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*Article*

# 40-Years Outcome of Old-School Non-Surgical Endodontic Treatment: Practice-Based Retrospective Evaluation

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**Abstract:** (1) Background: Non-surgical endodontic treatment has been repeatedly shown to be clinically successful, however, clinical data are scarce. This practice-based retrospective clinical study aimed to investigate endodontic outcome over 40 years and to identify relevant factors from clinical protocols. (2) Methods: Two experienced dental practitioners in two different private dental practices treated 174 patients with 243 teeth from 1969 to 1993. After obturation, either a new restoration (amalgam, resin composite, glass-ionomer cement), or re-cementation of pre-existing prosthetic restorations or its renewal followed. Metal posts (operator A) or screws (operator B) were inserted when indicated. The primary outcome (tooth survival) was achieved when the endodontically treated tooth was in situ, painless and in full function. Secondary outcome was to investigate the impact of potential prognostic factors on survival rates. (3) Results: Overall mean 40-years survival was 56.1% of all treated teeth after 40 years of clinical service resulting in an annual failure rate of 1.1%. Most investigated clinical factors (Jaw, tooth position, number of intracanal dressings, post/screw placement, sex) had no significant influence on survival. Among postendodontic restorations, resin composite was advantageous. (4) Conclusions: Even with materials and techniques from the 1970's and 1980's, successful root canal treatment was achievable. Except postendodontic restorations, most of the evaluated factors had no significant influence on clinical long-term survival of root-canal treated teeth.

**Keywords:** endodontic treatment; root canal disinfection; root canal preparation; root canal obturation; clinical outcome; root canal post; postendodontic restoration

## 1. Introduction

Despite the endpoint of caries excavation is today controversially discussed in order to protect pulp vitality[1–3], successful endodontic treatment is still a key factor in conservative dentistry when it comes to irreversible pulp inflammation[4,5]. Unfortunately, today a significant shift towards systematic reviews is clearly visible in the dental literature, involving the problem that in many cases collected data are more frequently cited than original research[6,7]. This inflation of literature papers may tempt young researchers to head towards their computer instead of going to lab or operatory in order to produce real data[8]. Additionally, in many countries prospective clinical trials are more and more impeded by sprawling bureaucracy as well as inadequate ethical concerns and burdens[9,10]. All of these factors make clinical research more and more expensive, less attractive for the dental industry as sponsor, and finally less accomplishable in general[10].

It is well-known that pulp treatment is strongly correlated with patients' quality of life[11–13], because simple tooth preservation is a major outcome being considered. However, missing outcome assessment leads to a weak scientific basis for clinical decision-making[14]. Therefore, more clinical

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research in endodontics has been repeatedly requested[15]. Beside randomized trials as gold standard, also prospective cohort studies [8,15], have been described promising[15]. Furthermore, inclusion of several variables combined with multivariate statistics are fundamental prerequisites to reduce the risk of confounding bias[16]. On the other hand, large-scale prospective cohort studies involving multiple variables are extremely time-consuming and thus expensive[8,15], and it is well-known from these studies that when after many years of recall assessments substantial results are available, the respective materials that had been used may not be on the market anymore[17]. These are the main reasons why very few endodontic prospective long-term trials have been published[17–19], additionally suffering relatively short follow-up periods. Real long-term data are therefore desired for both patient information and public health and insurance issues [4,15].

However, beside endodontic treatment alone, postendodontic restoration quality has been discussed to be an important factor for long-term success as well[20]. It is not decisive, whether quality of endodontic treatment or postendodontic restoration is more important[20] instead of focusing on both factors being extremely clinically relevant issues in this topic[21]. Nevertheless, when dealing with that old data like in the present investigation, it is interesting that almost all facts being relevant today have not been investigated before the present endodontic treatments have been made. This means that today's evidence about post-endodontic restorations[3,21–25] has been not available in the 1980's when metal posts and screws were clinical standard as well as amalgam restorations. When direct resin composite restorations were used, dentin was covered with a thick cement lining and moreover, dentin bonding was not established. This means that in every single adhesive approach, only enamel margins were really bonded.

Therefore, the present study retrospectively evaluated the 40-years outcome of endodontic treatment of 174 patients and 243 teeth having been endodontically treated by two different dentists in the 1970's and 80's.

