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Prosthodontic Maintenance of Fixed Implant Restorations vs. Implant Overdentures: A Systematic Review

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Abstract

Objectives: To compare the prosthodontic maintenance requirements of fixed implant prosthesis versus that of implant overdentures after an observation period of at least 1year. **Methods**: An electronic search was performed using PubMed and Cochrane CENTRAL databases for articles published in English till the end of September 2015. Inclusion criteria were randomized controlled trials (RCTs) and prospective cohort studies (PS) which compared maintenance requirements of fixed versus removable implant supported full arch prostheses. Two reviewers independently screened titles and abstract, made data extraction and appraised the quality of included studies. **Findings**: From a total of 21 relevant studies identified, 2 RCTs and 6 PS fulfilled the inclusion criteria. The most common prosthetic complications affecting both types of prostheses were abutment screw loosening and fracture, prosthetic teeth fracture, frame work/bar fracture, acrylic resin denture base crack/fracture and denture remake. Most of the included studies were PS, and the RCTs were considered of high risk of bias accordingly there is no enough evidence to conclude that a group is superior over the other. **Application/Improvements**: To perform a true comparison, well designed RCTs should be held out. Besides, the evaluation of prosthodontic maintenance should be standardized between studies to come out with a definite conclusion..

Keywords: Dental Implant, Fixed Prostheses, Maintenance, Overdenture, Systematic Review

1. Introduction

Previously, the only treatment option for edentulous patients was the conventional complete dentures which have many problems including difficulty in eating and speaking because of lack of denture retention[1]. Recently, prostheses retained with implants have demonstrated to be a successful alternative for replacing missing teeth. Restoration of edentulous patients can be with either implant overdentures or fixed implant prostheses[2]. Overdentures are usually indicated in cases of severe loss of hard and soft tissues. They can be easily removed by the patient thus facilitating oral hygiene process. Overdentures require the placement of 2-4 implants making it more economic and with easier surgical procedures. Besides, their prosthetic parts are cheaper than fixed prostheses[3]. The benefits of the fixed implant restorations are being nonremovable, the implants are splinted together by means of the superstructure making better distribution of forces and there are no risks of fracture or wear of the attachments used to retain overdentures[4].

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There are two types of complications in implant prostheses: biologic or technical complications. Biologic complications take place in the peri-implant tissues causing adverse effect in implant function. These consist of early or late failures of dental implants and unfavorable reactions in bone and soft tissues surrounding dental implants. Mechanical failure of the implant, implant elements, and suprastructures[5] are considered as technical complications in implant prostheses. Prosthetic complications after the insertion of the final prostheses do not necessarily result in the loss of dental implants, however an increased need for repair and maintenance can occur[6].

Recent systematic reviews were either addressing the maintenance requirements of either fixed implant prostheses[6,7] or implant overdentures[8,9]. Up to our knowledge there is no systematic review comparing both types of prostheses. The aim of our systematic review was to compare the prosthodontic maintenance requirements of fixed implant prostheses to that of implant-retained overdentures.

2. Materials and Methods

A prior protocol was made for this systematic review and registered at the International prospective register of systematic reviews (PROSPERO2016:CRD42016036022). Accessible from http://www.crd.york.ac.uk/PROSPERO/display_record.asp?ID=CRD42016036022.

2.1 Search Strategy

This systematic review was performed in accordance with the PRISMA-Equity 2012 checklist[10] as much as possible.

An electronic search was carried out utilizing the PubMed and the Cochrane CENTRAL databases for articles published in English till the end of September 2015. The following keywords were used: "edentulous maxilla" OR "edentulous mandible", oral/dental "implant", "implant overdenture", "Fixed implant prosthesis" AND "technical complications" OR "mechanical complications" OR "maintenance".

A manual search of the reference lists of the included studies, recent reviews and the following dental journals was conducted: International Journal of Prosthodontics, Journal of Oral Implantology, Journal of Prosthetic Dentistry, Journal of the American Dental Association, Implant Dentistry, British Dental Journal, Journal of Clinical Periodontology, Journal of Periodontology, Periodontology 2000, European Journal of Oral Implantology, Journal of Prosthodontics, Clinical Implant Dentistry and Related Research, International Journal of Periodontics and Restorative Dentistry, Journal of Advanced Prosthodontics, Journal of Prosthodontic Research, Clinical Oral Implants Research, International Journal of Oral and Maxillofacial Implants. Contact was made with authors of the published articles through e-mail if any data was missing.

