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Dentareport - Automated longevity and risk factor analysis in dental patient care

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ABSTRACT

Background and objective: During routine patient care practitioners have to document several aspects. However, currently it is difficult to methodically analyze the longevity of therapeutic concepts in dental private practice. Thus, the aim of the present paper was to introduce a software (Dentareport) to compare the success of different treatment options and to identify risk factors for failures in dental patient care.

Methods: Dentareport has a digital interface to automatically collect data of electronic patient files of practice management programs. By using computer-aided routines descriptive analyses of the treatments can be visualized. Dentareport also visually displays a bivariate risk factor analysis of treatment options. For this, crude associations between baseline characteristics (e.g. age) and time until failure (e.g. tooth loss) are calculated for the chosen treatment option by fitting separate models for each baseline characteristic as the independent variable. Furthermore, annual failure rates and survival graphs can be displayed.

Results: The software has already been used to self-analyze treatment decisions. It highlighted the most long-lasting treatments for specific indications. Risk factors on practice-, patient- and tooth-level were easily identified. Furthermore, the software has been used to collect data for analysis of retrospective practice-based, mono-as well as multi-center observational studies.

Conclusions: By using Dentareport practitioners can easily and objectively self-analyze treatment successes and risk factors. Furthermore, for researchers the software easily generates huge data sets in different fields in dentistry and enables the analysis on a multi-center level. Most relevant factors can, thus, be taken into account for treatment decisions.

1. Introduction

In patient care the chosen treatment options of a practitioner may change over time. At the start of the career treatment options are primarily based on the therapeutic concepts being educated in medical school. These concepts mostly base on scientific outputs and clinical practice guidelines. Over time treatment options are adapted due to the practitioner's skills, regional incidences of diseases, regional treatment needs, the health care providers' experience and one's own (subjective) experience of successes and failures [1,2]. However, an objective analysis if the own changes in the therapeutic concepts result in a higher longevity is not carried out (regularly).

Furthermore, during routine patient care practitioners have to document several aspects: The reason why the patient visited the practice, findings, diagnoses, the treatment procedures, follow-up procedure, their information about risks, chances of success and, of course, the settlement items of the national Scales of Fees. Thus, a lot of data are routinely recorded in private practices but only data on the fees that have been charged (e.g. Refs. [3–6]) have been analyzed by some insurance companies in only a few fields of dentistry. Regarding the longevity the complete data sets are often not analyzed at all or only on a rudimentary level.

In dental patient care differences in the longevity of treatment options and differences between risk factors on failure of e.g. dental materials appear only after longer observation times of up to 10 years [7]. Because of a long follow-up period this type of study is very expensive

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and time-consuming [8]. Furthermore, most of the studies on longevity are (prospective (non-)randomized controlled) university-based studies. Although university-based studies reveal clinical efficacy, data do not reflect effectiveness of daily dental care in general practices [8,9]. For this practice-based studies are necessary.

Recently, a few studies on long-term practice-based studies were published in the field of dentistry [10–13]. The longevities of direct restorations in a Dutch [10], endodontically treated teeth with [13] and without [12] post restorations in a German and indirect ceramic restorations [11] in an international dental practice-based research network have been analyzed. In two of the three networks data had to manually be collected via an online platform (www.csa-online.net, www.azt.de) [11–13]. Only one network used an application to extract data from two (Dutch) practice management programs [10]. However, the mentioned networks have only analyzed a few aspects in practice-based dentistry. A structured analysis of different fields in (practice-based) dentistry has not yet taken place.

Thus, the aim of the present paper is to introduce a software - with a standardized interface to different (German) practice management programs - to methodically analyze the longevity of treatment options in dental private practices. Practitioners can use the software to objectively self-analyze the success of different treatment options and to identify risk factor for failures over time or at certain time points. Thus, cost-longevity relation and dental patient care on patient level can be improved. Furthermore, researchers can use the software to easily generate huge data sets in different fields in (practice-based) dentistry and to analyze them by using semi-automatic analyses on a multi-center level. Thus, long-term effectiveness of daily dental care can cost-effectively be evaluated.