## 2. Materials and Methods

Endodontic treatments in the present retrospective study were performed by two experienced dental practitioners (P1: Albrecht, P2: Behrens) in two different private dental practices in Kiel, Germany. P1 treated 73 patients with 107 teeth, P2 101 patients with 138 teeth. The study protocol was approved by a local ethics committee (University of _____; Ref. No. 474/18) and all patients provided informed consent prior to treatment start. All endodontic treatments were performed from 1969 to 1993. Evaluations were carried out by the two practitioners until 2018. The paper was written in consideration of STROBE guidelines. Patients were included if a primary or secondary endodontic treatment was indicated and possibility of post-operative restoration was available. Teeth with any loosening, root resorptions or root fractures were excluded. Endodontic treatment procedures based on contemporary methods of the respective period. During vital exstirpation, root canals were prepared with hedstrom files, rinsed with $H_2O_2$, dried with paper points, and filled with gutta percha and sealer using lateral compaction. Prior to preparing root canals with endodontic instruments, patients were clinically and radiographically examined. Clinical examination included evaluation of tooth position, pre-existing restoration, periodontal status, pain symptoms, vitality status, and sensitivity to percussion. Presence and depth of caries as well as presence and size of apical radiolucency were evaluated radiographically. Working length was determined radiographically. Finally, a radiograph was taken to check quality/homogeneity and distance of the root canal filling to the individual apex. 3% sodium hypochlorite was used as disinfectant and if the treatment required several sessions, intracanal medication (ChKM/Speiko, Calxyl/OCO) were applied. Subsequent to root canal obturation, all teeth were either restored with a new restoration (amalgam, resin composite, glass-ionomer cement), or by recementation of pre-existing prosthetic restorations, or by manufacturing of new indirect prosthetic restorations. Cast metal posts were inserted when significant loss (>50%) of coronal tooth structure required additional intracanal retention. In cases of failed or lost post-operative restorations, endodontically treated teeth were newly restored at different times in the following years.

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In the period after completion of endodontic and restorative treatments, all patients joined an individual monitoring for clinical reevaluation including subsequent control radiographs. Depending on the associated findings, endodontically treated teeth received periodontal therapy, endodontic re-treatment, or dental apectomy. Both operators screened 243 teeth treated in the period from 1969 until 1993. Pre-, intra- and post-operative data and possible prognostic factors with corresponding data were collected in Excel sheets (Table 1,2). The primary outcome tooth survival was achieved when the endodontically treated tooth was in situ, painless and in full function[19]. The secondary outcome was to investigate the impact of potential prognostic factors on survival rates.

**Table 1.** Variables and Co-variables of Operator 1.

| Variables (P1) | | Endodontically treated teeth | Extractions |
|---|---|---|---|
| Preoperative | | | |
| | | n=107 | n=46 |
| Gender | male (29)<br>female (44) | 66 | |
| Tooth location | upper jaw<br>lower Jaw<br>anterior<br>posterior | 77<br>27<br>52<br>54 | |
| Coronal caries | | 63 | 31 |
| Root caries | | 4 | 2 |
| Sensitivity to percussion | Yes<br>no | 75<br>32 | 30<br>16 |
| Vitality status | Vital<br>Non-vital | 29<br>75 | 16<br>30 |
| Presence of apical radiolucency | Yes<br>no | 45<br>62 | 27<br>19 |
| Periapical space | normal<br>enlarged | 49<br>58 | 23<br>23 |
| Tooth function | Distal tooth in quadrant<br>Bridge in abutment<br>Double proximal contact | 13<br>10<br>84 | 4<br>9<br>33 |
| Distance root-canal filling to apex | 0-2 mm<br>2-3 mm<br>>=4 mm | 59<br>31<br>16 | 27<br>12<br>7 |
| Number of intracanal medications | 0<br>1<br>2<br>3<br>4 or more | 35<br>21<br>24<br>19<br>8 | 14<br>11<br>9<br>10<br>2 |
| Post | Yes<br>no | 49<br>58 | 17<br>29 |

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**Table 2.** Variables and Co-variables of Operator B and comparisons A vs. B.

| Variables (P2) | | Endodontically treated teeth | Extraction |
|---|---|---|---|
| Pre-operative | | | |
| | | n=138 | n=61 |
| Gender | male | | |
| | female | | |
| Deep caries | | 11 | 6 |
| Vitality status | vital | 46 | 23 |
| | non-vital | 60 | 23 |
| | no data | 32 | 15 |
| Pain symptoms | yes | 11 | 5 |
| | no data | 127 | 56 |
| Sensitivity to percussion | yes | 137 | 61 |
| | no | 1 | 0 |
| Operator | P1 | 104 | 42 |
| | P2 | 138 | 60 |
| | P1 anterior | 52 | 21 |
| | P1 posterior | 54 | 22 |
| | P2 anterior | 30 | 9 |
| | P2 posterior | 108 | 51 |
| Tooth location | Upper jaw | 82 | 30 |
| | Lower Jaw | 56 | 30 |
| | Anterior upper jaw | 30 | 9 |
| | Posterior upper jaw | 52 | 21 |
| | Posterior lower jaw | 56 | 30 |
| Number of intracanal medications | 0-1 | 38 | 17 |
| | 2-3 | 72 | 31 |
| | >/=4 | 26 | 11 |
| Duration from trepanation to root canal filling | 0 | 18 | 10 |
| | 1-14 days | 10 | 4 |
| | 15-28 days | 33 | 12 |
| | >28 days | 75 | 34 |
| Post | Yes | 86 | 37 |
| | no | 52 | 24 |
| Restoration | Amalgam | 66 | 33 |
| | Composite | 21 | 3 |
| | Recementation/Renewal of prosthetic restoration | 22 | 14 |
| | Glass-ionomer cement | 26 | 9 |
| Periodontal therapy | Yes | 30 | 13 |
| | no | 108 | 47 |