2.2 Inclusion Criteria

Inclusion criteria were adapted using the following PICOS items: (P) Types of patients: they are completely edentulous patients in either the maxilla or the mandible or both arches. (I) Type of intervention: Fixed implant prostheses. (C) Type of comparator: implant retained overdentures. (O)Type of outcome: Prosthodontic complications after a follow-up period of no less than 1 year. (S) Type of study: human studies in English language only including RCTs and PS studies.

2.3 Exclusion Criteria

Exclusion criteria were as follows: In vitro studies, case reports, technical reports, studies on animals, studies on maxillofacial defects, studies in language other than English language and combined data of the comparators.

2.4 Data Collection Process

The search included two stages. During the first stage titles and abstracts were monitored by two independent reviewers. Full texts were obtained if the studies meet the inclusion criteria or if the titles and abstracts are not giving obvious data to make a clear decision. In the second stage, data extraction was done separately by the same reviewers. Disagreements were discussed to reach a decision, and if not resolved a third reviewer was conferred.

Data extraction from the included studies were as follows: Authors, time of publication, study design, setting, gender, mean of age in years, follow-up period in years, number of patients in every group, implant system, number of implants in every group, type and total number of prostheses and opposing arch.

2.5 Quality Assessment

Assessment of the quality of individual studies was done separately and in duplicate by the same reviewers. The criteria for quality assessment among RCTs were performed by means of Cochrane Collaboration Risk of Bias Tool (CCRBT)[11]. This tool covers sequence generation, allocation concealment, blinding, incomplete outcome data, selective outcome reporting (reporting bias), and other potential sources of bias. Each domain was judged as low risk or high risk otherwise, when there is deficient data to make a decision the study is rated, unclear risk. Newcastle and Ottawa Scale (NOS) was used for PS[12]. Evaluation is done on three wide viewpoints: the selection and comparability of the groups; and the detection of the outcome. Stars are considered as a fast viewable judgment where studies of the maximum quality are given up to nine stars. Any disagreements in appraisal score were discussed and resolved by a third reviewer.

2.6 Summary Measures

Meta-analysis of the included studies was done in case of similarity of comparisons and outcomes considering the prostheses as the statistical unit, and neither the participants nor dental implants.

2.7 Publication Bias

In case of inclusion of 10 or more studies in the present systematic review, a funnel plot is performed. If asymmetry was shown in the plot, there is a possibility of publication bias.

3. Results

3.1 Search Results

A summary of the search results is summarized using PRISMA 2009[13] flowchart (Figure 1). 366 studies were

