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Implant Risk Assessment Validation Pilot Study with 6 Month Follow-up

by
Raime Shah

THESIS
Submitted in partial satisfaction of the requirements for degree of
MASTER OF SCIENCE

in

Oral and Craniofacial Sciences

in the

GRADUATE DIVISION
of the
UNIVERSITY OF CALIFORNIA, SAN FRANCISCO

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Contributions:

Curtis DA, Lin GH, Fishman A, et al. Patient-Centered Risk Assessment in Implant Treatment Planning. Int J Oral Maxillofac Implants. 2019;34(2):506-520.

Abstract: **Implant Risk Assessment Validation Pilot Study with 6 Month Follow-up**

Raime Shah

Objective: This short-term prospective pilot study aims to assess the validation of the patient-centered implant risk assessment tool in patients recruited at the University of California, San Francisco (UCSF) School of Dentistry.

Materials and Methods: Patients seen in the university periodontal clinics were enrolled into the study based on their eligibility for dental implant treatment. Dental surgeons completed a survey tool, called the Implant Risk Assessment Questionnaire (RAQ), for each implant placed. After at least 6 months of loading with the implant final prosthesis, patients were seen for a recall visit at which point, the implant was diagnosed as healthy or having peri-implant disease. Peri-implant disease was subcategorized as peri-implant mucositis, and peri-implantitis. The survey output classifies the implant as low, medium, or high aggregate risk, which was correlated to diagnoses of healthy, peri-implant mucositis, or peri-implantitis respectively. The RAQ scores and diagnoses were used to compute sensitivity, specificity, positive and negative predictive values to determine the tool validity.

Results: Forty-two subjects with 116 implants were recruited into the study. Thirty-eight of these implants were restored by the conclusion of the study, and of those, 28 were seen for follow-up at least 6 months after final prosthesis delivery. Eleven implants were diagnosed as healthy, sixteen as peri-implant mucositis, and one as peri-implantitis with a follow up between 6 -14 months (mean follow-up of 7.71 months). Four implants had early failures prior to the prosthesis delivery. Sensitivity, specificity, positive and negative predictive parameters were initially low, indicating a low predictive value of the RAQ tool. These parameters were improved by omitting questions which were lowering the predictive ability of the test within this time frame. Questions on restoration type, biologic width, treated periodontitis, tissue phenotype, maxillary posterior implant position, and clinician experience were removed to improve validity parameters for this short-term pilot study. Sensitivity was maintained at 82.4%, specificity

improved from 0 to 45.5%, positive predictive value increased from 57.7% to 70%, and negative predictive value increased from 0% to 62.5% when comparing before and after the omission of these questions.

Conclusion: In a short-term context, the RAQ survey tool may have limited utility in its original form to identify cases of health and disease, but if modified to omit certain risk categories, its predictive capacity may be increased. These risk questions or categories may regain relevance for their contribution to peri-implant disease as the study follow-up is extended.

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Introduction

Since their inception, dental implants have shown great promise in the restoration of edentulous spaces, yet they present a unique challenge when it comes to the management of peri-implant disease. Dental implants are being used in over 5.6% of the general population, and that trend is increasing[1]. Older age groups have seen a 13-fold increase in implant use from 1999-2000 to 2015-2016 compared to younger adults[1]. Although implants have served as a significant advance in the restoration of edentulous spaces, complications associated with implant treatment are also increasing in prevalence.[2] Complications associated with the implant fixture can be described as failure to achieve or maintain osseointegration. As defined by Branemark et al. in 1983, osseointegration is the direct structural and functional connection between the living bone and the surface of a load bearing implant.[3] Failure to establish initial osseointegration is considered an early complication, whereas late complications are those following established osseointegration and can be further classified as either mechanical or biological in nature. Biological complications can manifest as inflammation around the implant without bone loss, known as peri-implant mucositis, pathologic bone loss beyond that of physiologic remodeling, known as peri-implantitis, or implant loss.[4] A systematic review and meta-analysis by Atieh et al in 2013 reported 63.4% frequency of peri-implant mucositis among participants and 30.7% of implants, and peri-implantitis in 18.8% of participants and 9.6% of implants.[2] Multiple studies have investigated the potential etiologies of peri-implant disease but a consensus on risk factors and their relative importance is elusive. For example, Atieh et al. in 2013 found that a higher frequency of peri-implant diseases of 36.3% was recorded for smokers, whereas supportive periodontal therapy seemed to reduce the rate of occurrence.[2] Renvert et al. in 2013 completed a retrospective study of 172 patients receiving dental implants and found that the odds ratio of having peri-implantitis was 8.7 in patients with a history of cardiovascular disease, and 4.5 in those with a history of periodontitis; however, they did not find any relationship with smoking or gender.[5] Monje et al. in 2017 determined that the risk of peri-implantitis was 50% higher in patients with diabetes than those without diabetes.[6] Similarly, Daubert et al. in 2015 in a cross-sectional study found that