Statistical analysis of tooth survival was performed by Kaplan-Meier survival test considering the date of tooth extraction. Reasons for extraction were periodontal disease, root/crown fracture, untreatable caries and endodontic inflammation. Tooth-related variables to evaluate possible prognostic factors were compared by log-rank-, Mantel-Haenszel and Wilcoxon-test. Prism/GraphPad (Insight Partners, Praphpad Holdings, LLC, Los Angeles, USA) was used for statistical analysis and the level of significance was set at $p \leq 0,05$.

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## 3. Results

### *3.1. Clinical Outcome Practitioner A*

#### 3.1.1. Overall Tooth survival

Overall tooth loss after 40 years was 43.9%. The observed extraction rate was homogeneously distributed over the complete observation period, so no cumulative incidents like in many other clinical trials occurred (Figure 1).

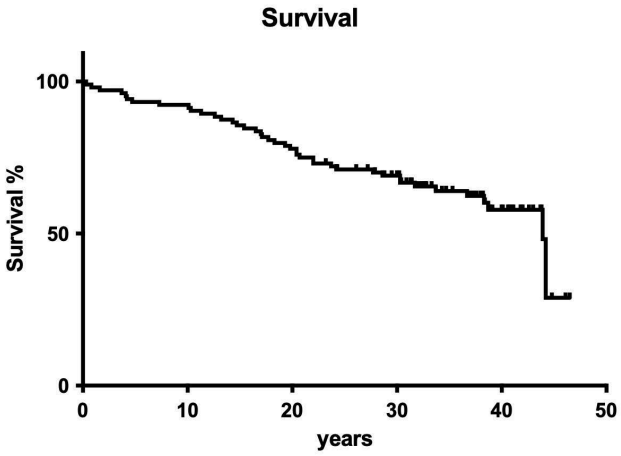


**Figure 1.** Overall clinical survival of teeth treated by operator A.

#### 3.1.2. Influence of jaw

Jaw position had no significant impact on overall survival (Figure 2; p>0.05).

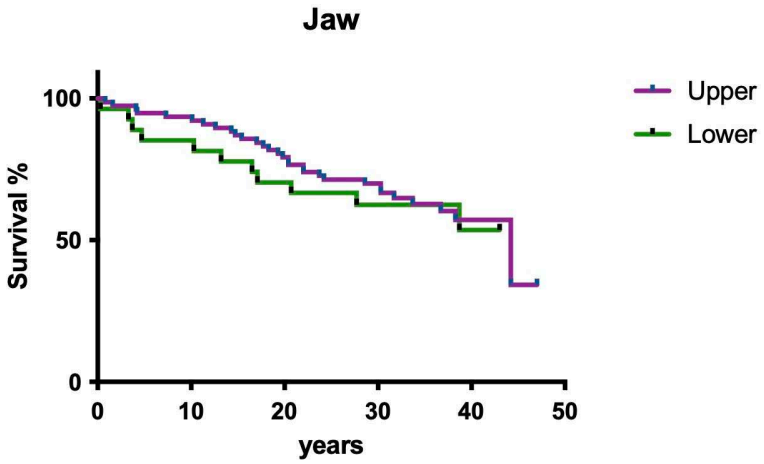


**Figure 2.** Overall clinical survival in upper and lower jaws.

#### 3.1.3. Influence of tooth position

Tooth position (i.e. anterior vs. posterior) had no significant influence on overall survival (Figure 3; p>0.05).

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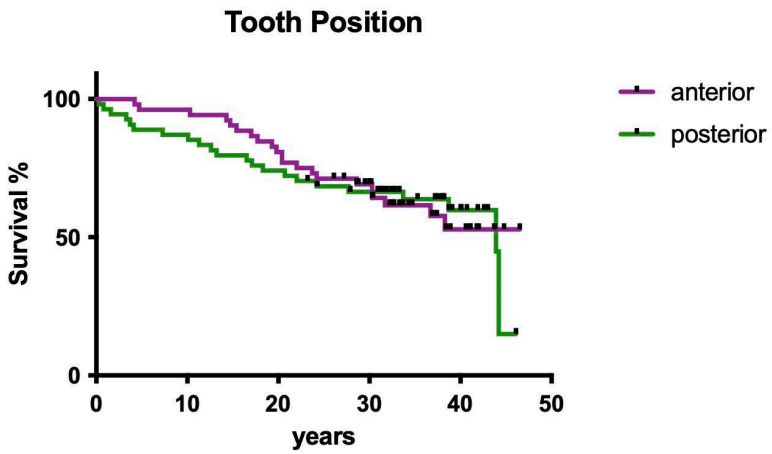


**Figure 3.** Overall clinical survival of anterior vs. posterior teeth treated by operator A.

3.1.4. Influence of root canal infection

The infection status (pulpectomy vs. infected canal) had no significant influence on overall survival (Figure 4; $p>0.05$).