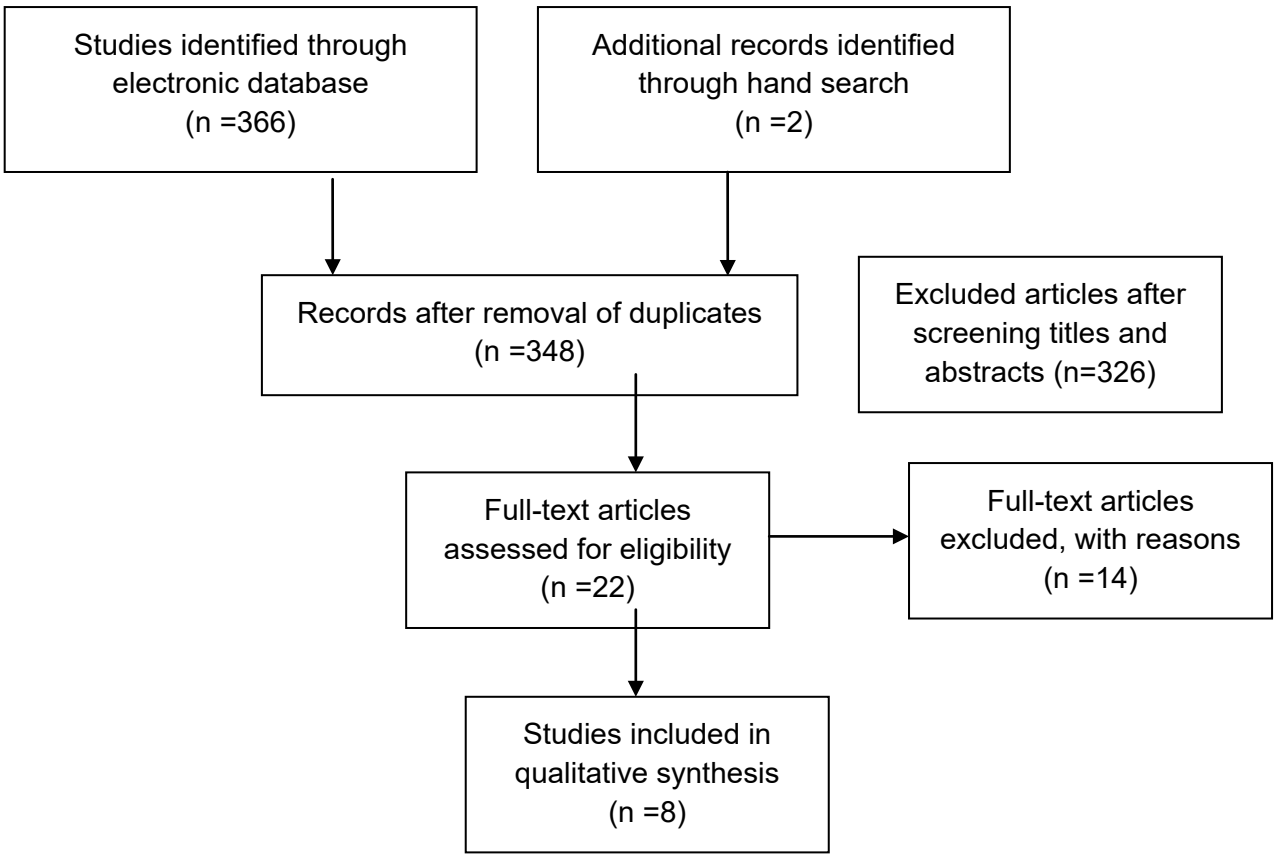

Figure 1. Search strategy.

Table 1. Excluded studies and reasons of exclusion

Study	Reason of exclusion
Buser 1997[16], Davarpanah 2002[17], De Semt 2007[18], Esposito 2015[19], Friberg 2008[20], Isaksson 2009[21], Quirynen 2005[22], Rodriguez 2000[23]	Prosthodontic complications were not mentioned.
Mangano 2009[24], Mangano 2011[25]	No enough details on prosthodontic complications.
Carlson 1994[262], Romeo 2004[27], Zinsli 2004[28]	Combined data of the comparators
Hemmings 1994[29]	Retrospective study

detected by the electronic search and 2 studies[14,15] by hand search. After removal of duplicates, 348 remained. Following screening of titles and abstract 326 studies were excluded as they were not related to the topic or they have one or more of the exclusion criteria. After assessing the full text of the remaining 22 studies; 14 studies[16-29] were excluded with reasons as summarized in Table 1.

3.2 Characteristics of the Included Studies

The electronic and hand search provided 2 RCTs[4] and 6 PS studies[14,15,30,31–34] which achieved the inclusion criteria. Thus a total of 8 studies were included for analysis. The most important features of the included studies are listed in Table 2.

Table 2. Demographic data of the included studies

Author	Year	Study design	Setting	Gender (M/F)	Age Y (mean)	Follow-up (Y)	No. of patients-drop out
Cannizaro[30]	2007	PS	Private	(18/15)	39 to 70 (56.6)	1	33- no drop out
De Kok[31]	2011	RCT	University	(9/13)	18 to 80	1	22- 2 drop out
Katsoulis[32]	2011	PS	NM	(18/23)	52 to 78 (63.3± 6.1)	2	41-NM
Makkonen[33]	1997	PS	University	(13/20)	OD: 42 to 75 (58) F: 39 to 69 (50)	5	33- 3 drop out

Table 2 Continued

Raghoebar[34]	2003	PS	Private	(12/28)	30-70 (56)	3	40-3 drop out
Tinsley[4]	2001	RCT	NM	(18/30)	37 to 80	6	48-NM
Watson & Davis[14]	1996	PS	Private	NM	NM	5	40-NM
Zitzmann & Marinello[15]	2000	PS	University	(9/11)	35 to 79	OD: 1.8 F: 2.8 mean:2.3	20-NM

PS: prospective study-RCT: randomized controlled trial-Y: year- NM: not mentioned

Table 2. Demographic data of the included studies

Author	Implant system	No. of implants	Type of prostheses	No. of prostheses	Treated arch	Opposing arch
Cannizaro[30]	Swiss Plus	OD: 4 F: 6	OD: bar F: screw- retained	OD: 12 F: 21	Maxilla	CD - natural teeth-fixed or ISP
De Kok[31]	Astra Tech	OD: 2 F: 3	OD: ball F: screw-retained	OD: 10 F: 10	Mandible	CD
Katsoulis[32]	Nobel Biocare	OD: 4 F: 5-6	OD: gold bar or CAD/CAM titanium bar F: CAD/CAM screw-retained	OD: 16 gold bar- 12 CAD/CAM titanium bar F: 13	Maxilla	Natural teeth and/or fixed or ISP
Makkonen[33]	Astra Tech	OD: 2-4 F: 5-6	OD: bar F: screw-retained	OD: 20 F: 13	Mandible	CD
Raghoebar[34]	Nobel Biocare	OD: 4 F: 5	OD: bar F: NM	OD: 30 F: 10	Mandible	NM
Tinsley[4]	Calcitek	OD: 2-3 F: 4-5	OD: stud F: screw-retained	OD: 27 F: 21	Mandible	OD: CD F: CD- natural teeth-Pd or ISP