patients with diabetes had up to three times the relative risk of peri-implantitis as healthy patients.[7] Monje et al. in 2017 also reported that peri-implant maintenance compliance was associated with 86% fewer cases of peri-implantitis at the patient level, speaking to the importance of maintenance to prevent peri-implant disease.[8] Though there is considerable debate as to which risk factors are more heavily implicated in peri-implant diseases, it is imperative that the dental provider discuss the potential impact of these risks with patients who may be candidates for implant treatment. It is the responsibility of the dental provider to carefully review the patient's medical history and exam findings to identify and communicate overall risk of implant therapy to the patient and other providers. A study by Insua et al. reported that patients' perceptions of implant therapy are often misconstrued, revealing 74.1% of surveyed participants with no knowledge of peri-implantitis, and 70.4% of patients falsely believing that ''implants are a life-lasting treatment''.[9]

Risk factors leading to unfavorable outcomes in implant therapy can often be extrapolated in a comprehensive patient interview and examination. Three main tools for implant risk assessment have been developed to present day. The first, the SAC assessment tool, was developed at the SAC Consensus Conference hosted by the International Team of Implant Dentistry (ITI) conference in 2007.[10] The tool has evolved over time but is meant primarily to objectively classify the complexity and overall treatment risk of an implant rehabilitation case from surgical and restorative perspectives as being Straightforward, Advanced, or Complex. It guides the clinician to determine the perceived difficulty of the treatment, to determine if the case is appropriate for their skill level, and thus potentially reduce risk to the patient especially in the case of the inexperienced clinician. For the experienced clinician, it can be used as a checklist to ensure all relevant risks for the patient have been considered. Lastly, the tool is meant to facilitate patient education, and improve communication between patient and provider.[10] The SAC tool has been validated in regard to agreement between users of the tool but has not yet been validated in terms of implant outcomes.[11]

Another tool, published by Heitz-mayfield in 2020, called the Implant Disease Risk Assessment (IDRA) evaluates risk specifically for peri-implantitis using eight factors including history of

periodontitis, bleeding on probing, probing depths, bone loss compared to patient's age, periodontitis susceptibility, frequency of compliance with supportive periodontal therapy, distance from the prosthesis margin to the bone crest, and prosthesis-related factors including cleansability and fit.[12] It was recently evaluated in a retrospective study by De Ry et al. in 2021, which found an odds ratio for developing peri-implantitis in patients identified as high risk as compared to moderate risk of 2.73 without a statistically significant difference. Although they noted multiple study limitations due to small sample size and limited generalizability due to a patient pool from a university setting, this paper importantly underscores the utility of such a tool to predict peri-implant disease and to increase patient awareness of these risk factors.[13]

