1-1-2016

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Accepted version. *Journal of Prosthodontics*, Vol. 25, No. S1 (January 2016): S2–S15. DOI.

A Systematic Review of Recall Regimen and Maintenance Regimen of Patients with Dental Restorations. Part 1: Tooth-Borne Restorations

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Journal of Prosthodontics, Vol 25, No. S1 (January 2016): pg. S2-S15. DOI.

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Abstract
Purpose: To evaluate the current scientific evidence on patient recall and maintenance of dental restorations on natural teeth, standardize patient care regimens, and improve maintenance of oral health. An additional purpose was

Journal of Prosthodontics, Vol 25, No. S1 (January 2016): pg. S2-S15. DOI.

to examine areas of deficiency in the current scientific literature and provide recommendations for future studies.
Materials and Methods: An electronic search for articles in the English language literature from the past 15 years was performed independently by multiple investigators using a systematic search process. After application of predetermined inclusion and exclusion criteria, the final list of articles was reviewed in depth to meet the objectives of this review.
Results: The initial electronic search resulted in 2161 titles. The systematic application of inclusion and exclusion criteria resulted in 12 articles that met the objectives of the study. An additional 4 articles were added through a supplemental search process for a total of 16 studies. Out of these, 9 were randomized controlled clinical trials and 7 were observational studies. The majority of the studies (14 out of 16) were conducted in the past 5 years, and most of the studies were conducted in Europe (10). Results from the qualitative data, on a combined 3569 patients, indicated that outcome improvements in recall and maintenance regimen were related to (1) patient/treatment characteristics (adherence to recall appointments, type of restoration and type of restorative material); (2) agent (chlorhexidine, fluoride, triclosan); and (3) professional interventions (repeated oral hygiene instruction, regular oral hygiene intervention).
Conclusions: There is minimal evidence related to recall regimens in patients with removable and fixed tooth-borne restorations; however, there is considerable evidence indicating that patients with tooth-borne removable and fixed restorations require lifelong dental professional maintenance to provide repeated oral hygiene instruction and regular oral hygiene intervention customized to each patient's treatment. Current evidence also indicates that use of specific oral topical agents like chlorhexidine, fluoride, and triclosan can aid in reducing risk for gingival inflammation, dental caries, and candidiasis. Therefore, these agents may aid in improvement of professional and at-home maintenance of various tooth-borne dental restorations. Furthermore, due to the heterogeneity of patient populations, restorations, and treatment needs, the evidence compels forethought of creating clinical practice guidelines for recall and maintenance of patients with tooth-borne dental restorations.

Patients seeking prosthodontic care often present with significant previous dental treatment, a complex etiology of factors contributing to the loss of tooth structure, and equally complex treatment needs to restore function and esthetics. Treatment plans to address patient needs using tooth-borne restorations range from intracoronal and partial extracoronal restorations, single crowns, veneers, and fixed dental prostheses (FDP) (formerly called fixed partial dentures) to partial removable dental prostheses (RDP) (formerly called removable partial dentures). Each requires careful planning, meticulous coordination of care, and a long-term partnership with the patient to maintain an enduring result. This includes an appropriate patient recall regimen, professional maintenance, as well

as at-home maintenance.[1-17] Although the dentist and patient share the mutual goal of esthetic and enduring treatment, the options and relative merits of maintenance protocols to predictably achieve stable results are lacking. Maintenance protocols in patients with tooth-borne removable and/or fixed restorations are necessary to prevent restoration failure, prevent disease (caries and periodontitis), and minimize risk for failure of the supporting teeth themselves. Furthermore, maintenance protocols in healthy adult patients with tooth-borne restorations may be significantly different when compared to patients with no restorations, or patients with acute or chronic oral and systemic diseases.

In medicine, recall and maintenance protocols have been increasingly emphasized to manage and improve patient health outcomes.[18-21] Human lifespans are increasing, and management of chronic diseases and associated morbidities has increased the emphasis on patient-centered management of professionally directed recall and maintenance programs.[18-21] For example, Liebs et al[18] showed that aquatic therapy in patients following knee replacement had the effect size of nonsteroidal anti-inflammatory medications in management of continuing osteoarthritis. Similarly, Mandic et al[19] showed that a community-based cardiac rehabilitation program improved survival and decreased both hospitalizations and required procedures in patients with cardiovascular disease. Maintenance programs for diabetics have focused on the most common complications such as ophthalmic and foot issues, which were influenced by the patient's age, health literacy, behavioral assessment, and economic situation.[20] Often, maintenance protocols have been structured to accommodate patients at high risk for relapse based on completed or anticipated procedures, and have factored in patient-specific factors to optimize recall intervals.[20]

Maintenance programs in dentistry have often focused on younger patient cohorts and on assessing and managing chronic processes such as dental caries or periodontal disease.[22-24] Primary prevention procedures such as fluoride varnish and sealant application have been advanced, but are often oriented to pediatric patients and geared toward prevention of caries.[25] Treatment planning by risk assessment of caries and periodontal disease has been advocated and adopted in educational settings and in clinical care with improved

outcomes.[26-28] In a systematic review of dental recall intervals and incidence of dental caries, it was determined that a 6-month recall protocol for caries prevention was not supported by the literature, and that existing evidence for current recall protocols is weak.[25,29] The authors concluded that clinicians might consider assigning recall intervals to patients on the basis of patients' risk of developing caries. Traditionally, both patients at low risk and at higher risk for dental disease have been placed on 6-month recalls with the logic of early detection of disease, prevention of disease, and oral cancer screening.[25,30] An additional consideration for continued practice of a 6-month recall is to allow the dentist to identify patients' systemic health issues such as sleep disorders, diabetes, or hypertension, and appropriately refer the patient to physicians in a timely manner.[31,32] Furthermore, the invaluable opportunity to perform an oral cancer exam at patient recall visits should not be underestimated.[33]