Table 2 Continued

Watson & Davis[14]	Nobel Biocare	OD: 2 F: 4-6	OD: bar F: screw-retained	OD: 20 F: 20	Mandible	CD
Zitzmann & Marinello[15]	Nobel Biocare	OD: 5-8 F: 6-10	OD: bar F: screw-retained	OD: 10 F: 10	Maxilla	NM

OD: overdenture- F: fixed-CD: complete denture-ISP: implant supported prostheses

The year of publication of the included studies ranged from 1996 to 2011. The range of age was 18 to 80 years. The range of the follow-up time was from 1 to 6 years. Four commercially available implant systems were used (Astra Tech, Calcitek, Nobel Biocare and Swiss Plus). The treated arch was the mandible in 5 studies and the maxilla in 3 studies. In all studies the materials used in the fabrication of fixed reconstructions were metal-acrylic resin except for one study[15] in which acrylic resin or porcelain veneers were used. Furthermore all fixed reconstructions were screw-retained and the type of retainer in the overdenture group in most of the studies was bar except for two studies[4,31] where stud retainers were used.

3.3 Risk of Bias

Quality assessment of the PS was performed using NOS. NOS scores ranged from 6 to 8 (probable scores range from 0 to 9). 2 studies[14,33] were awarded 8 stars and 3 studies had 7 stars[30,32,34] and only one study[15] had 6 stars as shown in Table 3.

Quality assessment of the RCTs was performed according to the CCRBT. All domains revealed a bias of low risk except for two domains which are allocation concealment and random sequence generation (Figure 2). CCRBT stated that if the risk of bias of one domain is high or unclear, the whole research is regarded as high risk. Consequently both RCTs are considered at high risk (Figure 3).

Table 3. Quality assessment of cohort studies according to NOS scale

Study	Selection				Comparability		Outcome			Total
Cannizzaro 2007[30]	*	*	*	*	-	-	*	*	*	7
Katsoulis 2011[32]	*	*	*	*	-	*	*	*	-	7
Makokonen 1997[33]	*	*	*	*	*	-	*	*	*	8
Raghoebar 2003[34]	*	*	*	*	-	-	*	*	*	7
Watson and Davis 1996[14]	*	*	*	*	*	*	*	*	-	8
Zitzmann 2000[15]	*	*	*	*	-	-	*	*	-	6

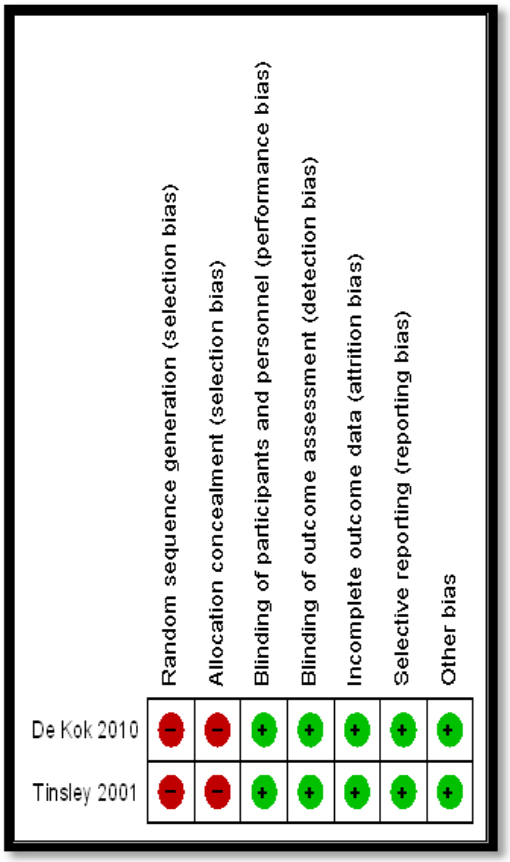

Figure 2. Risk of bias summary: review authors' judgments about each risk of bias item for each included study.