The tool that is the focus of this study emerged from a publication entitled "*Patient-Centered Risk Assessment in Implant Treatment Planning*" by Curtis et al. in 2019, which proposed a comprehensive implant risk assessment tool to help guide clinical recommendations based on individual and aggregate risk (Figure 1).[14] The intended use of the risk assessment tool was also to improve dialogue between providers and patients, and to identify pertinent risk factors specifically for late biological complications when treatment planning for implants. This tool was developed through a review of current literature on risk indicators, supplemented by the Delphi process, in which experts in prosthodontics and periodontics debated on inclusion of risk indicators into the tool. This tool was meant to primarily assess for late biologic complications, including peri-implantitis, implant loss, and non-inflammatory processes of bone remodeling in cases with minimal buccal bone. The risk assessment tool included subscales and weighting for 20 risk indicators divided into 3 categories: 1) Patient history, 2) Clinical findings, and 3) Clinician decisions and post-implant placement findings. The output score of the tool designates patients as low; less than 6 points, medium; 6-10 points, or high risk; greater than 10 points, which provides clinicians with an understanding of the patient's aggregate risk score.[14] Following its development, this risk assessment tool has not been validated in a prospective clinical study. Therefore, the purpose of this prospective pilot study was to validate the sensitivity, specificity, positive and negative predictive value of this risk assessment tool with a 6-month follow-up.

Given the time constraint of this initial assessment, this study is meant to serve as a cornerstone for future long-term and larger sample validation studies.

Materials and Methods

The research protocol was reviewed and approved by the UCSF Human Research Protection Program Institutional Review Board (IRB) #20-29904. Participant recruitment of patients eligible for implant placement was conducted in the UCSF Post-Graduate and Faculty Periodontics and Prosthodontics Clinics. At the time of recruitment, patients signed a consent form to be enrolled in the study, and the provider completed the first part of the Implant Risk Assessment Questionnaire (RAQ) on patient history and clinical findings. Patient history, such as diabetes diagnosis and glycated hemoglobin (HbA1c) within the last 3 months, was verified and determined to be current and accurate for this aspect of the survey. Following implant restoration, the clinician would complete the RAQ to answer the remaining questions on clinician decisions, and post-implant placement findings. For the purposes of this pilot study, a follow-up period of at least 6-months following implant final restoration or final prosthesis loading was used to determine diagnosis of peri-implant health, peri-implant mucositis, or peri-implantitis. The 2017 World Workshop Criteria for diagnosis of implant health status in a research context was utilized. Health was diagnosed as an asymptomatic implant without any thread exposure, bleeding on probing, suppuration, or bone loss beyond initial remodeling. Any implant with bone loss beyond 2mm or more from the time of final prosthesis delivery was deemed as having peri-implantitis, whereas those implants without at least 2mm of bone loss, and bleeding or suppuration were considered to have peri-implant mucositis.[15] Providers were asked to take both bitewing and periapical radiographs at the time of implant placement, and at follow-ups for accurate determination of bone levels throughout the healing process. Final diagnosis was completed by the patient's surgeon and a faculty member if the implant was placed by a resident and verified by an investigator at the time of chart and radiograph review. Additional information was retrieved from the patient chart on patient gender, detailed medical history, implant system used, bone or soft tissue grafting, and restoration type. Exclusion criteria included

patients not eligible for implant treatment in our clinics or those lost to follow-up. Implants lost before the time of final prosthesis delivery or before the 6-month follow-up were not included in the final statistical calculations, but data from their chart review and survey questions were still included for a qualitative analysis.

Statistical Analysis

RAQ scores were converted into their analogous disease categories such that a "Low" RAQ score of <6 points was converted to "Health", "Medium" score between 6-10 points to "Peri-implant mucositis", and "High" score >10 points to "Peri-implantitis'.[14] These were compared to implant diagnosis of Health, Peri-implant mucositis, and Peri-implantitis determined at least 6 months following implant final prosthesis delivery and loading to determine sensitivity, specificity, positive predictive value, and negative predictive value. As these formulas require a binary outcome, diagnosis categories of peri-implant mucositis and peri-implantitis were combined into a "Disease" category.

Additional chart information, including patient medical history, medications, implant specifications, implant brand, and bone or soft tissue augmentation, was evaluated by average scores corresponding to disease outcome categories to identify trends in these risk factors.