Patients receiving complex tooth-borne dental restorations are at an increased risk for aftercare, and the need for patient- and procedure-specific maintenance programs is important.[12,15,17] For example, in evaluating caries risk of an abutment for the more complex FDP compared to the less complex single crown, FDP abutments had a 27% increased risk for caries.[12] Additionally, when complex tooth-borne restorations such as FDPs are placed, and patients do not adhere to a maintenance program, plaque levels and loss of teeth due to periodontal disease were significantly higher than when patients did comply with a maintenance program.[12] In patients with RDPs, maintenance programs with an illustrated manual resulted in a significant decrease in denture plaque accumulation measures; however, this effect was lost 1 year later, prompting the authors to conclude that regular supervision can result in a good standard of oral and denture hygiene in RDP wearers over a prolonged period of time.[15] Overnight use of RDP, denture age, and storage conditions have also been shown to significantly increase the incidence of oral mucosal lesions in patients who wear an RDP.[1]

Maintenance of tooth-borne restorations has become more important in dentistry as a higher percentage of patients are retaining more of their dentition, our society is aging, and more patients are receiving complex dental procedures. With age-associated loss of tooth structure, an oral environment often altered from medication-induced

xerostomia, and with consideration of both functionally related quality of life and implications of financial burden, the need for maintenance programs for individuals with tooth-borne restorations is compelling.[1-17,33]

The purpose of this systematic review was to evaluate the current best scientific evidence on patient recall and maintenance of dental restorations on natural teeth, standardize patient care regimens, and improve maintenance of oral health. An additional purpose was to examine areas of deficiency in the current scientific evidence and provide recommendations for future studies. For the purposes of this systematic review, patient recall was defined as the routine follow-up of patients following insertion of tooth-borne dental restorations. Professional maintenance was defined as the procedures and guidance provided by the dentist and dental auxiliaries. At-home maintenance was defined as the daily oral hygiene and maintenance routine patients perform to maintain their natural teeth and dental restorations.

Materials and methods

An electronic search of the English language literature was performed independently by two investigators (AB, DC) using the PubMed search engine and Cochrane Library database. The specific search terms, search string, and limits are presented in Table 1. The specific PICO question for this systematic review was: in patients with tooth-borne restorations, does one specific recall regimen and dental maintenance regimen, or no regimen, improve clinical outcomes and patient care and optimize maintenance of oral health? The period searched was from January 1, 1999 to December 31, 2014. The search limits applied to the electronic search were the English language, search period, and clinical studies (Table 1). The anticipated tooth-borne restorations of interest in this study were intracoronal restorations, extracoronal restorations, single crowns, veneers, FDP, and partial RDP. The predetermined inclusion criteria were (1) English language article in a peer-reviewed journal; (2) any clinical study published between January 1, 1999 to December 31, 2014; and (3) any clinical study with the primary focus on patient recall regimen, professional maintenance, or home maintenance regimen for tooth-

borne restorations, in healthy patients. The predetermined exclusion criteria were (1) articles that did not pertain to items described in the inclusion criteria; (2) articles that did not pertain to the objectives of the systematic review; (3) articles that did not describe data on recall and maintenance of patients with tooth-borne restorations; (4) articles that described data on unhealthy patients or patients with periodontal disease; (5) review articles or technique articles without associated clinical study and data; (6) patients or data being repeated in other included articles; and (7) article description that would not allow extraction of qualitative or quantitative data related to objectives of the study.

Table 1. Description of the search terms and search process used in the PubMed search engine

Search	Query	Results
#1	((Prosthodontics[MeSH] OR prosthodontics[tiab] OR prosthodont*[tiab]) OR (Crowns[MeSH]) OR (Dental Abutments[MeSH] OR abutments[tiab]) OR (Dental Clasp[MeSH] OR dental clasp[tiab] OR denture clasp[tiab]) OR (Dental prosthesis[MeSH] OR dental prosthesis[tiab]) OR (Dental Prosthesis Design[MeSH]) OR (Dental Prosthesis Repair[MeSH]) OR (Dental Prosthesis Retention[MeSH]) OR (Dental Prosthesis, Implant-Supported[MeSH]) OR (Dental Restoration Failure[MeSH]) OR (Dental Restoration Repair[MeSH]) OR (Dental Restoration Wear[MeSH]) OR (Dental Restoration, Permanent[MeSH] OR permanent filling[tiab]) OR (Dental Restoration, Temporary[MeSH] OR temporary dental filling[tiab] OR temporary dental prosthesis[tiab]) OR (Dental Veneers[MeSH] OR dental veneers[tiab] OR dental laminat*[tiab]) OR (Denture Precision Attachment[MeSH] OR intracoronal attachment[tiab]) OR (Denture, Partial[MeSH] OR partial denture[tiab]) OR (Denture, Partial, Fixed[MeSH] OR fixed bridge*[tiab] OR pontic*[tiab]) OR (Denture, Partial, Fixed, Resin-Bonded[MeSH] OR resin-bonded bridge[tiab] OR Maryland bridge[tiab]) OR (Denture, Partial, Removable[MeSH] OR removable partial denture[tiab]) OR (Denture, Partial, Temporary[MeSH] OR temporary denture[tiab] OR interim dental prosthesis[tiab]) OR (Inlays[MeSH] OR inlays[tiab] OR onlays[tiab]) OR (Tooth, Artificial[MeSH] OR artificial tooth[tiab] OR artificial teeth[tiab])) AND (((Comprehensive dental care[MeSH] OR comprehensive dental care[tiab]) OR (Dental care[MeSH] OR dental care[tiab]) OR (Dental health services[MeSH] OR dental health services[tiab]) OR (General Practice, Dental[MeSH] OR dental practice[tiab]) OR (Oral health[MeSH] OR oral health[tiab]) OR (Oral hygiene[MeSH] OR oral hygiene[tiab] OR dental hygiene[tiab]) OR (Preventive Dentistry[MeSH] OR preventive dentistry[tiab])) OR ((Appointments and schedules[MeSH]) OR (Case management[MeSH] OR case management[tiab]) OR (Office Visits[MeSH] OR office visit[tiab]) OR (Patient compliance[MeSH] OR patient compliance[tiab] OR patient adherence[tiab] OR patient non-adherence[tiab]) OR (Self report[MeSH] OR self report[tiab] OR patient recall[tiab] OR motivational interview*[tiab]) OR (Time factors[MeSH] OR time factors[tiab])) OR ((Dental prophylaxis[MeSH] OR dental prophylaxis[tiab]) OR (Dental Scaling[MeSH] OR dental scaling[tiab] OR root scaling[tiab]) OR (Diagnosis, Oral[MeSH] OR oral diagnosis[tiab] OR oral examination[tiab]) OR (Periodontal Debridement[MeSH] OR periodontal debridement[tiab]) OR (Root planing[MeSH] OR root planing[tiab])) OR ((Dental Devices, Home Care[MeSH] OR dental floss[tiab]) OR (Toothbrushing[MeSH] OR toothbrushing[tiab]) OR (Toothpastes[MeSH] OR	15,238