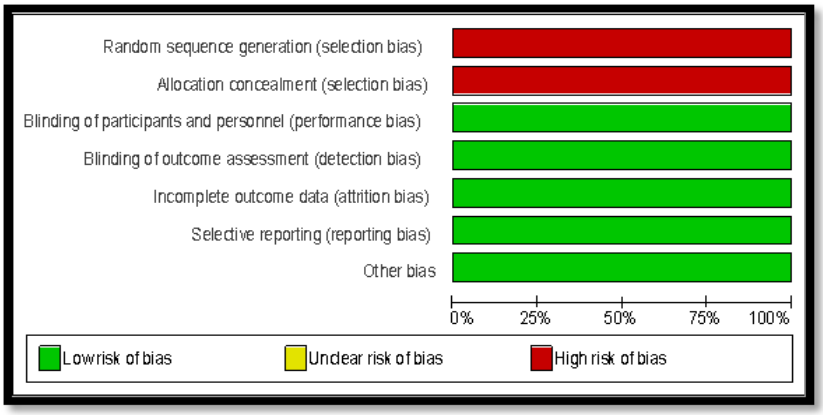

Figure 3. Risk of bias graph: review authors' judgments about each risk of bias item presented as percentages across all included studies.

3.4 Prosthetic Complications

The most common complications which occurred in both groups were loosening or fracture of the screw of the abutments, prosthetic teeth fracture, framework or bar fracture, acrylic resin fracture and denture remake. On the other hand there were complications which are related to the fixed group only like loosening or fracture of the prosthetic screw. Clip breakage, activation or dislodgement and overdenture reline are complications associated with the removable group only. A summary of the prosthetic complications which occurred in the studies are summarized in Table 4.

In a PS[30], it was reported that ten prosthetic complications occurred in both groups 6 in the screw-retained restorations and 4 in the overdentures retained with bar attachments. In the fixed group 4 provisional prostheses became loose while fracture in the resin coating and abutment screw loosening occurred once. Two overdentures had to be adjusted since they were making excessive pressure on the patient's mucosa. A tooth fractured off of 1 overdenture. In addition an overdenture fractured on the midline of the palate after 8 months.

In a RCT[31],10 patients received screw-retained restoration and 10 patients were restored with overdentures

Table 4. Events of prosthetic complications that occurred in the fixed and removable groups

Study	Fixed	Removable
Cannizzaro 2007[30]	Fracture in the resin coating (n=1), abutment screw loosening (n=1), loosened provisional prostheses (n=4).	Fracture in the mid line of the palate (n=1), adjustments (n=2), teeth fracture (n=1).
De Kok 2011[31]	Adjustments (n=25), abutment loosening (n=1), prosthetic screw loosening (n=1), teeth fracture (n=3), reline of opposing (n=2).	Adjustments (n=30), abutment loosening (n=1), reline of the overdenture (n=1), reline of opposing (n=2).
Katsoulis 2011[32]	Acrylic resin denture base fracture (n=5), teeth fracture (n=8), denture remake (n=1), reline (n=3), occlusal correction (n=5), excessive tooth wear (n=1), discoloration of acrylic resin (n=1).	Matrix fracture(n=2:gold bar), matrix activation (n=12:gold bar, 7:Ti bar), fracture of bar (n=4:gold bar), Acrylic resin denture base fracture (n=1:gold bar, 1:Ti bar), teeth fracture (n=11:gold bar), reline(n=2:gold bar, 2: Ti bar), occlusal correction (n=6:gold bar, 2:Ti bar), rearrangement of teeth (n=1: Ti bar), discoloration of acrylic resin (n=3: Ti bar).

Table 4 Continued

Makonen 1997[33]	Prostheses Screw loosening (n=1), framework fracture (n=1), denture fracture (n=1).	Bar fracture (n=1), Metal corrosion (n=1), clip fracture (n=1).
Raghoebar 2003[34]	Framework fracture (n=1).	Abutment screw loosening (n=2). Bar fracture (n=2), Clip fracture (n=2), clip out of place (n=10).
Tinsley 2001[4]	Lost fermit (n=17), Remake of prostheses (n=5), repair of opposing denture (n= 5), reline of opposing denture (n=9), remake of opposing denture (n=8), fractured abutment (n=1).	Repair of prostheses (n=4), remake of prostheses (n=17), reline of prostheses (n=11), repair of opposing denture (n=6), reline of opposing denture (n=15), remake of opposing denture (n=22).
Watson & Davis 1996[14]	Abutment screw loosening (n=2), abutment screw fracture (n=2), prostheses screw loosening (n=1), prostheses screw fracture (n=2), cracking in the acrylic (n=2), replacing teeth (n=2), opposing denture repair (n=1), opposing denture add dam (n=4), opposing denture rebase (n=2), opposing denture remake (n=3).	Abutment screw loosening (n=10), abutment exchange due to incorrect size (n=2), prostheses screw loosening (n=12), overdenture repair/ strengthen (n=8), overdenture remake/ rebase (n=8), replacing teeth (n=3), clip loosened/fractured/exchanged (n=10), clip tightening (n=15), opposing maxillary denture repair (n=1), opposing maxillary denture add dam (n=6), opposing maxillary denture rebase (n=3), opposing maxillary denture remake (n=8).
Zitzmann & Marinello 2000[15]	Abutment screw loosening (n=1), porcelain chipping (n=2), fracture of acrylic resin veneer (n=3).	Abutment screw fracture (n=1) Discoloration of teeth (n=2), lost attachment (n=1), lost clip (n=1).