Results

Forty-two subjects with 116 implants were enrolled into the study prior to dental implant placement. At the time of enrollment, the patient consented to the study, and the surgeon answered survey questions regarding patient factors and clinical findings. Following implant placement, the surgeon completed survey questions regarding perioperative clinician decisions. The age range for the sample was 23 to 79 years old, with a mean age of 56.4 years old. Demographic information was collected from the patient's chart and survey responses and compiled for both Patient and Implant level data as shown in Table 1.

RAQ scores were translated into predicted 6-month diagnosis outcomes, such that a Low score <6 points was “Health”, a Medium score 6-10 points was “Peri-implant mucositis”, and a High score of >10 points was “Peri-implantitis”. Initial RAQ outputs from the survey questionnaire were skewed towards Medium and High scores, indicating a propensity for disease around implants. This was not representative of the sample diagnosis outcomes, resulting in an initially poor specificity, positive predictive value, and negative predictive value as seen in Table 2. In order to improve the predictive value of the RAQ for short-term usage, averages for each survey question within Health, Peri-implant Mucositis, and Peri-implantitis diagnosis groups were computed. Questions with higher mean scores in Health compared to Peri-implant Mucositis, and Peri-implantitis were taken out of the survey output calculation. This way higher scores would more accurately predict disease and lower scores more accurately predict health. Questions about treated periodontitis, tissue phenotype, maxillary posterior position, clinician experience, cement-retained versus screw retained prosthesis, and biologic width accommodation were removed to calculate an adjusted survey output as seen in Table 3 and Figure 2. Sensitivity was maintained at 82.4%, specificity improved from 0 to 45.5%, positive predictive value increased from 57.7% to 70%, and negative predictive value increased from 0% to 62.5% when comparing before and after the omission of these questions.

Data on four early implant failures was compiled to review potential risk factors leading to failures. All failures occurred in males with history of bone grafting, one patient was a smoker, one had diabetes, two had hypertension, one had a history of cancer, all were bruxers, 50% of implants were bone level, 50% were tissue level, and two were placed in the maxillary posterior location (Table 5). The sample size was not sufficient to run additional analysis.

Discussion

Although the initial results of this prospective pilot study do not represent a true validation of the risk assessment tool, this study serves as a foundation to further evaluate the utility of the RAQ tool on a short-term basis prior to study continuation for longer term and larger sample size follow-up. Throughout the duration of the study, benefits of the RAQ tool were evident in the increased communication between providers and patients about implant risk and prevention. Additionally, modification of the tool to omit 6 questions resulted in improved RAQ predictive capacity for this short-term usage. Larger and longer follow-up studies are needed to validate these findings.

Rationale for omission of questions as short-term risk indicators from the patient history and clinical findings sections are speculative but may be explained overall by insufficient follow-up as many of these risk indicators have published evidence of a relationship to peri-implant disease. For the topic of treated periodontitis, Heitz-mayfield et al. in 2009 found a higher risk of peri-implantitis in patients with a history of treated periodontitis compared with those without a history of periodontitis with reported odds ratios between 3.1 to 4.7.[16] Similarly, Souza et al. in 2017 found that implants placed in patients with treated periodontal disease had a higher incidence of biologic complications, lower success, and survival rates as healthy patients, with more severe periodontal disease trending towards increased implant loss.[17] A possible explanation that our pilot did not find history of periodontal disease to have a predictive value for peri-implant disease is that possibly peri-implant disease in relation to treated periodontitis had not yet developed by the 6-month follow-up.

In the original RAQ paper by Curtis et al, the survey question about implant placement in the maxillary posterior was used as a proxy for Type IV bone,[18] the least dense bone in the mouth, due to a 2014 systematic review by Goiato et al. which found the lowest survival rates for implants placed in Type IV bone.[19] Interestingly, a more recent systematic review and meta-analysis by Song et al. in 2020 found that implants in the maxillary and mandibular anterior regions had a higher prevalence of peri-implantitis

compared to the maxillary posterior region.[20] Maxillary posterior site may not have served as a useful predictor in our pilot study for a few potential reasons: 6-month follow-up is not sufficient to show sufficient bone destruction in maxillary posterior regions for a peri-implantitis diagnosis, or this risk indicator may not be a strong predictor of bone loss or implant failure. Though, it is important to note that of the four early failures that were seen in our patient sample, two were placed in the maxillary posterior.