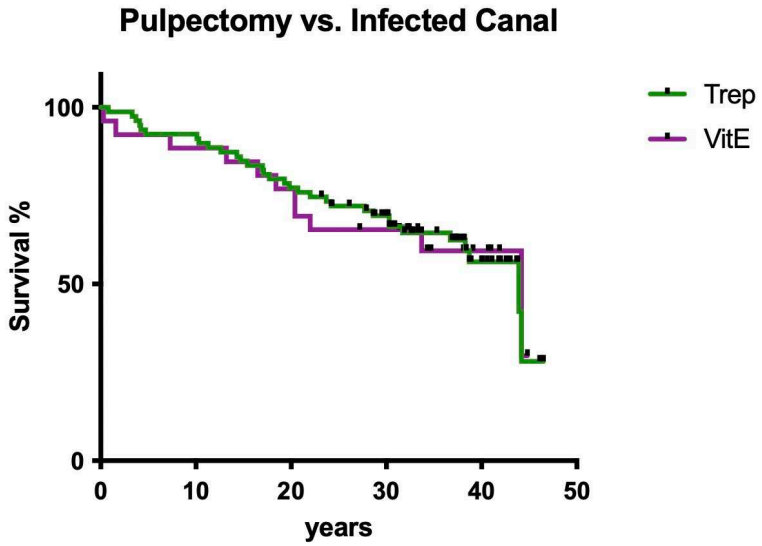


**Figure 4.** Overall clinical survival of teeth with different infection of the root canal system.

3.1.5. Influence of post insertion

The presence of postendodontically inserted root canal posts had no influence on clinical long-term success (Figure 5; $p>0.05$).

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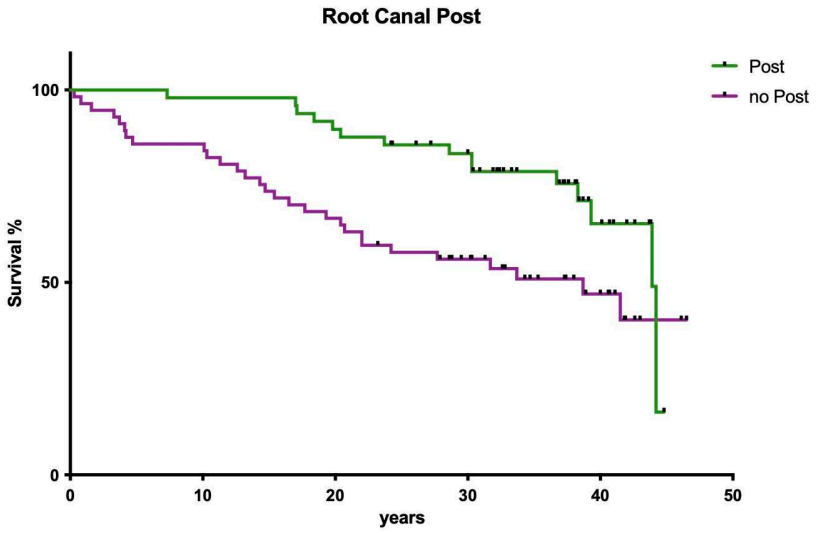


**Figure 5.** Clinical survival of teeth with post vs. no post postendodontic restoration.

3.1.6. Influence of periodontal ligament space

The radiographically evaluated width of the periodontal ligament space did not show a significant influence on clinical outcome (Figure 6; $p>0.05$).

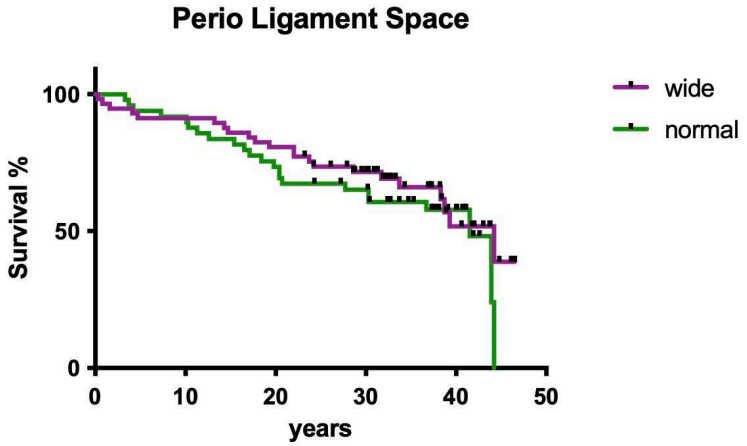


**Figure 6.** Clinical survival of teeth with differently wide perio ligament spaces.

3.1.7. Influence of gender

Sex of the patients did not show a significant influence on long-term tooth survival (Figure 7; $p>0.05$).