Search	Query	Results
	toothpaste[tiab]) OR (Dentifrices[MeSH] OR dentifrice[tiab]) OR (Mouthwashes[MeSH] OR mouthwash[tiab]) OR (Chewing Gum[MeSH] OR chewing gum[tiab]) OR (Triclosan[MeSH] OR triclosan[tiab]) OR (Mouth protectors[MeSH] OR mouth protectors[tiab] OR mouth piece[tiab] OR mouthpiece[tiab] OR mouth guard[tiab]))	
#2	#1 + English	13,069
#3	#2 + Humans	11,257
#4	#3 + 1999-present	7,187
#5	#4 + Limit to Clinical Trial, Comparative Study, Controlled Clinical Trial, Multicenter Study, Observational Study, Randomized Controlled Trial, or Validation Study	2,161

The electronic search process was systematically conducted in three stages. A PRISMA[34] (Preferred Reporting Items for Systematic Reviews and Meta-analyses) format was used as a filter to remove duplicate articles and to ensure a systematic search process. In stage 1, the investigators independently screened all relevant titles of the electronic search, and any disagreement was resolved by discussion. In situations where the application of the exclusion criteria was not clear, the controversial article was included for consideration in the abstract stage. In stage 2, the investigators independently analyzed the abstracts of all selected titles, and disagreements were resolved by discussion. In situations of uncertainty, the abstract was included for the subsequent full-text stage. After the application of the exclusion criteria, the definitive list of articles was screened at stage 3 by the investigators to extract qualitative and quantitative data (when available). A supplemental electronic search for articles from Scopus, Google Scholar, and CINAHL (Cumulative Index to Nursing and Allied Health Literature) search engines along with a hand search of references of all included articles was conducted using systematic methods. Additionally, articles that had a lag time to appear on the PubMed search engine were also screened for the three stages, as part of the supplemental search. Data from all included studies were then tabulated, analyzed, and compared to satisfy the objectives of the review.

Results

The initial electronic search using the specific search terms from the PubMed search engine resulted in a total of 2161 titles, out of which 54 abstracts were applicable to the study. Reviewing the abstracts resulted in 22 full-text articles being appropriate for further

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review. Incorporating a supplemental and electronic hand search process and systematic exclusion, eventually resulted in 16 full text articles, all of which reported data on maintenance of dental restorations on natural teeth (Fig 1). These 16 studies were included for qualitative data extraction and analysis (Table 2). Given the nature of the topic and PICO question posed in this systematic review, the authors did not identify any significant quantitative data. Therefore, no statistical analysis was performed.