Tissue phenotype was excluded in the adjusted statistics, though there is considerable evidence to support the influence of phenotype parameters on implant health.[21] A potential reason that phenotype was not highly predictable is that the noted tissue phenotype characteristic was at the time of the exam, likely before any augmentation had taken place. A systematic review and meta-analysis by Tavelli et al. in 2020 found that tissue phenotype modification techniques, which affect keratinized mucosa width, mucosal thickness, and supracrestal tissue height, via soft tissue augmentation was associated with reduction of probing depth, soft tissue dehiscence, and plaque index compared to non-augmented sites.[22] All of these parameters could affect the final implant diagnosis, and these techniques could have been performed following the survey completion. Thus, this survey question may have limited utility, as the timing of the tissue phenotype characterization being at the start or end of implant treatment is not specified, or it may be a better predictor with a longer study follow-up.

Clinician experience was omitted mainly because the survey population was overly biased towards inexperienced clinician, with a large majority of implants being placed in the Postgraduate Periodontics resident clinic compared to faculty providers. In a systematic review and meta-analysis in 2017, Sendyk et al. discovered that surgeon inexperience, defined as surgeons who had placed less than 50 implants, did significantly affect the implant failure rates with an odds ratio of 2.18.[23] This question will likely increase in relevance with a more variable study population.

Two questions were omitted from the surgical and restorative section of the survey for improved predictive capacity. Cement-retained prosthesis have some conflicting evidence regarding their

contribution to peri-implant disease. In a prospective clinical study in 2009, Wilson et al. showed that 81% of implants with peri-implantitis around single crowns had excess extracoronal dental cement present. Following cement removal, clinical signs of peri-implant disease improved to the point of being absent in 74% of those cases.[24] On the other hand, Kotsakis et al. in 2016 in a cross-sectional study found that there was no association between type of prostheses retention and peri-implant disease. They posited that with appropriate cement removal, cement retention is not a risk indicator for peri-implant diseases.[25] It is possible that cement-retained prostheses in this study were being cleaned at an expert level in the Prosthodontics Clinic under the supervision of an experienced clinical faculty, or that it may be too soon to identify the biologic sequelae of residual cement including peri-implantitis.

The final omitted question was regarding biologic width dimension. The original RAQ paper intended for this question to encompass the movement of the implant-abutment interface away from the bone through the use of tissue level implants or platform switch designs to reduce the proximity of the bacterial presence at this interface to the bone. In the 2017 World Workshop definitions, biologic width was removed in favor of the term supracrestal tissue attachment.[26] This question had variable responses, as most clinicians were not certain of its intent.

One potential focus for a new RAQ iteration could be on early, or pre-prosthesis delivery, failures, or implant loss. This subset of the study population, including 4 failures in 4 different individuals, could only complete the first part of the survey, so their scores on the RAQ were not usable. Table 5 highlights the different risk factors found in this group as collected from the chart review and survey responses. The new iteration for early implant loss could include a different scale based on scoring from the first part of the survey only which would correlate to different

peri-implant outcomes. Inclusion of cancer history and cardiovascular disease as risk indicators, as was seen in this population subset, for the early implant loss iteration may be indicated, though larger scale studies are needed to verify this.