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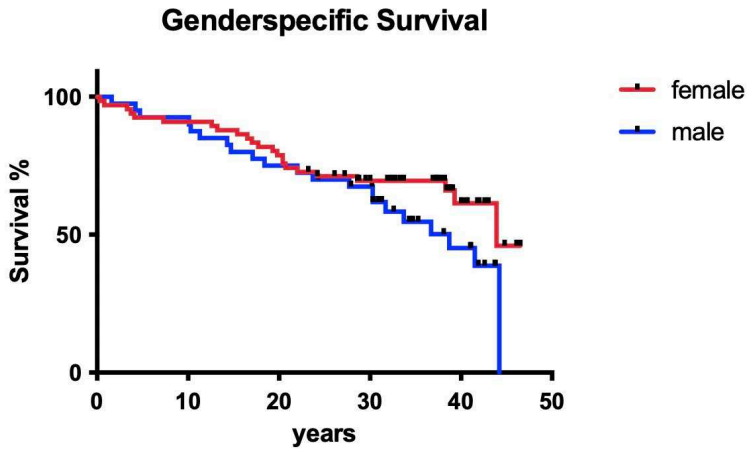


**Figure 7.** Clinical survival of teeth in males vs. females.

3.1.8. Influence of working length

The measured distance of the root canal filling to the radiological apex did not have a significant influence on clinical long-term survival of endodontically treated teeth (Figure 8; p>0.05).

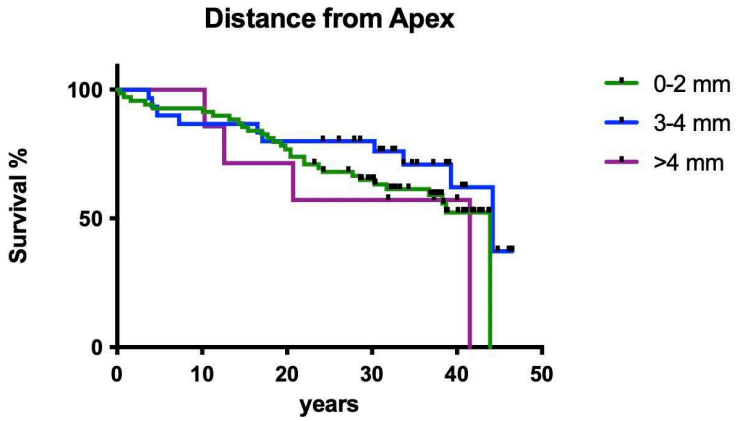


**Figure 8.** Clinical survival of teeth with different working lengths.

3.1.9. Influence of intracanal dressing changes

The number of intracanal medicament dressing changes did not have a significant effect on clinical outcome (Figure 9; p>0.05).

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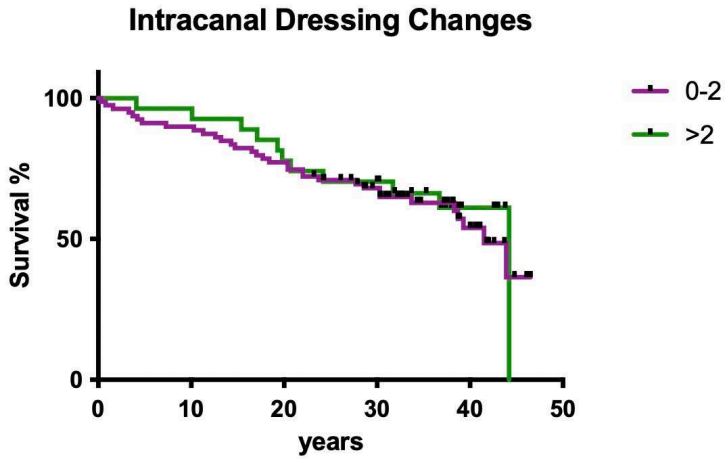


**Figure 9.** Clinical survival of teeth with differently frequent root canal dressings.

*3.2. Clinical outcome practitioner B*

3.2.1. Overall survival

Overall clinical survival of operator B was slightly higher compared to operator A, but not statistically significant (Figure 10; $p>0.05$).