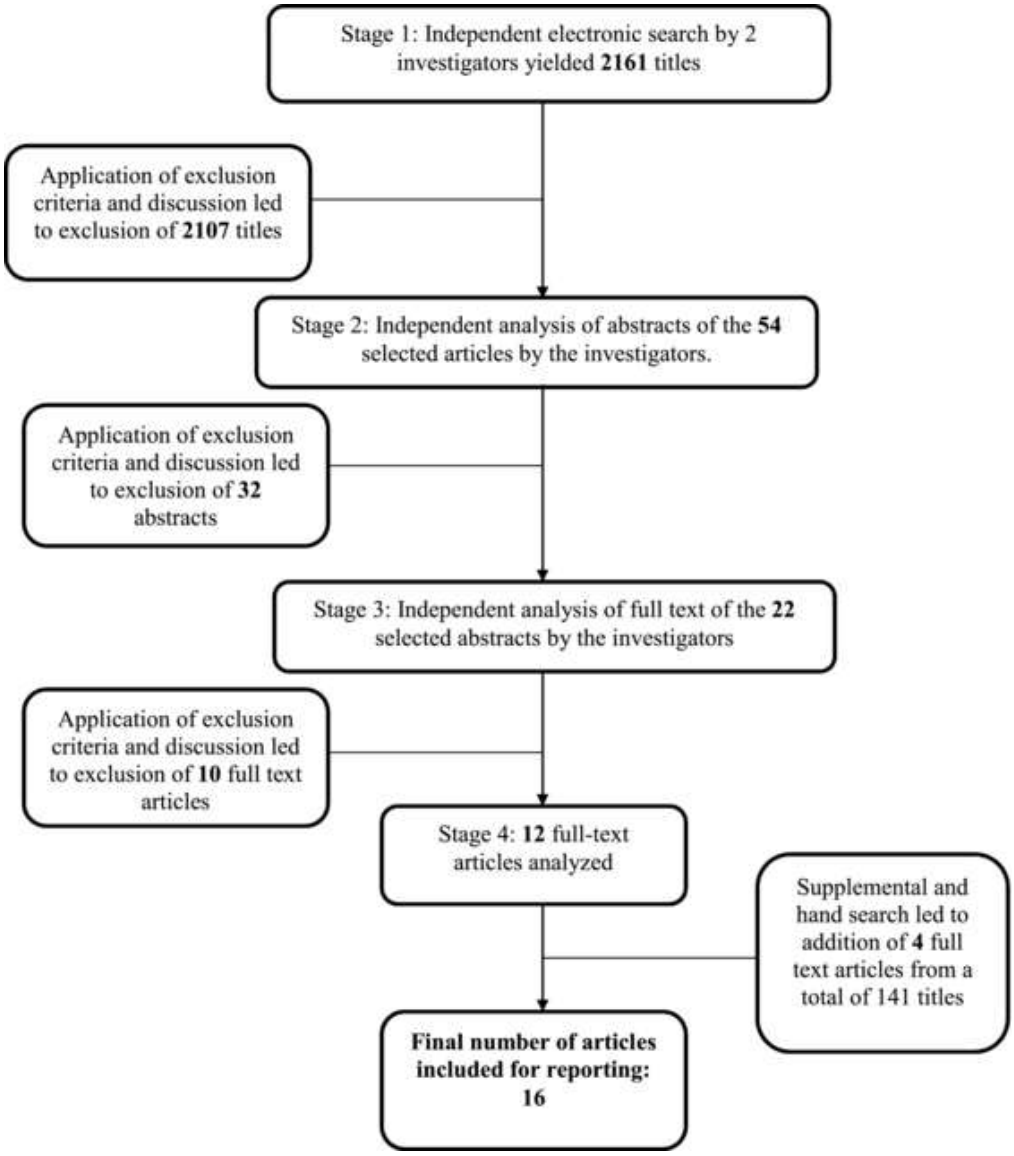

Figure 1. Systematic search process.

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Table 2. Descriptive data from the 16 included studies that reported on maintenance of tooth-borne restorations

Author and year	Type of study	Study setting	Geographic region	Number of patients	Age of patients (range and mean or median age)	Type of tooth-borne restorations included in the study	Study sponsorship
Ercalik-Yalcinkaya and Ozcan (2015)[1]	Observational	University	Europe (Turkey)	314	Range: 29 to 86 yearsMedian age: 58	Natural teeth and partial RDP	University
Morino et al (2014)[2]	RCT	Elderly care facility	Asia (Japan)	34 enrolled; 30 completed	Range: NRMean age: 85.5	Natural teeth and partial RDP	Government
Ekstrand et al (2013)[3]	RCT	Elderly care facilities (6)	Europe (Denmark)	176 consented; 125 completed	Range: 45 to 103 yearsMean age: 81	Natural teeth and partial RDP and FDP	Corporate; Colgate Palmolive
Fardal and Grytten (2013)[4]	Observational	Single private practice	Europe (Norway)	43	Range: 29 to 74 yearsMean age: 67.4	Natural teeth and partial RDP and FDP	Self-sponsored
De Visschere et al (2012)[5]	RCT	Elderly care facilities (12)	Europe (Belgium)	360	Range: 52 to 102 yearsMean age: 84.8	Natural teeth and partial RDP	Corporate (oral health care products were provided free by GABA International, Eureka Pharma Belgium, Oral-B Belgium and Johnson & Johnson)
Lopez-Jornet et al (2012)[6]	RCT	Elderly care facilities	Europe(Spain)	70	Range: 65 to 94 yearsMean age:75	Natural teeth and partial RDP	Not reported
van der Putten et al (2012)[7]	RCT	Elderly care facilities (12)	Europe (Netherlands)	342	Range: NRMean age: (>80)	Natural teeth and partial RDP	Private foundation and corporate sponsorship (GABA Internationa

1. RCT: randomized clinical trial; RDP: removable dental prosthesis; FDP: fixed dental prosthesis.

Author and year	Type of study	Study setting	Geographic region	Number of patients	Age of patients (range and mean or median age)	Type of tooth-borne restorations included in the study	Study sponsorship
							l, Johnson & Johnson, and Novia Cura)
Wolfart et al (2012)[8]	Observational	University	Europe (Germany)	493 total enrolled (but 399 attended the recall)	Range: NRMean age: 59	Natural teeth and partial RDP and FDP	Not reported
Zenthöfer et al (2012)[9]	RCT	Elderly care facilities	Europe (Germany)	106	Range: 49 to 95 years Mean age: 81	Natural teeth and partial RDP	University and corporate support (GABA GmbH, Lorrach, Germany)
Ababnaeh et al (2011)[10]	Observational	University	Middle East (Jordan)	102	Range: 15 to 70 years Mean age: 34	Intracoronal restorations (Class II, III, V), single crowns and FDP	Not reported
Nassar et al (2011)[11]	RCT	University	South America (Brazil)	20	Range: 18 to 70 yearsMean age: NR	Intracoronal restorations (Class V composite resin) on the cervical area of of anterior teeth	University
Ikai et al (2010)[12]	Observational	University	Asia (Japan)	55	Range: NR	FDP	Not reported
					Mean age: 61		
Ortolan et al (2010)[13]	Observational	University	Europe (Croatia)	93	Range: 21 to 95 years Mean age: 51.8	Single crowns and FDP	Government
Vered et al (2009)[14]	RCT	Multiple community centers (25)	Middle East (Israel)	1357	Mean age 58.8 ± 8.8 for test patients and 58.2 ± 8.3 for control patients	Natural teeth and single crowns	Corporate; Colgate Palmolive