retained with ball attachments. The incidence of prosthetic complications in both groups was 66; 32 related to the fixed group while 34 were related to the removable group. Adjustments in the prostheses were the most common in both groups. In the fixed group, abutment and prosthetic screw loosening, teeth fracture as well as reline of opposing were reported. On the other hand, complications related to the ball overdentures were abutment loosening and reline of the overdenture and the opposing prostheses. The differences between both groups were below the level of significance.

In another PS[32] 41 patients were participating, 16 were restored with an implant overdenture retained with a bar made of gold, 12 obtained a CAD/CAM-fabricated implant overdenture with a bar made of titanium, while 13 had a CAD/CAM implant supported fixed restoration. The most common complication in the fixed prostheses was teeth fracture while matrix activation was the most common in the bar overdentures. The maintenance rates during an observation period of 2 years were 1.24, 1.36 and 0.98 for the three groups respectively. These differences were statistically insignificant.

20 patients were restored with bar-retained overdentures and 13 patients with screw-retained prostheses in a PS. Few complications occurred through the 5 years follow-up. Prostheses Screw loosening, framework fracture and denture fracture occurred once in the fixed group while bar fracture, metal corrosion, clip fracture occurred once in the removable group.

In a 3- year prospective multicenter study[34] it was found that prosthetic complications were more common in the bar overdenture group recording 16 events compared to 1 event in the fixed group. Clip dislodgement happened in 10 occasions.

Information about prosthetic outcome was also available in the 6-year randomized prospective clinical trial[41]. It was stated that maintenance was more than predicted in both groups with more visits in the removable prostheses. The frequency of remakes, relines and adjustments was more in the overdentures. Following the first year, 23 % needed more than 5 maintenance visits per year, in comparison to 5 % recorded in the fixed group.

Nevertheless, in a PS[14], 40 patients with completely edentulous mandibular arch were divided into 2 equal groups, restored with either implant stabilized screw-retained restoration or bar overdentures. Significantly, more prosthetic complications occurred in the removable group than the fixed group, with mean of treatments of 16.3 and 10.6 respectively. Most of the complications in the fixed prostheses occurred in the opposing denture while clip tightening was the main complication in overdentures.

Finally, in a PS[15] investigating the prosthetic complications of screw-retained prostheses and bar overdentures, there was insignificant difference between the two types of prostheses. Fracture of acrylic or porcelain veneering was responsible for the most of the complications in the fixed prostheses while in the removable group, the used attachment system hardly ever needed maintenance or repair.

4. Discussion

This systematic review was conducted to compare prosthetic complications of fixed implant restorations versus implant overdentures. This included 2 RCTs[4,31] and 6 PS studies[14,15,30,32–34] which are considered of a level of evidence lower than that of RCTs.

This review is the first to evaluate both types of prostheses together and not as a separate entity. Furthermore, drawbacks within this systematic review have to be discussed. Only English language studies were included which means that there is a possibility of missing some studies published in non English language[35]. It was found that language bias affect publication models with positive outcomes more likely to be accepted into international English journals and negative outcomes in local journals[36]. Yet a study found that there is little effect of excluding studies in a language other than English language on the results of meta-analyses of RCTs[37].

A follow-up of at least 1 year was chosen in the present review. Studies have shown that prosthodontic complications take place both during the first year after treatment and in the long term, while it was stated that the rate of complications decreases over time[38,39]. Taking this opinion into consideration, the evaluation time can be expressive for overall maintenance requirements.

Comparing the prosthodontic maintenance requirements of fixed versus removable implant stabilized

prostheses, most of the included studies showed either insignificant difference among the groups or more maintenance problems in the removable prostheses. However, meta-analysis was not carried out because of the discrepancy in the characteristics of the included studies. The decision was supported by the fact that meta-analysis cannot be carried out unless the studies are similar enough to perform an analysis[40]. There was heterogeneity between the studies regarding types and number of implants, follow-up periods, treated arch and the opposing arch. In addition, due to lack of standardization of the method of the evaluation of the prosthodontic maintenance in the included studies, drawing a definitive conclusion was difficult.