2. Program description

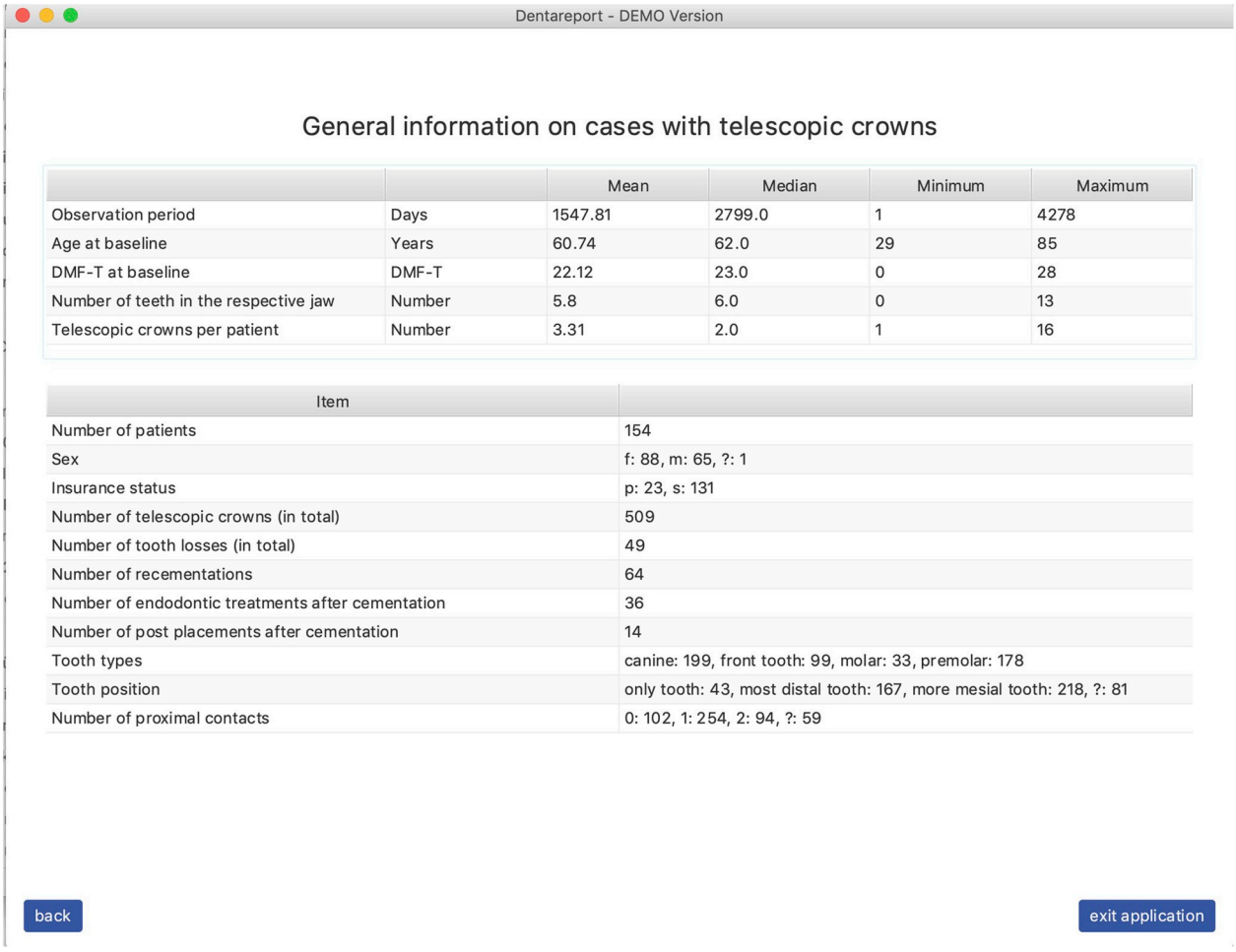
2.1. The software

The software 'Dentareport' is a beta release (www.dentareport.de). It automatically summarizes overall information of treatment options (descriptive analysis) and visualizes the longevity of treatment options (inductive analysis). Due to its user-oriented platform the software can be used by practitioners not being familiar with statistic.

