Title: The influence of age on tooth supported fixed prosthetic restoration longevity. A systematic review.

Short title: Age and fixed prostheses longevity

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Summary

Title: The influence of age on tooth supported fixed prosthetic restoration longevity. A systematic review.

Objectives: The purpose of this study was to investigate the possible influence of age on the longevity of tooth supported fixed prosthetic restorations, using a systematic review process.

Data sources: To identify relevant papers an electronic search was made using various databases (MEDLINE via Pubmed, EMBASE, The Cochrane Register of RCTs, the database of abstracts of Reviews of Effects – DARE), augmented by hand searching of key prosthodontic journals (International Journal of Prosthodontics, Journal of Prosthetic Dentistry and Journal of Prosthodontics) and reference cross-check.

Study selection: Assessment and selection of studies identified was conducted in a two phase procedure, by two independent reviewers utilizing specific inclusion and exclusion criteria. The minimum mean follow up time was set at 5 years.

Results: The initial database search yielded 513 relevant titles. After the subsequent filtering process, 22 articles were selected for full text analysis, finally resulting in 11 studies that met the inclusion criteria. All studies were classified as category C according to the strength of evidence. Meta-analysis was not possible due to the non-uniformity of the data available. The final studies presented with conflicting results. The majority of the final studies did not report a statistically significant effect of age on fixed prostheses survival, while only one study reported poorer prognosis for elderly patients, and two studies reported poorer prognosis for middle-aged patients.

Conclusions: The results of this systematic review showed that increased age of patients should not be considered a risk factor for the survival of fixed prostheses. Although the majority of studies did not show any effect of age on the survival of fixed prostheses, there was some evidence that middle-aged patients may present with higher failure rates.

Introduction

The profile of the patient population seeking prosthodontic treatment is changing over time. Epidemiological studies have shown that, as life expectancy gradually increases, so does the percentage of elderly individuals (over 65 years old) in the population.[1-4] The tendency in this group of patients is to retain more teeth in their late years[5-10] and desire fixed rather than removable prosthetic rehabilitation.[11]

The natural process of ageing affects the integrity and function of the stomatognathic system. Teeth develop sclerotic dentin which is more caries resistant[12] but they present with a higher prevalence of root caries.[13,14] Caries incidence also increases in the elderly due to alterations in the rate of salivary flow induced by hypo function of the salivary glands or medication.[14,15] Fracture toughness is decreased in aged dentin and crack propagation is facilitated due to an internal rearrangement of its structure.[12,16-19] The production of sclerotic dentin and the ageing process lead to a reduced pulp chamber, with reduced blood flow and a lower capacity to recover from irritants.[12,20] Finally, motor capacity decreases with age, which in turn leads to reduced ability to maintain satisfactory oral hygiene.

All the aforementioned changes due to ageing may affect the prognosis and longevity of tooth-supported fixed prosthetic restorations and therefore increased age may pose a risk factor for success. There are conflicting results in the literature regarding the influence of patients' age on the longevity of fixed restorations. Some studies[21,22] show no association whereas a recent study[23] reported a significant association between age and irreversible complications.

The purpose of this study was to systematically review clinical studies for the influence of age on the longevity of tooth supported fixed prosthetic restorations.

Materials and methods

Search strategy

The literature search was conducted by two reviewers (GI, TP) using medical databases (MEDLINE via Pubmed, EMBASE, The Cochrane Register of RCTs, the database of

abstracts of Reviews of Effects – DARE) for clinical studies on humans reporting on the influence of age on tooth supported fixed prosthetic restoration longevity. The search covered the time span between the years 1980 to 2008. The same search terms were applied in all databases and included the term 'age', combined with the following terms: 'failure', 'survival', 'complication', 'longevity', 'risk factor,' 'crown', 'fixed partial denture', 'fixed prosthodontics'. The option of "related articles" was also used. Additionally, hand searching was applied to the following journals for the years 1990 to 2008: International Journal of Prosthodontics, Journal of Prosthetic Dentistry and Journal of Prosthodontics.

