
Fig. 1. Patient-reported implant years in function (n=78)

Author Manuscript

Conflict of interest statement:

Two of the authors have no conflicts of interest to disclose. One of the authors is the CEO of the Australian Dental Association Victorian Branch, the professional association for dentists in Victoria, Australia.

This article is protected by copyright. All rights reserved



adj_12806_f1.tif

Author Manuscript

This article is protected by copyright. All rights reserved