A digital interface automatically extracts relevant data of the electronic patient files of two (dental) practice management programs (DS-WIN, Dampsoft GmbH – Die Zahnarzt-Software, Damp, Germany; CGM Z1, CompuGroup Medical Dentalsysteme GmbH, Koblenz, Germany). A third practice management program (Charly, solutio GmbH, Holzgerlingen, Germany) will be included in a further release. These three practice management programs were chosen since the electronic patient files are saved in non-encrypted databases. For data extraction the software reads out the settlement items of the national Scales of Fees for Dentists. By using predefined terms in the electronic files text entries can be read out as well.

2.2. User interface – practitioners' view

After starting the software the user can select the subject of interest.



		Mean	Median	Minimum	Maximum
Observation period	Days	1547.81	2799.0	1	4278
Age at baseline	Years	60.74	62.0	29	85
DMF-T at baseline	DMF-T	22.12	23.0	0	28
Number of teeth in the respective jaw	Number	5.8	6.0	0	13
Telescopic crowns per patient	Number	3.31	2.0	1	16

Item	
Number of patients	154
Sex	f: 88, m: 65, ?: 1
Insurance status	p: 23, s: 131
Number of telescopic crowns (in total)	509
Number of tooth losses (in total)	49
Number of recementations	64
Number of endodontic treatments after cementation	36
Number of post placements after cementation	14
Tooth types	canine: 199, front tooth: 99, molar: 33, premolar: 178
Tooth position	only tooth: 43, most distal tooth: 167, more mesial tooth: 218, ?: 81
Number of proximal contacts	0: 102, 1: 254, 2: 94, ?: 59

Fig. 1. Descriptive analysis. The software provides structured information (descriptive analysis) of the chosen treatment option. This is a translated screen shot. The original program language is German.

At the moment different fields in preventive dentistry (preventive treatments, sealants), restorative dentistry (endodontic treatments, posts, restorative materials, direct/indirect restorations), in prosthodontics (crowns, bridge anchors, telescopic crowns, implants), in surgery (general surgery e.g. extractions) and general information on the own patients can be analyzed (figure not shown).

By selecting the subject of interest (e.g. telescopic crowns) the descriptive analysis of the selected treatment option is shown (Fig. 1). The number of patient being treated, gender, insurance status (private or statutory), number of tooth types, number of proximal contacts, mean observation time, mean age of the patients at the date of intervention, number of treatments per patients, mean decayed, missing, and filled teeth (DMF-T) index at the date of intervention and treatment depending information (e.g. endodontic treatments before and after crowning) is automatically listed.

The software also visually displays a bivariate risk factor analysis of the treatment option (Fig. 2). For this analysis different events for failure and baseline characteristics can be chosen (Fig. 2). The eligible events for failure and baseline characteristics are chosen based on previous studies on risk factor in the respective fields. By using computer-aided routines crude associations between baseline characteristics (e.g. age) and time until failure (e.g. tooth loss) are calculated for the chosen treatment option by fitting separate models for each baseline characteristic as the independent variable [14].

Furthermore, the number of treatments in each subcategory, the annual failure rate (AFR) after 5 and 10 years and survival curves up to the maximum observation period are presented (Fig. 3). For this, AFR are calculated from life tables and the independent method is used for Kaplan-Meier statistic [15].

2.3. Use for scientific issues

Computer-aided routines enable the bivariate Cox proportional hazard analysis. However, for scientific issues mutual interaction of several factors should be analyzable. Thus, a multivariate Cox proportional hazard analysis is needed. Currently, this is not possible with the present release. Nonetheless, the collected data can be exported in xlsx- or csv-files. In both files one tab shows the exported data (Fig. 4) and one a legend explaining the headings of the first one.

Furthermore, by exporting the data in xlsx- or csv-files and combining the data of practices comparisons between practitioners in different practices are possible. However, for this several aspects have to be considered. For instance treatment processes, decisions for reintervention and documentations have to be calibrated for comparability.

The exported data can be imported in any statistical program. Factors associated with time until failure in the separate models can, thus, be analyzed in a multivariate Cox regression model.