Selection of studies

The selection process was conducted in two phases. During the first phase the titles and abstracts were screened by the two reviewers according to the following exclusion and inclusion criteria:

Exclusion criteria

1. Studies with implant supported restorations or removable restorations
2. Studies in a language other than English
3. Case Reports
4. Expert opinion papers

Inclusion criteria

1. Studies evaluating age as a risk factor for the longevity of all types of tooth supported fixed prosthetic restorations
2. Prospective and retrospective cohort studies
3. Studies with clinical examination of all included patients at the follow up visit

Any disagreement was resolved by discussion, and in case of doubt the full-text of the article was obtained. The full text of all the articles that passed the first review phase was obtained. Additionally, manual search of the references of all full-text articles selected, as well as hand searching of the selected dental journals was implemented at this point.

The second phase of the selection process was carried out by the two reviewers independently on the full-text of the studies obtained from the first phase using the following inclusion criteria: 1) Mean follow-up time of at least 5 years, 2) number of patients included in the study stated, 3) number of prostheses stated, 4) one of the study outcomes being "age" as a risk factor. The inter-reviewer agreement for the four inclusion criteria of the second phase of the selection process was determined using Cohen's kappa coefficients. In studies reporting on the same cohort of patients, the most recent study was included.

The finally included studies that passed the second phase in the review process were classified according to the strength of evidence into 4 categories according to Jökstad et al.[24]: A1 (controlled clinical trial with patient randomization), A2 (controlled clinical trial with split-mouth randomization-split-mouth RCT), B (prospective controlled trial without randomization), and C (clinical studies with designs other than category A and B-retrospective, case series etc).

The results were tabulated according to demographics, study design and results and an effort was made to combine cohorts from different studies and assess the effect of age on the survival of tooth-supported fixed restorations.

Results

The database search yielded initially 513 articles (Table 1). Twelve studies[21-23, 25-33] passed the first review phase and ten more studies[34-43] were obtained from hand searching of particular journals and from manual search of the bibliographies of the articles selected from the databases during the first phase. From the 22 studies screened in the second phase of the selection process 9 did not meet the inclusion criteria (Table 2) and two studies[21,35] reported on the same cohort of patients as more recent ones, and therefore 11 studies[22-23,27,28,30,31,33,36-39] were finally selected for analysis (Fig.1). Inter-reviewer agreement during the second review phase ranged from 'substantial agreement' to 'perfect agreement' (kappa: 0.62-1; Table 3).

All selected studies were published between 1985 and 2007. All studies were classified as category C according to the strength of evidence and most of them, with the exception for two studies[31,39], were retrospective. The majority of the selected studies were carried out in a private setting. A total of 2811 patients with an age range between 17 and 94 years were followed. The demographics and design of the included studies are described in detail in Table 4.

The majority of the selected studies reported on the survival of fixed partial dentures (FPDs). One study[28] reported on the survival rates of cantilever fixed dental prostheses with tissue borne saddle pontics. The included studies reported on the survival of 5854 fixed prostheses for a mean follow up time ranging between 5 and 25 years. The selected studies showed great variation regarding methods, statistical analysis, definition of failure, age group categorization, and result reporting. Age was used as a variable in different ways. In particular some studies divided their population in various non-uniform age groups, whereas others considered age as a continuous variable. Therefore a statistically sound meta-analysis of the effect of age on the survival of fixed prostheses could not be performed and the 11 selected studies were analyzed only descriptively (Table 5).

Only 3 studies [23,31,36] reported a significant association between age and fixed prostheses survival. Two of these studies[31,36] reported that patients between 30-52 years of age were at higher risk of fixed prostheses failure compared to both older and younger age groups. The third study[23] showed that patients over 60 years old were at higher risk for irreversible complications. All three studies based their results on sound statistical analyses.

Eight other studies[22,27,28,30,33,37-39] reported no significant association between age and fixed prostheses survival. Only 4 of these studies[22,27,30,37] based their conclusion on sound statistical test reporting.