There are many complications that can occur in fixed and removable prostheses. These complications should not be neglected as they have their effect on esthetic, function, comfort and self-confidence[41].

4.1 Screw Complications

Abutment screw loosening was more common in the fixed group in 4 studies[14,15,30,31]. Regarding the removable group this complication occurred in 3 studies[14,31,34] abutment screw loosening was recorded in fixed prostheses affecting two patients in two events and involving 6 screws. Seven screws were loose in overdenture prostheses worn by seven patients for whom tightening was performed on a total of ten events. Abutment screw fracture took place in only 2 studies[14,15]. In the first study[14] 2 patients had fractures of 5 screws in fixed prostheses occurring in 2 events. In the second study[15] screw fracture occurred in the removable group in one patient occurring in the distal implant located near the retentive element. Screw loosening and/or fracture are due to forces which exceed the clamping force of the screw. Screws can be improved with titanium coating thus decreasing the frequency of screw loosening, which can lead to screw fracture. Commercially pure titanium and gold alloy components are more affected than titanium alloy components[42]. Numerous factors may result in screw complications: insufficient preload on the screws, overtightening of the screws leading to stripping and/or screw deformation, and/or occlusal overload from parafunction, occlusal interferences, or remarkably long cantilevers[43].

Screw Loosening of the prostheses occurred in 1 study[30] in 4 occasions where the prostheses became loose in 4 patients, while it happened once in 3 studies[14,31,33]. Screw fracture of the prostheses was in 1 study[14]where 2 gold alloy fixing screws fractured in only one patient wearing a fixed prostheses.

4.2 Veneer/Prosthetic Teeth Fracture

A previous systematic review[6] pointed out that the most frequent technical complication was veneer/prosthetic teeth fracture or chipping. This complication was recorded in 5 studies[14,15,30–32]. It occurred in the fixed group in 2 studies[15,31] and 3 studies[14,30,32] mentioned this complication in both groups.

Loss of acrylic resin or porcelain facing can take place due to flexure or fracture of the fixed implant superstructure. Acrylic resin demonstrated higher incidence of fracture when compared to porcelain. Chipping of porcelain occur due to poor design, high occlusal load or excessive shear at the metal ceramic junction[44]. Thin frameworks can cause flexure during function leading to failure of the metal ceramic junction. Acrylic facings exhibit low modulus of elasticity so they are less likely to debond due to framework flexure[45]. Veneer fracture is due to material fatigue or plastic deformation, prosthetic design factors as lack of passive fit of the framework or insufficient prosthetic space and long cantilevers, patient features as parafunctional activity, and laboratory faults in casting and firing[46]. Absence of the receptors of the periodontal ligament and defective motor control of the mandible[47] in completely edentulous patients can result in uncontrolled elevated biting forces causing fractures of the resin coating[48].

Teeth fracture can also occur due to decreased vertical dimension of occlusion owing to extreme wear of posterior teeth which can lead to premature contact of anterior teeth. Unlike posterior teeth anterior teeth appear to undergo fracture rather than wear. There are possible factors for this; occlusal loads on anterior teeth are less than posterior teeth and the difference in force directions which are shear in nature. In contrast, vertical and are compressive forces acting on posterior teeth help the bonding of teeth[49].

4.3 Frame Work/Bar Fracture

Frame work/bar fracture took place in 3 studies[32–34]. Bar fracture occurred in a study[32] comparing screw retained restorations with gold and titanium bars affecting the gold bars only. This incidence happened in both the fixed and removable groups in two studies[33,34].

In fixed prostheses frameworks are fabricated from gold alloys, cobalt chromium alloys or titanium alloys, which have enough rigidity. Substructure fracture are rare and may happen due to defective design or overloading resulting from parafunctional habits, wrong occlusal schemes, lack of passive fit in frameworks misfit or long cantilevers[50]. Cantilever extensions >15 mm showed higher rates of failure[51]. Fractures often take place at the beginning of the cantilever arms. To avoid fractures, the thickness of the framework should be increased around the last abutment and the cantilever arm should be kept as short as possible[52]. Casting technique is another reason of fracture of full-arch frameworks. Usual lost-wax casting procedures are inaccurate while computer-milled titanium frameworks show improved passive fit and are stronger than the porous cast alloys[53].