Author and year	Type of study	Study setting	Geographic region	Number of patients	Age of patients (range and mean or median age)	Type of tooth-borne restorations included in the study	Study sponsorship
Ribeiro et al (2008)[15]	RCT	University	South America (Brazil)	53	Range: 36 to 74 yearsMean age: 55	Natural teeth and partial RDPs	University
Zoellner et al (2002)[17]	Observational	University	Europe (Germany)	100	NR	Natural teeth, single crowns and FDPs	Not reported

Out of the 16 studies, 9 were randomized controlled clinical trials and 7 were observational studies. A majority of the studies (14/16) were conducted in the past 5 years, and most were conducted in Europe (10), followed by Asia (2), South America (2), and the Middle East (2). A total of 3569 patients were included in these 16 studies. Eight studies were conducted in a university setting, six were conducted in elder care facilities, one was conducted in a private practice setting, and one was conducted in a community center. The study setting directly correlated with the nature of patients and types of restorations seen in each study. Studies in elder care facilities included geriatric patients who were partially edentulous and either had partial RDP or FDP and additional restorations. Studies in university settings, private practices, and community centers comprised adult patients with a broad age range and different types of tooth-borne restorations. Five studies received corporate support (partial or full), six were supported by universities and/or governments, and five did not report on study sponsorship. To segregate the qualitative data and provide a meaningful method of understanding outcomes, the analyzed data were grouped into three categories: (1) outcomes related to patient-specific restorative treatment; (2) outcomes related to maintenance using oral topical agents, and (3) outcomes related to maintenance using professional intervention (Table 3).

Table 3. Professional maintenance, at-home maintenance, and patient recall data from the 16 included studies that reported on maintenance of tooth-borne restorations

Author and year	Categorization of study outcome in this systematic review	Primary objective of the study	Professional maintenance regimen reported in the study	At-home maintenance regimen reported in the study	Patient recall regimen used in the study
Ercalik-Yalcinkaya and Ozcan (2015)[1]	Patient/treatment characteristic-related outcome	To study the influence of self-reported prosthesis hygiene regimens and prosthesis usage habits on the presence of oral mucosal lesions in complete removable and/or partial RDP wearers	NA	Daily habits of prosthesis use and cleaning habits and hygiene methods recorded	NA
Morino et al (2014)[2]	Professional intervention-related outcome	To investigate the role of the professional oral health care for elderly in improving geriatric oral health, the effects of short-term professional oral health care including on oral microbiological parameters	On the test group, manual brushing of remaining teeth with a toothbrush by dental hygienists performed once per week for 1 month.	For cleaning dentures, a toothbrush, denture cleaner (tablet type), and ultrasonic cleansing apparatus were used	Baseline, 1 month, 3 months, and 5 months
Ekstrand et al (2013)[3]	Agent-related outcome	To compare the effectiveness of tooth brushing with 5000 ppm vs. 1450 ppm of fluoridated toothpaste for controlling root caries in nursing home residents	Participants had their teeth brushed by nursing staff twice a day with either 5000 ppm toothpaste (test) or with 1450 ppm toothpaste (control)	NA	Baseline and 8-month recall for evaluation
Fardal and Grytten (2013)[4]	Patient/treatment characteristic-related outcome	To compare teeth and implants during maintenance therapy in terms of the number of disease-free years and costs	Professional maintenance included scaling and root planing according to needs of the patient. When there was increase in	Written oral hygiene instructions and individualized instructions based on patient needs	Recall was 2 to 4 times a year and sometimes alternated between the periodontist and general dentist

1. NA: not applicable.

Author and year	Categorization of study outcome in this systematic review	Primary objective of the study	Professional maintenance regimen reported in the study	At-home maintenance regimen reported in the study	Patient recall regimen used in the study
		as part of a quality control measure	probing depth, surgical intervention was performed but no attempt at regeneration		
De Visschere et al (2012)[5]	Professional intervention-related outcome	To compare a supervised vs. a nonsupervised implementation of an oral health care guideline	Oral health education and instruction and monitoring visits by investigator every 6 weeks	Followed the oral hygiene instructions given in the intervention (oral health care guideline)	Baseline and 6-month recall
Lopez-Jornet et al (2012)[6]	Agent-related outcome	To determine the effects of a 0.2% alcohol-free chlorhexidine mouthwash applied twice a day during 30 days in patients over 65 years of age	Patients received instructions on correct oral and denture hygiene, with the supply of a whitening rinse and toothbrush with 0.05% fluoridated toothpaste, and an instruction sheet. After 7 days, they were provided with the chlorhexidine rinse	Twice daily use of 10 ml 0.2% alcohol-free chlorhexidine mouthwash for 60 seconds	Instructions, recall at 8 days for baseline, evaluation at 15 days and 30 days
van der Putten et al (2012)[7]	Professional intervention-related outcome	To assess the effectiveness of a supervised implementation of the "Oral Health Care Guideline for Older People in Long-Term Care Institutions" (OGOLI) in Netherlands	The control group received oral health care according to the nonsupervised implemented OGOLI, the intervention consisted of a supervised implementation of the OGOLI and a daily oral health care protocol derived from the OGOLI. The same products and materials were provided in all care homes of the intervention group	Was individually determined in control group and followed a controlled OGOLI protocol, which included daily monitoring of brushing	Baseline, monitoring visits of the dental hygienist every 6 weeks and a final recall at 6 months
Wolfart et al (2012)[8]	Patient/treatment characteristic-related outcome	To study the recall attendance and	Recall at 6 months, motivation and	NA	Recall at 6-month intervals;