2.4. Hardware and software specification

The software can be installed on any personal computer using windows or macOS. No internet access is needed, no data is send to any server in the internet. Thus, the data remain in the private praxis. Furthermore, within the software, the collected data will be analyzed anonymously (without references to patient identifying factors e.g name, birthday, patient no.). Thus, by exporting the data in a xlsx- or csv-file and by sharing the data with colleagues data privacy is still guaranteed.

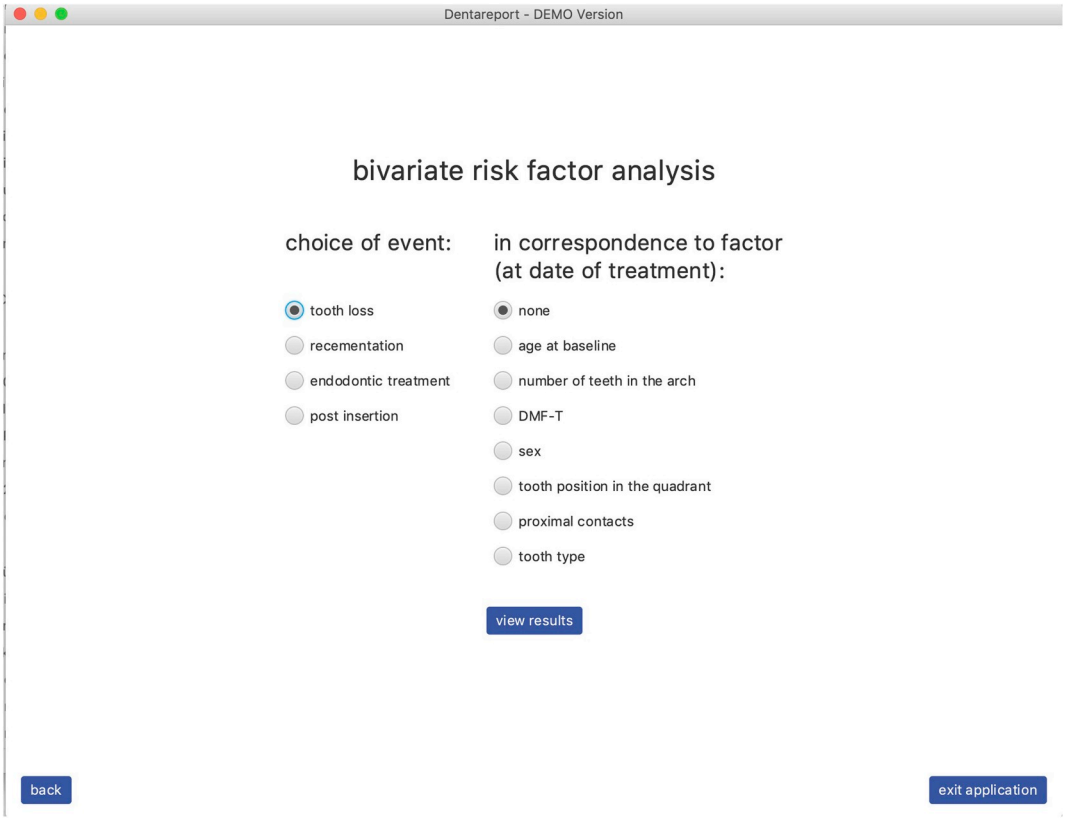
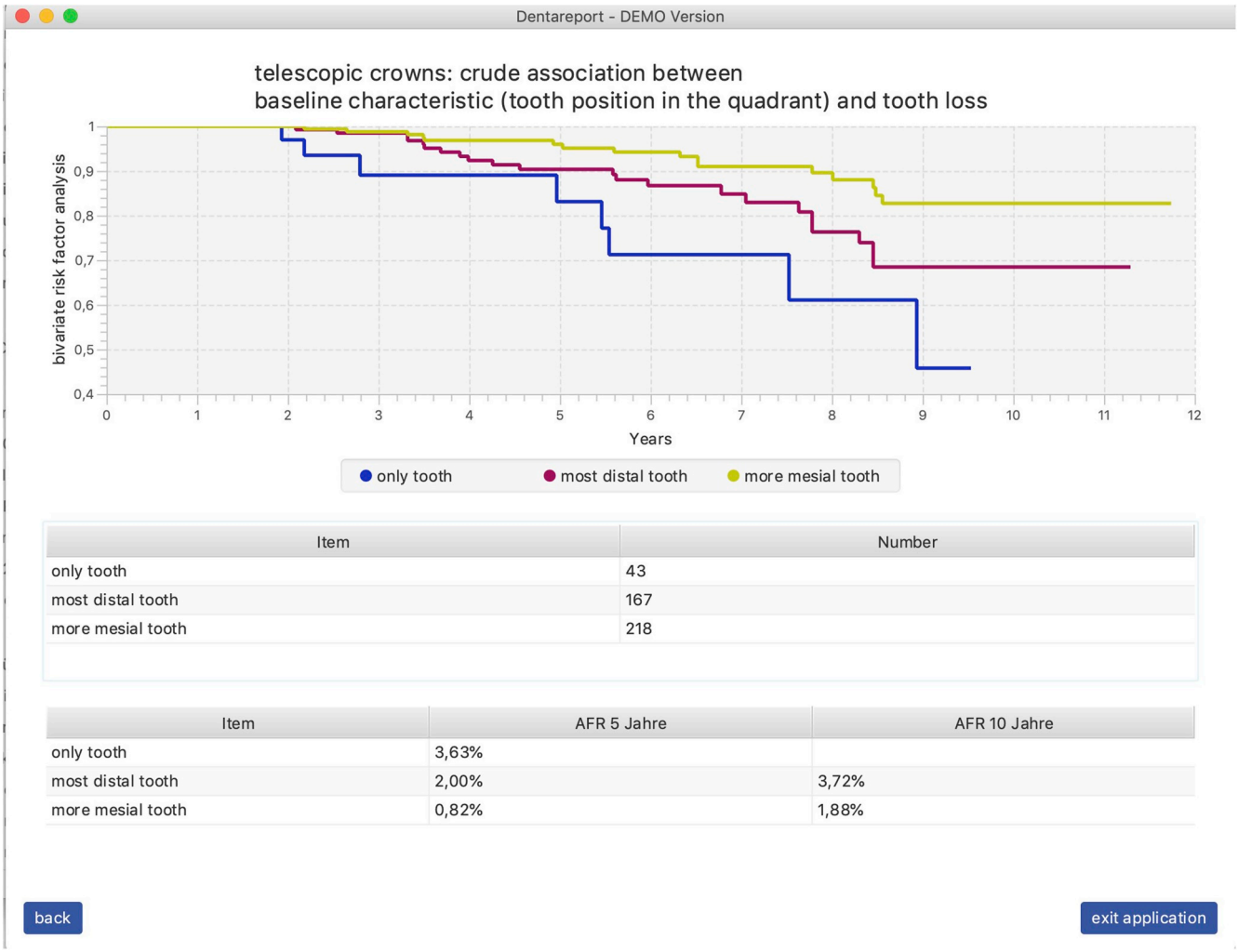


