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

Short title: Age and fixed prosthesis 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.\textsuperscript{1-4} The tendency in this group of patients is to retain more teeth in their late years\textsuperscript{5-10} and desire fixed rather than removable prosthetic rehabilitation.\textsuperscript{11}

The natural process of ageing affects the integrity and function of the stomatognathic system. Teeth develop sclerotic dentin which is more caries resistant\textsuperscript{12} but they present with a higher prevalence of root caries.\textsuperscript{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.\textsuperscript{14,15} Fracture toughness is decreased in aged dentin and crack propagation is facilitated due to an internal rearrangement of its structure.\textsuperscript{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.\textsuperscript{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\textsuperscript{21,22} show no association whereas a recent study\textsuperscript{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 studies21-23, 25-33 passed the first review phase and ten more studies34-43 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 studies21,35 reported on the same cohort of patients as more recent ones, and therefore 11 studies22-23,27,28,30,31,33,36-39 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\textsuperscript{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\textsuperscript{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\textsuperscript{23,31,36} reported a significant association between age and fixed prostheses survival. Two of these studies\textsuperscript{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\textsuperscript{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\textsuperscript{22,27,28,30,33,37-39} reported no significant association between age and fixed prostheses survival. Only 4 of these studies\textsuperscript{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 interreviewer 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\textsuperscript{31,39} had a retrospective experimental design. Furthermore, several studies\textsuperscript{30,36,38,39} had a rather high (>40\%) drop out rate, and one study\textsuperscript{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\textsuperscript{23} reported a statistically higher incidence of irreversible complications in elderly patients. Two other studies\textsuperscript{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\textsuperscript{31,36} showed a higher failure rate for patients between 30-52 years old. The explanation given by the authors of one study\textsuperscript{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\textsuperscript{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\textsuperscript{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\textsuperscript{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.
Bibliography


33. Foster, L. V. Failed conventional bridge work from general dental practice: clinical aspects and treatment needs of 142 cases. *British Dental Journal* 1990; 168:199-201


### Table 1. Electronic Search Strategy

<table>
<thead>
<tr>
<th>Databases</th>
<th>Limits</th>
<th>Results</th>
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<td>MEDLINE via Pubmed</td>
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<tr>
<td>EMBASE</td>
<td>Publication year: from 1980 to present Limited to humans</td>
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<td>Cochrane Central Register of Controlled Trials</td>
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<td>Publication year: from 1980 to present</td>
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<td>Total number of titles after removal of duplicates</td>
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Table 2. Articles excluded during the second review phase

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<td>Janus et al&lt;sup&gt;29&lt;/sup&gt;</td>
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<td>mean follow up time &lt;5 years</td>
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<td>Göhring &amp; Roos&lt;sup&gt;26&lt;/sup&gt;</td>
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<td>age as a risk factor was not one of the study outcomes</td>
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<td>mean follow up time &lt;5 years</td>
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<td>Torbjörner et al&lt;sup&gt;34&lt;/sup&gt;</td>
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<td>mean follow up time &lt;5 years</td>
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<td>Dunne &amp; Millar&lt;sup&gt;25&lt;/sup&gt;</td>
<td>1993</td>
<td>mean follow up time &lt;5 years</td>
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<td>Hussey et al&lt;sup&gt;31&lt;/sup&gt;</td>
<td>1991</td>
<td>mean follow up time &lt;5 years</td>
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<tr>
<td>Marinello et al&lt;sup&gt;42&lt;/sup&gt;</td>
<td>1988</td>
<td>mean follow up time &lt;5 years</td>
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<tr>
<td>Bentley &amp; Drake&lt;sup&gt;43&lt;/sup&gt;</td>
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<td>age as a risk factor was not one of the study outcomes</td>
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<td>Williams et al&lt;sup&gt;31&lt;/sup&gt;</td>
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Table 3. Inter-reviewer agreement

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<tr>
<td>number of prostheses stated</td>
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<td>Izikowitz²⁸</td>
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<td>De Backer et al³⁹</td>
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<td>C (R)</td>
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*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
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<th>results</th>
<th>conclusion</th>
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<td>completely or partially removed</td>
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<td>14</td>
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<td>completely removed</td>
<td>Chi-square test</td>
<td>&lt;55, 55-64, 65-69, &gt;69</td>
<td>percentage of removed reconstructions per age group: &lt;55:13%, 55-64:10.5%, 65-74:17.2%, 65-69:20%, &gt;69:20.5%</td>
<td>no significant correlation between patient age and the rate of failure. Older patients with a tendency for higher % of failures</td>
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<td>requiring repair or removal-studied only failed prostheses</td>
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<td>16-20, 21-30, 31-40, 41-50, &gt;51</td>
<td>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, &gt;51:5.3</td>
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<td>18-23</td>
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<td>(1) remaining unchanged, (2) remaining but repaired, (3) partly remaining, and (4) totally removed.</td>
<td>chi-square test / logistic regression model</td>
<td>&lt;29, 30-49, &gt;50</td>
<td>Bivariate/multivariate odds ratio with FPDs remaining unchanged or not by age group: 20-29 (ref. cat.), 30-49: 2.06/2.62, &gt;50: 1.15/0.90, with FPDs totally removed or not: 20-29 (ref. cat.), 30-49: 2.04/2.94, &gt;50: 1.76/2.10</td>
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<td>NR</td>
<td>log rank test</td>
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<td>Survival rates for each age group after 12 years: 0-30:88.8%, 31-50:86.1%, &gt;50:87.1%</td>
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<td>10 to 46</td>
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<td>0-20, 21-40, 41-60, 61+</td>
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<td>the restored teeth not remaining intact</td>
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<td>log rank test</td>
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<td>7.6</td>
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<td>Age of patient did not influence survival</td>
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<td>18-20</td>
<td>CCs group 10, 3uFPDs 11.6, FDP group 11.4</td>
<td>irreversible complications</td>
<td>Mann-Whitney U test, Fisher exact test</td>
<td>&lt;60, &gt;60</td>
<td>1. Mean age of surviving/failing restorations: CC group: 59.5/64.8 (p&lt;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 &lt;60, &gt;60. Statistically significant differences for CCs (P&lt;0.001) and FPDs (P=0.016) but NOT for 3uFPDs (P=0.135)</td>
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</tbody>
</table>

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.

First Electronic Search
513 Titles, Abstracts Obtained

Titles and abstracts screened for 1st phase.
Discussion. Agreed on 12 studies - full text obtained

Further hand searching, 3 studies

7 studies retrieved from references

Total full-text 22, screened for inclusion/exclusion criteria for second phase

Final selected studies 11