Author and year	Categorization of study outcome in this systematic review	Primary objective of the study	Professional maintenance regimen reported in the study	At-home maintenance regimen reported in the study	Patient recall regimen used in the study
		maintenance for a patient population after prosthodontic treatment	re-motivation of patients. Maintenance was classified as: "minimal"—group intervention included tooth cleaning; "moderate" included root planing; "extensive" included extraction, or post and core		patients contacted up to 6 times for recall appts. Cumulative attendance rate determined after up to 60 months. Actual mean for FDP was 40 months and partial RDP was 38 months
Zenthöfer et al (2012)[9]	Professional intervention-related outcome	To compare three types of intervention for improving oral hygiene with a control	For the three intervention groups, professional cleaning and oral hygiene instructions to all patients except controls; included 30 minutes of individualized oral hygiene instructions, based on each patient's manual and cognitive ability	Brushing of teeth and any partial dentures and use of mouth rinses	Baseline, 2 weeks, 6 weeks, and 12 weeks
Ababnaeh et al (2011)[10]	Patient/treatment characteristic-related outcome	To investigate the relationship between the type and material of dental restorations and periodontal health	Not reported	Patient frequency of brushing, method, and auxiliary brushing data were collected	NA
Nassar et al (2011)[11]	Agent-related outcome	To evaluate the effects of maintenance therapy with or without the use of 0.12% chlorhexidine in the periodontal tissues of patients with diabetes mellitus who had carious	Oral hygiene instructions for mechanical control of plaque and periodontal treatment with antibiotic prophylaxis that was the same for both groups. The 0.12% chlorhexidine rinse was given	Oral hygiene instructions for mechanical control of plaque that was the same for both groups	Baseline examination and 90 days

Author and year	Categorization of study outcome in this systematic review	Primary objective of the study	Professional maintenance regimen reported in the study	At-home maintenance regimen reported in the study	Patient recall regimen used in the study
		lesions restored with composite resin	for the test group		
Ikai et al (2010)[12]	Patient/treatment characteristic-related outcome	To evaluate survival rate and the reasons of failure of FDPs without having regular maintenance in the long-term after insertion	NA	Not reported	NA
Ortolan et al (2010)[13]	Patient/treatment characteristic-related outcome	To assess and observe the oral hygiene and gingival condition in patients before and after fixed prosthodontic therapy through a 12-month period in combination with oral hygiene instructions	Oral hygiene instructions were given at baseline followed by professional cleaning at 14 days, 1 month, 6 months, and 12 months	Not reported	Baseline, 14 days, 1 month, 6 months, and 12 months
Vered et al (2009)[14]	Agent-related outcome	To compare fluoride-containing toothpastes with or without 0.3% triclosan on root caries over a 3-year period on patients with tooth-borne restorations (crowns)	Not reported	Participants were asked to either brush twice daily with toothpaste containing fluoride and 0.3% triclosan dentifrice or a fluoride-containing toothpaste without triclosan	Baseline, 1 year, 2 years, and 3 years
Ribeiro et al (2008)[15]	Professional intervention-related outcome	To determine the effect of two different preventive oral hygiene education and motivation programs on the plaque and gingival index, as well as denture hygiene of patients provided with	Oral hygiene instruction, with or without detailed self-instructions with illustrated photographs	Not reported	Baseline, day 7, 15, 30 days, 3, 6, 12 months following partial RDP placement

Author and year	Categorization of study outcome in this systematic review	Primary objective of the study	Professional maintenance regimen reported in the study	At-home maintenance regimen reported in the study	Patient recall regimen used in the study
		RDP during a 12-month follow-up			
Zoellner et al (2002)[17]	Patient/treatment characteristic-related outcome	To compare diagnosis of caries on the interproximal surfaces of natural teeth and teeth with crowns by clinical exam and by radiographic exam	NA	NA	NA

Outcomes related to patient-specific restorative treatment

Seven studies (all observational studies) reported on a specific patient/treatment characteristic-related improvement for professional and/or homecare maintenance of tooth-borne restorations. Ortolan et al[13] conducted a study on 93 patients and reported that patients with single crowns showed better oral hygiene levels than patients with FDPs during professional recall and maintenance. Restorative material selection between metal ceramic and metal acrylic did not influence plaque levels in this study. Along similar lines, Ikai et al[12] showed that in FDP patients who did not participate in a professional maintenance program, the mean plaque index was high (43.2%), and the failure rate of the FDPs was also high (33%) over an average follow-up period of 16.5 years. The most common reason for failure and complications for FDP abutments was periodontal disease. Interestingly, Wolfart et al,[8] in a large retrospective study of 493 patients, studied the recall behavior of prosthodontic patients and found that patients treated with fixed restorations showed a higher recall attendance than patients treated with RDPs. Additionally, patients with RDPs needed more "extensive" and "moderate" maintenance than patients with fixed restorations.[8] The authors cautioned that this difference should be considered during prosthetic planning and patient consultation.