Fig. 2. Events for failure and baseline characteristics for bivariate cox regression hazard analysis. In this software level events for failure and baseline characteristics for bivariate cox regression hazard analysis can be chosen. This is a translated screen shot.



Item	Number
only tooth	43
most distal tooth	167
more mesial tooth	218

Item	AFR 5 Jahre	AFR 10 Jahre
only tooth	3,63%	
most distal tooth	2,00%	3,72%
more mesial tooth	0,82%	1,88%

Fig. 3. Survival graphs and annual failure rates. The software provides structured information (inductive analysis) of the chosen treatment option. When the observation period is shorter than 10 years no values for the AFR after 10 years are presented. This is a translated screen shot.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1		1.1	1.2	1.4	1.5	1.6	1.7	1.8	1.9	1.10	2.1	2.2	2.3	2.4	2.5	2.6	2.7
2		Pat-Nr (1.1)	tooth (1.2)	toothtype (1.4)	jaw (1.5)	birhtday (1.6)	gender (1.7)	Insurance (1.8)	(1.9)	(1.10)	(2.1)	D2.2)	(2.3)	(2.4)	(2.5)	(2.6)	(2.7)
3	1	1072	33	canine	lower	27745	m	g	1	0	2006-06-23	2016-03-24	3562	0	no_data	63	23318
4	2	1096	13	canine	upper	31414	w	g	1	0	2008-04-17	2012-11-26	1684	0	no_data	75	27651
5	3	1118	33	canine	lower	30149	m	g	3	0	2009-03-10	2009-04-20	41	1	VitE/Trep/	73	26713
6	4	1118	42	incisor	lower	30149	m	g	3	0	2009-03-10	2011-03-01	721	1	VitE/Trep/	73	26713
7	5	1118	43	canine	lower	30149	m	g	3	0	2009-03-10	2009-03-12	2	1	VitE/Trep/	73	26713
8	6	1126	13	canine	upper	29278	w	g	2	0	2010-05-31	2015-07-29	1885	0	no_data	71	26289
9	7	1126	23	canine	upper	29278	w	g	2	0	2010-05-31	2015-07-29	1885	0	no_data	71	26289
10	8	1149	34	premolar	lower	26976	m	g	2	1	2006-02-08	2015-11-23	3575	0	no_data	61	22414
11	9	1149	47	molar	lower	26976	m	g	2	1	2006-02-08	2015-11-23	3575	0	no_data	61	22414
12	10	127	13	canine	upper	32471	w	g	2	0	2005-10-07	2016-01-26	3763	0	no_data	76	27785
13	11	127	21	incisor	upper	32471	w	g	2	0	2005-10-07	2016-01-26	3763	0	no_data	76	27785
14	12	1275	43	canine	lower	30178	m	p	2	0	2004-12-16	2008-10-23	1407	0	no_data	68	25197
15	13	1275	44	premolar	lower	30178	m	p	2	0	2004-12-16	2008-10-23	1407	0	no_data	68	25197
16	14	1277	12	incisor	upper	25224	w	g	6	0	2006-02-23	2015-11-30	3567	0	no_data	56	20677
17	15	1277	13	canine	upper	25224	w	g	6	0	2006-02-23	2015-11-30	3567	0	no_data	56	20677
18	16	1277	21	incisor	upper	25224	w	g	6	0	2006-02-23	2015-11-30	3567	0	no_data	56	20677
19	17	1277	22	incisor	upper	25224	w	g	6	0	2006-02-23	2015-11-30	3567	0	no_data	56	20677

Fig. 4. Exported xlsx-file. The anonymized data can be exported into xlsx-files (Microsoft Excel-file). Thus, data of several practices can be combined for a multi-center analysis.

3. Results

3.1. Practitioners' view

The present software has already been used by selected practitioners. In preventive dentistry (preventive treatments, sealants), restorative dentistry (endodontic treatments, posts, restorative materials, direct/indirect restorations), in prosthodontics (crowns, bridge anchors, telescopic crowns, implants) and in surgery (general surgery e.g. extractions) the software were successfully used to self-analyze treatment decisions (Fig. 2) and to display general information on the practice's patients (Fig. 1). It easily highlighted the most long-lasting treatments for specific indications (Fig. 2).

3.2. Researchers' view

The software was used to collect data for analysis of retrospective practice-based, mono- [16] as well as multi-center [17](unpublished data) non-interventional studies. Thus, risk factors on practice-, patient- and tooth-level were easily identified [16,17].

3.3. Ongoing developments

In one of the next releases the descriptive results of the Kaplan-Meier statistic, the hazard ratio and its p-value will also be displayable in the software. Furthermore, user-friendly computer-aided routines for multivariate Cox regression models including factors being associate with failure in the bivariate models will also be implemented.

Furthermore, it is intended to implement the automatic comparison to the results of previous (university-based) studies in the respective field and of data given by the insurance companies (e.g. Ref. [6]).