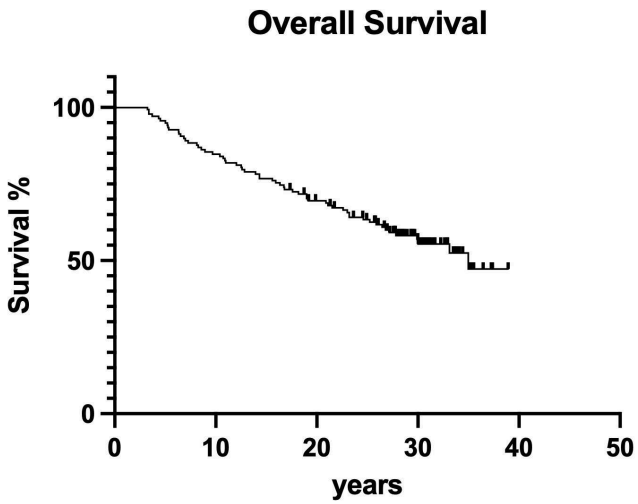


**Figure 10.** Overall clinical survival of operator B.

3.2.2. Jaw

Jaw position had no significant impact on overall survival (Figure 11; $p>0.05$).

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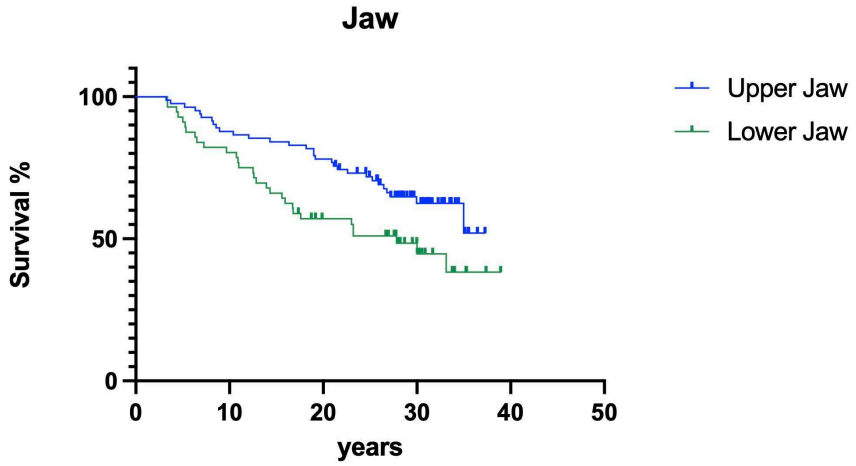


**Figure 11.** Overall clinical survival of teeth in different jaws.

3.2.3. Number of intracanal dressing changes

The number of intracanal medicament dressing changes did not have a significant effect on clinical outcome (Figure 12; $p>0.05$).

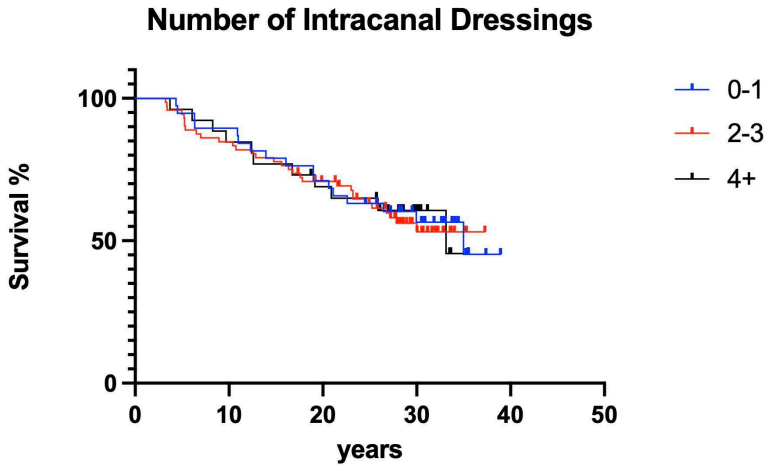


**Figure 12.** Overall clinical survival of teeth with different numbers of intracanal dressings.

3.2.4. Screws

The presence of postendodontically inserted root canal retention screws had no influence on clinical long-term success (Figure 13; $p>0.05$).

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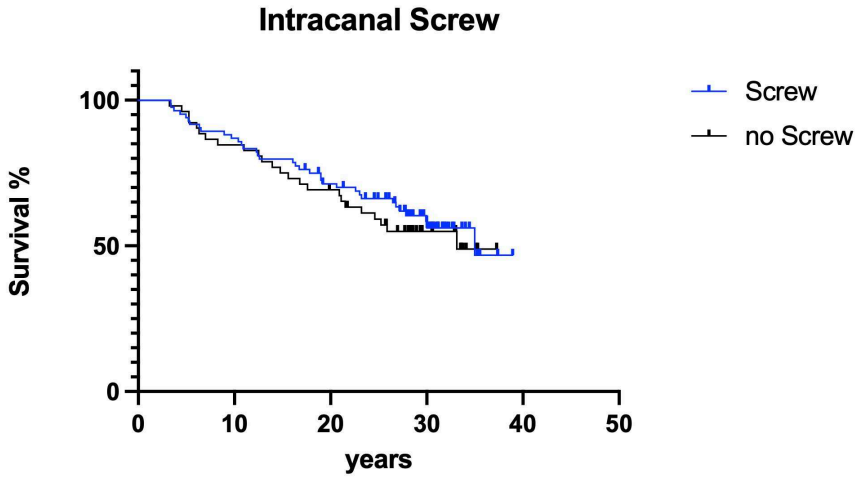