Discussion

Systematic reviews differ from other types of reviews because they are not based on the subjective opinion of the author in order to identify and select studies, as well as to draw conclusions. Instead they follow a transparent and explicit methodology aiming to minimize the chance of bias and draw objective conclusions based on sound data. Moreover, systematic reviews can prove valuable in identifying gaps in research or the design of available studies.[44]

Two reviewers were used in order to ensure that tasks such as study selection and data extraction could be performed independently, minimizing the risk of errors. The inter-reviewer agreement during the final selection phase ranged from 'substantial agreement' to 'perfect agreement'. The exclusion of papers in language other than English may have led to the omission of some papers. This could have led to the introduction of bias if the results of studies published in English differed systematically from those published in other languages. However, a recent empirical study[45] found little effect of the inclusion/exclusion of trials published in language other than English on combined effect estimates in meta-analyses of RCTs. Moreover, it is difficult to have access to non-English journals all over the world, and it is hard to establish the features of peer-review processes of these journals. When these non-English papers are selected, based on their abstracts, the contents must be translated. This includes the risk of interpretation problems.[46]

During the search, a significant number of relevant publications were identified not by the initial electronic search but via handsearching and reference cross-check. This was due to the fact that although a number of the final papers reported on the effects of "age", it was not stated as a primary variable and it was not included in the title, keywords or medical subject headings. The use of the specific search strategy broadened the scope of the search and permitted the identification of relevant articles.

Ideally, a systematic review should be based on randomized clinical trials (RCTs), which are the studies with the most robust design. In the absence of RCTs, all papers included in this review were cohort studies, classified as category C according to strength of evidence[24]. All

papers except for two[31,39] had a retrospective experimental design. Furthermore, several studies[30,36,38,39] had a rather high (>40%) drop out rate, and one study[23] did not report the drop out rate. This may indicate a high possibility of bias in the selected articles and therefore their results should be interpreted with caution.

The majority of the included studies were mainly designed to assess the survival rates of fixed restorations and only a few focused on investigating the influence of age on the survival of fixed restorations. Patients were divided into arbitrarily defined age groups, and in some instances age was used as a continuous variable. The variation of the age groups used, together with heterogeneity regarding methods, statistical analysis, definition of failure, and result reporting, was the main reason that data pooling and statistical meta-analysis was not feasible. Under this scope, the need for more studies focusing on the influence of age on fixed prostheses survival with better and uniform design is apparent.

The final studies included in this systematic review presented conflicting results and conclusions. The majority of the studies did not report a statistically significant effect of age on fixed prostheses prognosis. However half of these studies did not describe any statistical analyses used to draw their conclusions. Only one study[23] reported a statistically higher incidence of irreversible complications in elderly patients. Two other studies[27,30] found a tendency of the elderly group of patients to have higher failure rates, although the difference with the other age groups was not statistically significant. It seems, therefore, that increased age of patients does not pose a risk factor for the survival of fixed prostheses. Two studies[31,36] showed a higher failure rate for patients between 30-52 years old. The explanation given by the authors of one study[36] for these results was that the need for fixed prosthodontics at early ages showed an early onset of dental diseases, which certainly was not favorable for the prognosis of the restorations. All three studies[23,31,36] reporting a significant association between age and fixed prostheses survival, based their results on sound statistical analyses and age was one of the principal variables examined. The explanation for the conflicting results of the included studies may be the absence of studies

with a robust experimental design like RCTs. Therefore, there is a need for future randomized controlled clinical trials to assess the influence of the age of patients on fixed prostheses survival.

The results of this systematic review show that, at the moment, there is no robust evidence to suggest that elderly patients under fixed prosthodontic treatment present with a higher risk of failure The only study[23] that reported a statistically higher incidence of irreversible complications in elderly patients, failed to determine a cutoff age point, strong enough to be used in clinical practice. The fact that two studies[31,36] found a higher failure rate for the middle aged group, may indicate that other risk factors are more important than high age for the survival of fixed prostheses. The explanation given in one of these studies was that the early onset of dental diseases, thus the need of prosthodontic treatment in an early age, was the significant factor that negatively affected prognosis.