Ababnaeh et al[10] showed that the choice of restorative material may adversely impact periodontal health, and that unrestored teeth have better periodontal health than restored teeth. There were 102 patients in this cross-sectional study, which found that Class III restorations, tooth-colored restorative material, and porcelain were associated with relatively better periodontal conditions than other restoration types and materials. Class II restorations, crowns, and FDP abutments made of acrylic and nonprecious alloys were associated with the greatest periodontal breakdown. Class V restorations were associated with the greatest attachment loss due to periodontitis or perhaps due to gingival recession. Ercalik-Yalcinkaya et al,[1] in a study on removable prosthesis use, showed that overnight use and storage conditions of complete or partial RDPs had a larger impact on the incidence of oral mucosal lesions than the frequency of prosthesis cleaning. The authors also showed that overnight use of removable prostheses had a direct influence on the occurrence of oral mucosal lesions and interestingly, letting them dry overnight did not have a significant effect on the development of oral mucosal lesions.

Regarding clinical and radiographic examination at professional maintenance appointments, Zoellner et al[17] examined 100 randomly selected patients who underwent restorations with fixed prostheses and had at least one secondary carious lesion. They compared the use of clinical examination to the use of radiographs in the diagnosis of caries in the interproximal areas of nonrestored teeth and teeth with crowns. The authors concluded that radiographs improved the diagnostic sensitivity for interproximal caries in nonrestored teeth, yet clinical examination was more reliable than the radiographic exam on teeth with crowns. Fardal and Grytten[4] conducted a retrospective study in a private practice setting on 43 patients with tooth-borne removable and fixed restorations and implant-supported restorations, all of whom had a history of periodontitis. The authors aimed to determine if implant-supported restorations are as expensive as tooth-borne restorations to maintain. They concluded that the number of disease-free years was similar for teeth and implants, but the cost of implant maintenance was higher than that of tooth maintenance.

Outcomes related to maintenance using oral topical agents

Four studies (all randomized controlled clinical trials [RCTs]) reported on a specific agent-related improvement for professional and/or homecare maintenance of tooth-borne restorations. Ekstrand et al[3] compared fluoride toothpastes with 5000 ppm or 1450 ppm in a RCT on 125 patients and determined that toothpaste with 5000 ppm of fluoride was significantly more effective for controlling root caries lesion progression and in promoting remineralization. Patients involved in this study were from elder care facilities in Denmark and had some remaining teeth and either a partial RDP or FDP. Nassar et al[11] reported in an RCT on 20 patients that using 0.12% chlorhexidine could be effective for the health of periodontal tissues around teeth restored with composite resin. In this study, done in a university setting in Brazil on patients with diabetes mellitus, the effect of maintenance therapy with and without 0.12% chlorhexidine rinse was studied on periodontal tissues of teeth restored with Class V composite resin. Vered et al[14] showed that 0.3% triclosan-containing fluoride toothpaste significantly decreased root caries (by 6 times) over a 3-year period. The crown failure was three times higher when using toothpaste without triclosan. In this large-scale RCT on 1357 patients, fluoride-containing toothpastes were compared with or without 0.3% triclosan toothpaste to evaluate primary caries on root surfaces and recurrent caries around crowns over a 3-year period.[14] In a double-blind RCT, Lopez-Jornet et al[6] showed that twice-daily use of 10 ml of 0.2% alcohol-free chlorhexidine rinse for 60 seconds significantly decreased colony forming units (cfu) of *Candida albicans* and improved gingival health in elderly patients with partial RDPs.

Outcomes related to maintenance using professional intervention

Five studies (all RCTs) reported on professional interventions (oral hygiene instruction or oral hygiene intervention) that demonstrated improvement of oral health outcomes. Zenthöfer et al[9] and Morino et al[2] independently conducted studies in nursing homes on partially edentulous patients with both natural teeth and partial RDPs and concluded that professional oral health intervention

(including professional cleaning of teeth and dentures and manual brushing by hygienists) significantly improved oral health conditions in the elderly. Two additional RCTs by De Visschere et al[5] and van der Putten et al[7] also conducted in nursing home settings on partially edentulous patients showed that implementation of an oral hygiene instruction program was more effective than a nonsupervised program in improved oral health conditions in the elderly. De Visschere et al[5] also noted that additional individual factors such as the nursing home institution might also have an impact on outcome improvement. Along similar lines, Ribeiro et al[15] in an RCT in Brazil concluded that oral hygiene instructions improved gingival indexes compared to the control group of no oral hygiene instructions. The authors also noted that reinforcement of these professional instructions was necessary to maintain compliance.

Discussion

The aim of this systematic review was to examine the current scientific evidence on patient recall and maintenance of dental restorations on natural teeth, to identify and compare existing patient care regimens with the goal of improving oral health. An additional purpose was to examine areas of deficiency in the current scientific evidence and provide recommendations for future studies. It is important to note that the focus of this systematic review was on articles that provided data on patient recall and maintenance regimens on periodontally stable/healthy patients. Management of patients with periodontal disease or other diseases is outside the scope of this systematic review. Though tooth-borne fixed and removable restorations are performed extensively, there is little knowledge related to maintenance and recall regimens for these patients. Additionally, several patients may have implant restorations in addition to tooth-borne restorations, warranting incorporation of protocols for recall and maintenance of two distinct types of restorations in the oral cavity. The authors of two previous systematic reviews[25,29] noted that the popular 6-month patient recall system may not necessarily be based on sound scientific evidence, and some patients may be placed on up to a 2-year professional recall; however, these two systematic reviews included pediatric patients with routine pediatric dental needs, and not adult patients with complex tooth-borne restorations.[25,29]

Based on the evidence identified in this systematic review, it can be anticipated that patients with tooth-borne fixed or removable restorations present a higher risk for subsequent dental care burden, compared to routine patients with no restorations. Therefore, institution of a patient recall regimen, as well as professional and homecare regimens, can aid in long-term maintenance of tooth-borne restorations and improved oral health.