4.4 Crack/Fracture of the Denture Base

A study[30] recorded this complication, where an overdenture fractured on the midline of the palate after 8 months. It was stated in a second study[32] that acrylic resin denture base fracture occurred in 5 occasions in the fixed prostheses and 2 events were recorded in the removable prostheses; 1 with the gold overdenture and the other with the titanium. In a third study[14] 2 patients developed cracking in the acrylic resin of the fixed superstructure.

Fracture of the prostheses is observed when the functional loads exceed the material's proportional limit or fracture strength[54]. The main cause of fractures of acrylic resin bases is insufficient space for the acrylic resin between the artificial teeth and the attachments or metal frameworks causing weakening of the denture.

4.5 Denture Remake

This complication was stated in 3 studies[4,14,32], where a study[41] reported that 5 patients needed a remake in the fixed group. Two of which were caused by teeth wear, two were due to soft tissue overgrowth below the cantilever arm, while one was as a result of fracture of the prosthesis. In the removable group almost half of the subjects required remaking of the mandibular prostheses, whereas 30% needed relining.

4.6 Matrices Fracture, Activation or Dislodgement

Fracture or loosening of the matrices is described as the most common mechanical complication with implant overdentures[29]. Five studies[14,15,32–34] recorded this type of complication. A PS[32] involving 16 gold bar and 12 CAD/CAM titanium bar noted that the majority of attachment problems were caused by the matrices, which needed activation. Fractures of matrices were observed in the gold overdenture group only. A study[34] investigated 30 bar overdentures and found that clip fracture occurred twice while clip dislodgement occurred in 10 occasions. In a PS[14] out of 20 complete mandibular overdentures 5 patients experienced fracture or looseness of the clip requiring exchange on a total of ten occasions.

Bar attachment was used in 6 of the included studies[14,15,30,32–34]. Controversy still exists between the rate of prosthodontic complications between splinted and unsplinted designs[9]. Nevertheless, according to a Vancouver group it was reported that ball attachments present with more complications compared to bars[55]. This may be due to decreased amount of rotation in splinted designs, thus reducing the wear on the clips[56]. In contrast another study[57] stated that prostheses retained with bar and clip attachments had higher mechanical complications than ball attachments.

4.7 Overdenture Reline

The need of relining due to loss of retention or stability was mentioned in 3 studies[4,31,32]. Relining was needed once in the mandibular overdenture in one study[31]. Another study[32] reported that 4 overdentures required relining 2 in the gold overdenture and 2 in the titanium group. On the other hand, a study[4] stated that 30% of the overdentures required a reline over the study period. Undesirable forces transmitted to the denture bearing area results in bone resorption with constant changes and atrophy of the denture bearing area overtime making relining necessary[58].

4.8 Opposing Dentures

Modifications also were needed in the opposing denture in most of the studies. In one study[41] 15 of the 16 patients in the fixed group opposed with complete removable prostheses had complication events in one or more of the dentures. 6 patients had remakes, 7 patients required relining or rebasing and 3 patients had fractured prostheses. In the removable group, several patients had complications with the denture in the opposing arch. Remake was needed to 56% of the prostheses, while 30% required relining. A study[14] reported that the maxillary complete dentures were rebased or remade for 5 patients having a mandibular fixed prosthesis and 6 having an opposing overdenture. The addition of a new postdam was performed in 20-25% of patients in each group.

Occlusal forces and contact area are larger and located more anterior in patients with metal reinforced acrylic resin implant-stabilized fixed prostheses opposed with a complete removable dental prosthesis[59].

5. Conclusion

Comparing the prosthodontic maintenance requirement of fixed versus removable implant stabilized prostheses, most of the included studies showed either insignificant difference among both types of prostheses or more complications in the removable group. However, due to heterogeneity in the prosthodontic designs and attachment systems it is hard to come out with a definitive conclusion.

The majority of the included studies are prospective cohort studies and the RCTs are showing a high risk of bias. Additional RCTs of high quality should be performed with standardization of the method of the evaluation of the prosthodontic maintenance to perform an accurate data analysis.

6. Recommendations

- Funding and organizational searching for large amount of data that should be collected to conduct a systematic review would be of greater help rather than individual data searching and self-funding[60].
- Studies need to progress at a fast pathway from being conventional clinical trials towards being more imaginative in hypothesis and ideas of research. As for instance in more chemical modification[61-65].
- Computer Aided Manufacturing can provide exponential advances in efficiency and productivity, but only if the basis is laid. The benefits of CAD/CAM will not be fully achieved if the organizational structure and decision-making processes are not controlled to take advantage of available system[66].

7. Conflict of Interest

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