Conclusions

The results of this systematic review showed that increased age of patients should not be considered a risk factor for the survival of fixed prostheses. Although the majority of studies did not show any effect of age on the survival of fixed prostheses, there was some evidence that middle-aged patients may present with higher failure rates.

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Table 1. Electronic Search Strategy

Electronic Search Strategy		
Search date	11th March 2009	
Keywords used for all databases (in all fields)	age AND (failure OR survival OR complication OR longevity OR risk factor) AND (crown OR fixed partial denture OR fixed prosthodontics)	
Databases	**Limits**	**Results**
MEDLINE via Pubmed	Publication year: from 1980 to present Limited to Humans	389
EMBASE	Publication year: from 1980 to present Limited to humans	16
Cochrane Central Register of Controlled Trials	Publication year: from 1980 to present	139
Database of Abstracts of Reviews of Effects	Publication year: from 1980 to present	6
Total number of titles after removal of duplicates		513

Table 2. Articles excluded during the second review phase

Study	Publication year	Reason for exclusion
Janus et al[29]	2006	mean follow up time <5 years
Göhring & Roos[26]	2005	age as a risk factor was not one of the study outcomes
Van Nieuwenhuysen et al[32]	2003	mean follow up time <5 years
Torbjörner et al[34]	1995	mean follow up time <5 years
Dunne & Millar[25]	1993	mean follow up time <5 years
Hussey et al[40]	1991	mean follow up time <5 years
Marinello et al[42]	1988	mean follow up time <5 years
Bentley & Drake[43]	1986	age as a risk factor was not one of the study outcomes
Williams et al[41]	1984	mean follow up time <5 years

Table 3. Inter-reviewer agreement

Criterion	Kappa	Interpretation
mean follow up period >=5y	0,899	Almost perfect agreement
number of patients stated	1	Perfect agreement
number of prostheses stated	1	Perfect agreement
one of the study outcomes being age" as a risk factor	0,62	Substantial agreement

Table 4. Study design and demographics

Study	Year of publication	Category of evidence*	Planned number of patients	Actual number of patients	Drop out %	Gender		Age (years)				Setting
						M	F	Range		Mean	SD	
								from	to			
Izikowitz[28]	1985	C (R)	69	69	0	25	44	40 (men), 28 (women)	71 (men), 79 (women)	NR	NR	private
Karlsson[30]	1989	C (R)	164	97	41	44	53	NR	NR	64	NR	private
Foster[33]	1990	C (R)	130	130	NA	58	72	19	72	NR	NR	private
Palmqvist & Söderfeldt[36]	1994	C (R)	122	66	46	23	43	NR	NR	NR	NR	university
Leempoel et al[37]	1995	C (R)	1080	944	13	416	664	NR	NR	most patients 31-50	NR	private
Hawthorne & Smales[27]	1997	C (R)	100	100	0	45	55	NR	NR	29.5	14.6	private
Valderhaug et al[38]	1997	C (R)	114	32	72	NR	NR	25	69	48	NR	university
Malament & Socransky[31]	1999	C (P)	417	417	0	NR	NR	17	91	NR	NR	private
Näpänkangas et al[22]	2002	C (R)	150	132	12	48	84	39	82	56.8	NR	university
Glantz et al[39]	2002	C (P)	150	77	49	NR	NR	NR	NR	48.2/48.9 (men/women)	12.5/13.5 (men/women)	private
De Backer et al[23]	2007	C (R)	NR	747	NR	294	453	18	94.2	CCs 41y, 3uFDPs 61.2y, FDPs 63y	NR	university

*Study design shown in parentheses. R = retrospective, P= prospective, NR = not reported, NA = non-applicable, CCs = complete crowns group, 3uFPDs = 3 unit fixed partial dentures group, FPDs = fixed partial dentures group