**Figure 13.** Overall clinical survival of teeth screw vs. no screw.

3.2.5. Postendodontic restoration

Different postendodontic restorations showed a significant effect on overall survival, direct resin composite restorations lead to less failures compared to prosthetic restorations (Figure 14; $p<0.05$).

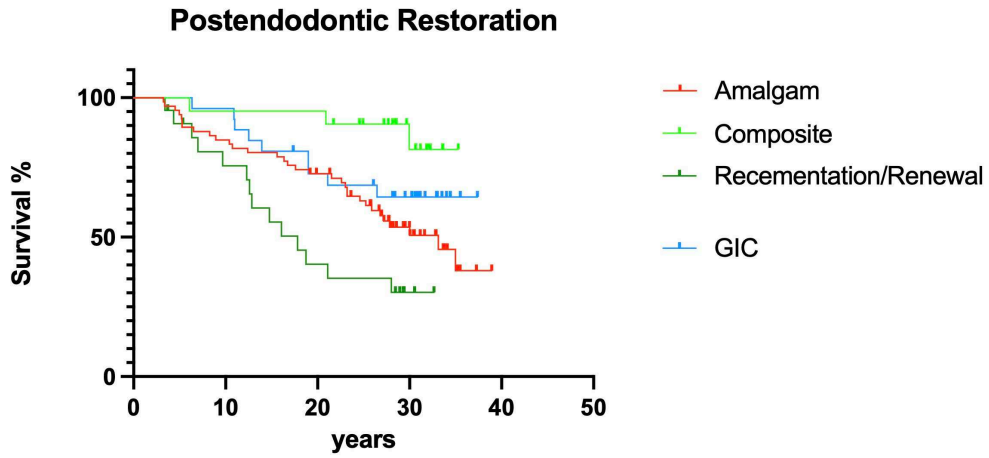


**Figure 14.** Clinical survival of teeth with different postendodontic restorations.

*3.3. Interoperator comparison*

Between the operators having been involved in the present study, no significant influence could be computed (Figure 15; $p>0.05$).

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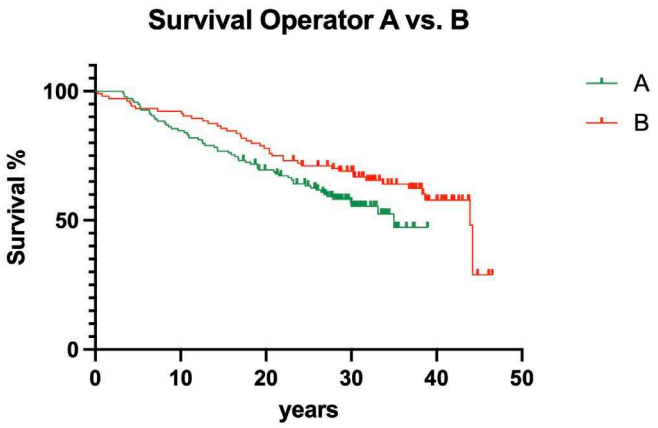



**Figure 15.** Clinical survival of teeth with different operators.

*3.4. Overall survival*

Overall survival for the whole retrospective study was 56.1% after 40 years of clinical service (Figure 16).

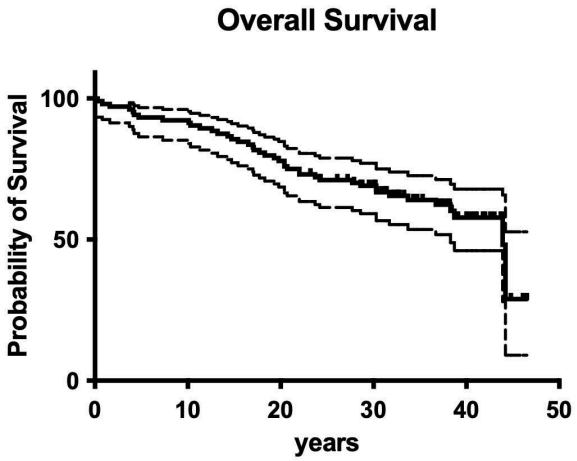
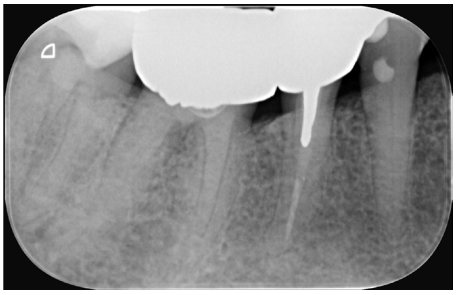