Some limitations of this study design became evident as it progressed through patient recruitment, and follow-up. The largest potential drawback being that 6-month implant follow-up is insufficient to adequately determine an implant diagnosis. Additionally, there was no calibration or standardization of providers taking the survey regarding which time-point the question was directed at, or how to answer for modifiable risks. Survey and recall bias were a significant concern, as most providers were likely to report their own work subjectively, and most often respond more favorably of their work compared to a third-party evaluator. Clinically, investigators were not blinded to patient and implant history at the time of follow-up, so there may have been bias in the final diagnosis determination. Radiograph standardization for the purpose of bone level comparison at the time of implant placement, prosthesis delivery, and follow-up radiographs was not always completed. Though bitewings radiographs from the time of prosthesis delivery and follow-up were generally completed as the standard of care, thus easy comparison for diagnosis determination was often achievable. In the original paper by Curtis et al, the RAQ tool was meant as an initial iteration and a living document.[14] Following the RAQ publication, vast amounts of research has already been published allowing additional controversy and change to the body of knowledge that was used to build the RAQ tool. For instance, as the RAQ tool only inquires about the patient's current usage of selective serotonin reuptake inhibitors, a recent study by Carr et al. in 2019, found that only history of Sertraline use was associated with implant failure, whereas another study by Hakam et al. in 2021 reported on 5 other classes of antidepressants that may influence implant failure.[27,28] As new research and understanding is brought to light about risk factors and their relative influence on peri-implant disease, the RAQ tool is destined for continuous modification and improvement.

Conclusion

The RAQ may have limited utility in its original form to identify cases of health and disease on a short-term basis, but if modified to omit certain risk categories, its predictive capacity may be clinically acceptable. These risk categories may regain relevance for their contribution to peri-implant disease as the study follow-up is extended. Though the clinical relevance of this study correlating RAQ scores to short-term implant health is limited, the RAQ remains an important tool to increase clinician awareness of risk indicators for implant therapy and spark conversations about implant risk with patients and other providers.

Tables:

Table 1: Demographic Data from Chart and Survey Questions

PATIENT LEVEL	**CHART REVIEW**			
Gender	Male: 71.43%	Female: 28.57%		
Implant Platform	Bone Level: 82.73%	Tissue Level: 17.27%		
Implant Company	Straumann: 52.73%	Nobel: 47.27%		
Antidepressant Medication	Yes: 14.29%	No: 85.71%		
Past/Current Smoker	Yes: 26.19%	No: 73.81%		
Diabetes Mellitus	Yes: 7.14%	No: 92.86%		
Cardiovascular Disease	Yes: 21.43%	No: 78.57%		
Cancer History	Yes: 12.20%	No: 87.80%		
	SURVEY QUESTIONS			
Smoking Status (cigarettes/day)	Not smoking: 88.10%	<5: 2.38%	6-20: 7.14%	>20: 2.38%
Diabetic Status (HbA1c)	Not diabetic: 92.50%	5.7-7%: 5.00%	7-8%: 2.50%	>8%: 0.00%
Antiresorptive Use	None: 100.00%	Oral: 0.00%	Intravenous for osteoporosis: 0.00%	Intravenous for cancer: 0.00%
SSRI Use	Yes: 5.00%	None: 95.00%		
PPI Use	Yes: 10.00%	None: 90.00%		
H&N Radiation (55Greys)	Yes: 0.00%	None: 100%		
Treated Periodontitis	No: 42.50%	Yes, slight chronic: 17.50%	Yes, moderate/ severe chronic: 40.00%	Yes, aggressive: 0.00%
Active Untreated Periodontitis	No 100.00%	Yes, slight chronic 0.00%	Yes, moderate/ severe chronic: 0.00%	Yes, aggressive: 0.00%
Plaque Levels	Light 75.00%	Moderate: 22.50%	Heavy: 2.50%	
Bruxer	Yes: 45.00%	No: 55.00%		
Clinician (#s Implant Placed)	<50: 92.50%	50+: 7.50%		

IMPLANT LEVEL	SURVEY QUESTIONS		
Previous Implant Site Failure	No: 93.97%	Yes: 6.03%	
Maxillary Posterior	No: 66.38%	Yes: 33.62%	
2mm Attached Tissue	Yes: 86.02%	No: 13.97%	
3mm Coronal Tissue	Yes: 92.04%	No: 7.95%	
2mm Buccal Bone	Yes: 89.36%	No: 10.63%	
Mesio-distal Space Adequate	Not from implant: 7.44%	Not from tooth: 1.06%	Yes: 91.49%
Limited Hygiene Access	Yes: 24%	No: 76%	
Cement-retained Restoration	Yes, supragingival margin: 9.52%	Yes, subgingival margin: 4.76%	No: 85.71%
Compliant with Recall	Yes: 60%	No: 40%	
Biologic width Acceptable	Yes: 90.79%	No: 9.21%	