Table 5. Design of final studies

study	year	type of prostheses	no of prostheses	Follow up range (y)	mean follow up time (y)	definition of failure	statistical analysis of the affect of age	studied age groups (y)	results	conclusion	relationship
Izikowitz[28]	1985	cantilever fixed dental prosthesis	87	at least 10	10	completely or partially removed	NR	division at age 55	non functioning bridges: 29% for the >55 group and 41% for the <55 group	patient's age does not have a significant influence on the prognosis	**No**
Karlsson[30]	1989	FPDs	140	14	14	completely removed	Chi-square test	<55, 55-64, 65-69, >69	percentage of removed reconstructions per age group: <55:13%, 55-64:10.5%, 65-74:17.2%, 65-69:20%, >69:20.5%	no significant correlation between patient age and the rate of failure. Older patients with a tendency for higher % of failures	**No**
Foster[33]	1990	FPDs	142	0.17 to 34	6.2	requiring repair or removal-studied only failed prostheses	NR	16-20, 21-30, 31-40, 41-50, >51	Years of service of failed work by age group 16-20:7.3, 21-30:5.8, 31-40:7.4, 41-50:4.5, >51:5.3	no correlation between age and years of service	**No**
Palmqvist & Söderfeldt[36]	1994	FPDs	103	18-23	18	(1) remaining unchanged, (2) remaining but repaired, (3) partly remaining, and (4) totally removed.	chi-square test / logistic regression model	<29, 30-49, >50	Bivariate/multivariate odds ratio with FPDs remaining unchanged or not, by age group: 20-29 (ref. cat.), 30-49: 2.06/2.62, >50: 1.15/0.90, with FPDs totally removed or not: 20-29 (ref. cat.), 30-49: 2.04/2.94, >50: 1.76/2.10	There was a significantly higher failure rate for patients aged 30 to 49 years	**Yes**
Leempoel et al[37]	1995	FPDs	1674	12	12	NR	log rank test	0-30, 31-50, >50	Survival rates for each age group after 12 years: 0-30:88.8%, 31-50:86.1%, >50:87,1%	no significant difference in the survival rate between different age groups	**No**

Hawthorne & Smales[27]	1997	crowns and gold castings	399	10 to 46	24.8	replaced partially or wholly	Life table analysis	0-20, 21-40, 41-60, 61+	No statistically significant effect of age group on survival	No statistically significant effect of age on survival, the lowest survival rates for CCs in the <20 and 61+ year age groups.	**No**
Valderhaug et al[38]	1997	CCs, FPDs	38	25	25	the restored teeth not remaining intact	NR	NR	No differences on survival rates depending on patients' age	No differences on survival rates depending on patients' age	**No**
Malament & Socransky[31]	1999	Dicor CCs	1444	NR	5	A fractured Dicor ceramic piece that necessitated that the restoration be remade.	log rank test	<33, 33-52, >52	There was 1.86 times greater risk of failure in group II and 1.20 times greater risk in group III than for group I	Risk of failure was greater within age groups between 33 and 52 years.	**Yes**
Näpänkangas et al[22]	2002	FPDs	132	2.3-15.1	7.6	severe and extensive complications	log rank test	NR	Age of patient did not influence survival	Age of the patient did not influence the survival	**No**
Glantz et al[39]	2002	FPDs	77	22	22	Restorations lost	NR	NA	Age of patient did not influence survival	Patient age did not have any influence on the prognosis	**No**
De Backer et al[23]	2007	CCs, FPDs	CC group 1037, 3uFDPs 134, FDP group 322	18-20	CCs group 10, 3uFDPs 11.6, FDP group 11.4	irreversible complications	Mann-Whitney U test, Fisher exact test	<60, >60	1. Mean age of surviving/failing restorations: CC group: 59.5/64.8 ($p<0.001$), 3uFPD group: 61.6/67.1 ($P=0.41$), FPD group 63.0/ 67. ($P=0.05$) 2. Fischer exact test for 2 age groups <60, >60. Statistically significant differences for CCs ($P<0.001$) and FPDs ($P=0.016$) but NOT for 3uFPDs ($P=0.135$)	There was a clear statistically significant association between age and irreversible complications	**Yes**

CCs = complete crowns, FPDs = fixed partial dentures, 3uFPDs = three unit fixed partial dentures, NR = not reported, NA = non-applicable

Figure 1. Search strategy and results.