4. Discussion

The described software was developed to methodically analyze the longevity of therapeutic concepts in private practice and to identify risk factors for failures. For both, one's own as well as the scientific analysis of the longevity and the identification of risk factors the software could easily be used. The present software was even capable to collect data for retrospective practice-based, mono-as well as multi-center observational studies.

Dentareport easily enables the automatic analysis of the huge data set being recorded in the daily routine of a private practice. Practitioners are, thus, not only able to objectify if subjective predictors for success and failure are true objective predictors but they are also able to easily compare one's own treatments to the analyses of insurance companies (e.g. Ref. [6]) and to previous university and practice-based long-term studies [11,18]. Furthermore, by the regular analysis of one's own treatment options the software may help to improve the long-term success of patient care.

Regarding the analysis on a multi-center level the software can be used indirectly by exporting the collected data into xlsx- and csv-files. However, for the multi-center analysis several aspects have to be considered prior prospective and/or retrospective evaluation [16,17]. To minimize bias and confounders treatment decisions and processes in the included practices have to be harmonized. Furthermore, study criteria for inclusion, failure, success/survival as well as, re-intervention and documentation for this study have to be calibrated. Thus, depending on the grade of calibration the gained information of multi-center analysis has to be interpreted with caution.

At the moment the software uses a digital interface to automatically extract relevant data of 'only' two practice management programs. These programs are being used by 50% of the German practitioners. However, not every practitioner can use the introduced software. When a practice management program uses an encrypted databases the interface is not able to communicate with the program. Interestingly, although the practitioners are the owner of the medical records (at least in Germany) the manufactures of the programs with an encrypted databases have to be asked to open there databases for the implemented interface prior any analysis is possible.

The introduced software has already been used to analyze the longevity of invasive and non-invasive treatment options in one mono-center [16] and one multi-center study [17](unpublished data). It was shown that the long-term success in private practice could be considered as satisfying from a clinical perspective [18]. Furthermore, the long-term success seemed to be similar to the one in university-based studies [19,20]. Contrastingly, risk factors in private practice were either in accordance (e.g. frequency of check-ups per year) [3,4] or differentiated (e.g. patient age) [21] when compared to previous (university-based) studies. However, for both studies only data on restorative treatment of carious cervical lesions have been collected. Thus, by using the introduced software further analyses of the huge data set (being recorded in the daily routine) should be performed in different fields of dentistry to compare risk factors and the longevity in practice-based dentistry with the results of university-based studies.

One of the first practice-based research networks started in 1994 (Ceramic Succes Analysis). At the beginning the participating practitioners were asked to regularly send their data on indirect restorations via disc to the Society for Dental Ceramics. Since 2008 data is inserted via an internet platform [11]. A second practice-based research network (Arbeitskreis Zahnärztliche Therapie) started their first study in 2003. Data were also inserted via an internet platform [12]. Both networks prospectively analyzed therapeutic concepts in private practice. However, an automatic transfer between the practice management programs and online platform was not implemented. Furthermore, in both networks it was not monitored if all cases – which fulfill the inclusion criteria – were reported by the participating practitioners. Due to the huge data set being recorded in the daily routine of a private practice it was justifiably not feasible that a second person controlled all patient files in the respective practices. Only the third practice-based research network used an application to automatically extract data from Dutch practices. However, this program was developed for scientific analysis and not for the practitioners themselves. Contrastingly, Dentareport was initially developed to be used by practitioners not being familiar with statistic to methodically analyze (and thus improve) the longevity of therapeutic concepts of practitioners in private practice. One secondary effect was that data can also be analyzed scientifically in retrospective and/or prospective mono-as well as multi-center (observational) studies.

In conclusion, by using the software Dentareport practitioners can easily and objectively analyze treatment successes and risk factors. Even if practitioners are not familiar with statistic this can easily be done. Thus, failure rates in practices can be reduced and dental patient care be optimized. Furthermore, for researchers the software easily generates huge data sets in different fields in dentistry and enables the scientific analysis on a multi-center level. Thus, most relevant factors can not only be evaluated but also be taken into account for treatment decisions.

Conflicts of interest statement

The authors declare no potential conflicts of interests. E.J.K. was one of the developer of the software Dentareport.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.compbiomed.2019.103437.

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