**Figure 16.** Clinical survival of both operators.



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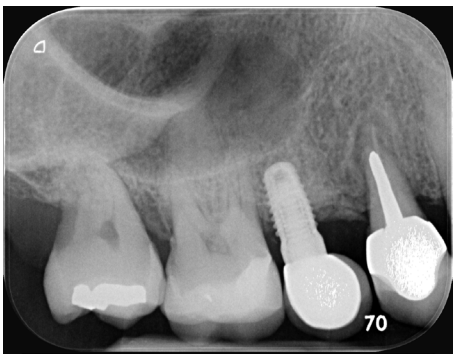


**Figure 17.** Radiographic outcome.

## 4. Discussion

Without having an overwhelming load of clinical long-term studies in endodontics available, it is well-known from the literature in the field that endodontic treatments are both successful and responsible for tooth preservation in the long run[4,18,19].

Although there is an enormous progress in root canal preparation techniques documented using any kind of more flexible and less deviating NiTi-instruments[17,26], it is still not fully understood and known whether old-fashioned root canal treatment regimens of the past have been successful, too. There may be the primary concern of using too stiff steal instruments causing routine deviation of the root canal system potentially leading to significantly less overall success of endodontic measures. Furthermore, also clearly obsolete intracanal medicaments and sealer materials have been used back then and today no one would even think to use them again because meanwhile exist much better alternatives in any indication[5,27,28]. Therefore, the aim of the present retrospective evaluation was to investigate 1970/80's style endodontic treatment outcome over more than four decades.

To cut a long story short: Also old-fashioned non-surgical endodontic treatment was successful over the observation period of 40 years. It is astonishing that after 40 years, more than 50% of endodontically treated teeth are still in function (Figures 16, 17). Although materials and techniques have been used that are completely disregarded as obsolete today, in the end the observed and documented outcome was excitingly good. So when materials and techniques are obviously less decisive factors for clinical outcome, what is it? Having a closer look into the treatment protocols of the available documentations clearly shows two important aspects: 1. Both operators have been very experienced, a factor that has been shown to be of predominant importance in other fields of dentistry[29], and 2. Only teeth with absolutely no loosening have been included in the study because both operators also had a strong background in Periodontology. So based on the data of the present evaluation both factors seem to positively influence long-term outcome of endodontic treatments.

Concerning the evaluated co-factors for clinical success, it was shown that gender of patients, jaw, tooth position (anterior vs. posterior), and number of intracanal dressing/medication changes did not show a significant influence on clinical outcome. Compared to the literature in the field of endodontology, the most surprising finding of the present study was clearly that the distance from root filling to radiographical apex apparently did not affect clinical outcome. This may be justified by the fact that many pulpectomies have been performed as primary endodontic treatment with less need for disinfection protocols[4,5,17], however, it remains astonishing.

It has been reported that the quality of the individual post-endodontic restoration is an important factor for long-term tooth survival[21,23–25], sometimes it was even regarded as more important than the quality of root canal obturation itself[20]. Also in the present trial, significant differences between the involved post-endodontic restorations have been computed. Although adhesive technologies have been neither fully understood nor extremely advanced back in the 1980's, the outcome of resin composite fillings as post-endodontic restorations was surprisingly good. However, as normally smaller defects receive more direct resin composite restorations[24], retrospectively this observation may just be correlated to primary cavity as well as defect size and

therefore be somewhat questionable. And although screw-retained post-endodontic build-ups have been reported as inferior measures[30], the present data revealed no difference between screws and posts, however, compared to more adhesive times, every single post was luted with conventional cements and not fully adhesively luted like today [23–25]. This may explain the similar results when it comes to screws vs. posts for post-endodontic build-up[23–25].

Nevertheless, facing the array of clinical variables that have not been known or fully understood in the 1980's combined with the fact that flexibility of root canal instruments has been mainly underdeveloped[26], the overall outcome of the present retrospective investigation is surprisingly good. This also has a significant impact on quality of life for the investigated group of patients[12]. The final critical question remains: Although we know so much more today in almost every aspect that has been investigated here[23], and although we definitely have access to much more advanced materials, methods, and protocols[21]: Are really more successful today in clinical endodontics?[16]

## 5. Conclusions

Endodontic treatment of root canals having been filled in the 1980's showed a good clinical outcome over 40 years of clinical service. Both experience of the operators and narrow/strict indication seem to be decisive factors for clinical success.

**Supplementary Materials:** on file.

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