In this systematic review, patient recall and maintenance (professional and homecare) regimen was divided into three elements: (1) outcomes related to patient-specific restorative treatment; (2) outcomes related to maintenance using oral topical agents, and (3) outcomes related to maintenance using professional intervention. The authors believe that any patient recall and maintenance (professional and homecare) regimen on tooth-borne restorations should incorporate these three elements, as they are complimentary in ensuring an improved long-term clinical outcome. For outcomes related to patient-specific restorative treatment, seven observational studies showed that specific factors such as adherence to recall appointments, restorative material, and type of restoration could affect the professional maintenance and homecare regimens. For outcomes related to maintenance using oral topical agents, four RCTs successfully demonstrated that the tested agent (chlorhexidine, fluoride, triclosan) was effective for the oral conditions studied. Similarly, for outcomes related to maintenance using professional intervention, five RCTs successfully demonstrated that professional intervention (oral health intervention and oral health instruction) was effective in the professional or homecare maintenance protocol. This knowledge is valuable for clinicians and patients when choosing the best agent(s) in conjunction with the professional intervention and at-home maintenance for a given tooth-borne restoration. It is remarkable that 10 of 16 included studies reported on patients with partial RDPs with some remaining natural teeth. Most patients included in these studies were geriatric patients, and six of these studies were conducted in elder care facilities. Results from these studies unequivocally showed that remaining natural teeth and restorations require lifelong dental professional maintenance to provide repeated oral hygiene instruction and regular oral hygiene intervention. With an increased number of patients maintaining more teeth later in life, the

finding of lifelong need for professional maintenance may have public health and policy implications worldwide.

The predetermined inclusion criteria for this systematic review were broad to permit the inclusion of as many articles as possible. Therefore, the search terms were expansive to maximize the selection choices from the list of articles. Scrutiny of all articles was performed by both investigators to decrease errors during the review process and minimize the selection bias of the articles included. Articles determined for exclusion in the full-text analysis stage were analyzed in-depth and debated before finalizing their exclusion with various predetermined criteria. The search dates were restricted to the past 15 years in order to identify evidence from current best practices for tooth-borne restorations. Incorporating older studies with older restorative/prosthetic materials as well as outdated oral hygiene aids and practices may not be applicable to contemporary dental practice; however, it is remarkable to note that 14 of 16 included studies were conducted in the past 5 years. Additionally, 10 of 16 studies were conducted in Europe and none were conducted in the United States. The impact of this geographical disparity on the extrapolation of these research findings to the general population is unknown.

This systematic review satisfied most PRISMA checklist guidelines, yet there are some limitations to this review. First, some aspects of the results section were not applicable or amenable to the PRISMA checklist. Second, due to the nature of the topic and PICO question posed in this systematic review, the authors did not find significant quantitative data, and a statistical analysis was not performed. Third, the selection of all articles in this review was restricted to peer-reviewed journals of the English language literature. Although limiting the electronic and hand searches to English minimized problems of interpretation, there is the potential for bias if a substantial number of articles in languages other than English exist; however, a recent empirical study has shown minimal consequences of exclusion or inclusion of trials published in non-English languages on combined effect estimates in meta-analyses of RCTs.[35] Fourth, given the nature of this topic and the PICO question posed, only articles with a primary focus on patient recall and maintenance were included in the electronic search process. Like most systematic reviews, despite an exhaustive search process, it may be possible that the authors failed

to identify some additional articles in the systematic search process.[36] Gray literature was not considered in this systematic review because articles of this type are usually non-peer reviewed, with a potential for biased information or information that is restricted for use.[37] Additionally, published trials tend to be larger and show an overall greater treatment effect than gray trials.[38] However, it is unknown whether incorporation of these omitted articles would change the conclusions of this systematic review.

This systematic review identified little evidence related to patient recall regimens for removable and fixed tooth-borne restorations. Most studies had a recall regimen that satisfied the study's particular objectives, but no study compared different recall regimens for tooth-borne restorations. Also, the anticipated tooth-borne restorations of interest in this study were intracoronal restorations, extracoronal restorations, single crowns, veneers, FPDs, and partial RDPs. Most data were restricted to single crowns, FDPs, and partial RDPs. Given the limited number of studies in this systematic review, the authors did not restrict the inclusion criteria to only RCTs, nor did they perform a risk of bias analysis on any of the included studies (as typically done in Cochrane systematic reviews). Doing so would have eliminated most selected studies and resulted in an inconclusive and ineffectual conclusion from this systematic review. This would have been of little benefit to clinicians and patients. Similarly, no comparison was made for studies that reported or did not report financial support. To the author's knowledge, this is the first systematic review on recall and maintenance of patients with tooth-borne restorations and serves to provide baseline information and deficiencies on this important topic as well as provide clues for development of future long-term studies.

Conclusions

There is minimal evidence related to recall regimens in patients with tooth-borne removable and fixed restorations. However, there is an existing body of evidence indicating that patients with tooth-borne removable and fixed restorations require lifelong dental professional maintenance including providing repeated oral hygiene instruction and regular oral hygiene intervention customized to each patient's needs.

Journal of Prosthodontics, Vol 25, No. S1 (January 2016): pg. S2-S15. DOI.

Current evidence also indicates that use of specific oral topical agents like chlorhexidine, fluoride, and triclosan can aid in reducing risk for gingival inflammation, dental caries, and candidiasis. Therefore, these agents may aid in improvement of professional and at-home maintenance of various tooth-borne dental restorations. The characteristics of the patient, type of tooth-borne restoration, and restorative material can affect the professional maintenance and homecare regimens. Furthermore, due to the heterogeneity of patient populations, types of restorations, and varying treatment needs, the evidence compels forethought for creating clinical practice guidelines for recall and maintenance in patients with tooth-borne dental restorations.

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