Table 2: Average Scores per Survey Question within Final Diagnosis Categories

Question	HEALTH	MUCOSITIS	IMPLANTITIS
Smoking	0.55	0.00	3
Diabetes	0.00	0.19	0
Previous Implant Failure	0.00	0.12	0
Anti-resorptive Use	0.00	0.00	0
SSRI Use	0.00	0.00	0
PPI Use	0.00	0.00	0
H&N Radiation	0.00	0.00	0
Treated Periodontitis	3.27	0.50	2
Untreated Periodontitis	0.00	0.00	0
Plaque Levels	0.55	0.38	0
Tissue Phenotype	0.91	0.25	0
Bruxer	0.82	2.06	0
Maxillary Posterior	1.27	0.62	0
Clinician Experience	2.45	3.00	0

Question	HEALTH	MUCOSITIS	IMPLANTITIS
Attached Tissue	0.18	0.00	0
Supracrestal Tissue Dimension	0.55	0.00	0
Buccal Bone Width	0.00	0.00	4
Mesiodistal Spacing	0.73	0.75	0
Prosthesis Cleansibility	0.55	3.38	6
Cement-retained Prosthesis	0.91	0.38	0
Compliant with Recall	2.18	2.06	0
Biologic Width Dimension	0.55	0.25	0

Table 3: Raw and Adjusted Survey Output Compared to 6-Month Diagnosis Outcomes

Raw RAQ Output		
	Counts	% of total
LOW	23	20%
MEDIUM	25	22%
HIGH	68	59%
Total:	116	100%

Adjusted RAQ Output		
	Counts	% of total
LOW	62	53%
MEDIUM	39	34%
HIGH	15	13%
Total:	116	100%

6-Month Diagnosis		
	Counts	% of total
HEALTH	11	39%
MUCOSITIS	16	57%
IMPLANTITIS	1	3.5%
Total:	28	100%

Table 4: Adjusted versus Raw Survey Validity Metrics

Raw Data

Negative Predictive Value	Positive Predictive Value	Specificity	Sensitivity
0.00%	57.7%	0.0%	82.4%

Adjusted Data

Negative Predictive Value	Positive Predictive Value	Specificity	Sensitivity
62.5%	70.0%	45.5%	82.4%

Table 5: Early (Pre-prosthesis Delivery) Failures Risk Factors

Implant Site #	Age	Gender	Bone Graft	Tissue vs Bone Level
28 (failed)	60	Male	Bone graft at implant placement	Bone
3 (failed)	53	Male	External Sinus	Tissue
23 (failed)	57	Male	Bone graft at implant placement	Bone
14 (failed)	69	Male	Internal Sinus	Tissue

Implant Company	Antidepressant	Diabetes	Cardio-vascular Condition	Current / Past Smoker
Straumann	none	no	none	Yes
Straumann	none	no	none	no
Nobel	Yes	Yes	Yes	no
Straumann	none	no	Yes	no

Treated Periodontitis	Plaque Levels	Tissue Phenotype	Bruxer	Maxillary Posterior	Clinician implant Experience #
none	Moderate	Thick	Yes	No	<50
none	Low	Thin	Yes	Yes	<50
none	Moderate	Thick	Yes	No	<50
Yes, moderate-severe chronic periodontitis	Low	Thick	Yes	Yes	<50

Figures:

Risk indicators/subscales	Points
Smoking	
≤ 5 cigarettes/day	1
6–20 cigarettes/day	3
> 20 cigarettes/day	6
Diabetes	
Controlled or pre-diabetic; HbA1c < 6.5%	0
HbA1c levels above > 6.5%–8% at the time of implant placement	3
HbA1c levels > 8% at time of implant placement	6
Implant placement in site of previous implant loss	2
Use of antiresorptive agents	
Oral antiresorptive agents	0
Currently use IV antiresorptive agents for treatment of osteoporosis but without MRONJ history	4
Currently use IV antiresorptive agents for treatment of cancer	Red flag
Patient with any stage of MRONJ	Red flag
Current use of SSRI	1
Current use of PPIs	1
History of irradiation to the head and neck	Red flag

Risk indicators/subscales	Points	
Periodontal disease	Treated/ inactive	Untreated/ active
Aggressive periodontitis	6	Red flag
Moderate/severe chronic periodontitis	4	6
Slight chronic periodontitis	2	4
Plaque levels at exam (Plaque Index)		
Moderate plaque PI > 20% to 50%		2
Heavy plaque PI > 50%		4
Thin tissue biotype/phenotype		2
Bruxism		3
Implant placed in maxillary posterior		2
Inexperienced clinician		3

Risk indicators based on clinician decisions/subscales	Points
Soft tissue	
Lack 2 mm attached tissue around implant	2
Distance < 3 mm from peri-implant tissue margin to bone crest	2
Bone	
Bone volume less than 2 mm to buccal side of implant	4
Implant position	
Closer than 3 mm to adjacent implant	4
Closer than 1.5 mm to adjacent tooth	4
Treatment plan includes prostheses that limits access for cleaning resulting in an increase in bacterial load	6
Cemented restorations	
Cemented at or above the gingival margin	2
Cemented and subgingival	4
Poor compliance with recommended recall	3
Not accommodating for biologic width with the implant/prosthesis design	2

Figure 1: Implant Risk Assessment Questionnaire (RAQ)

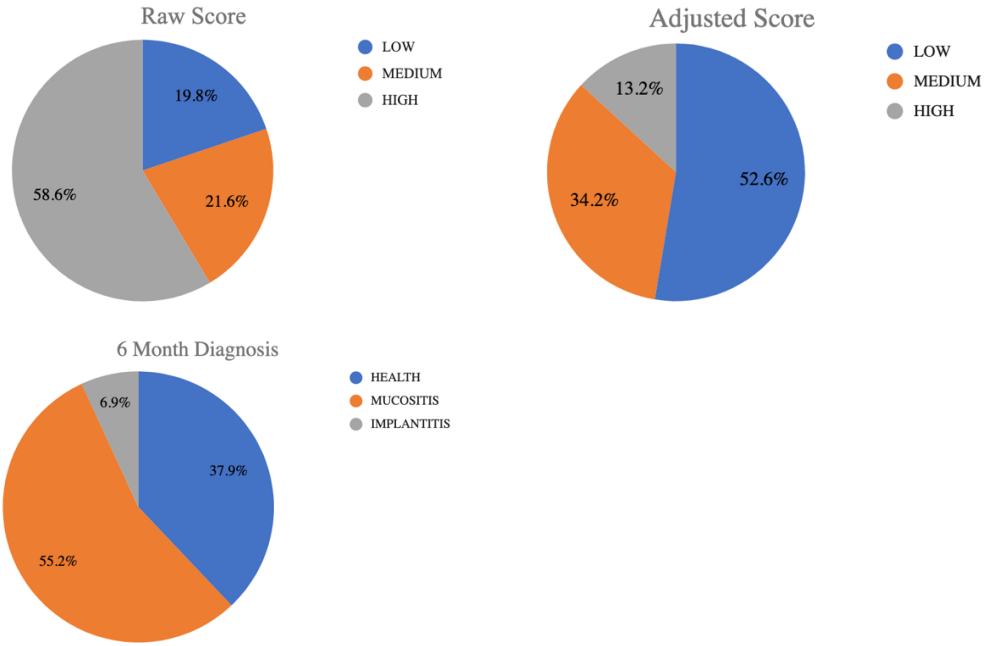

Figure 2: Pie Charts of Raw and Adjusted RAQ Scores versus 6-Month Diagnoses Percentiles

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