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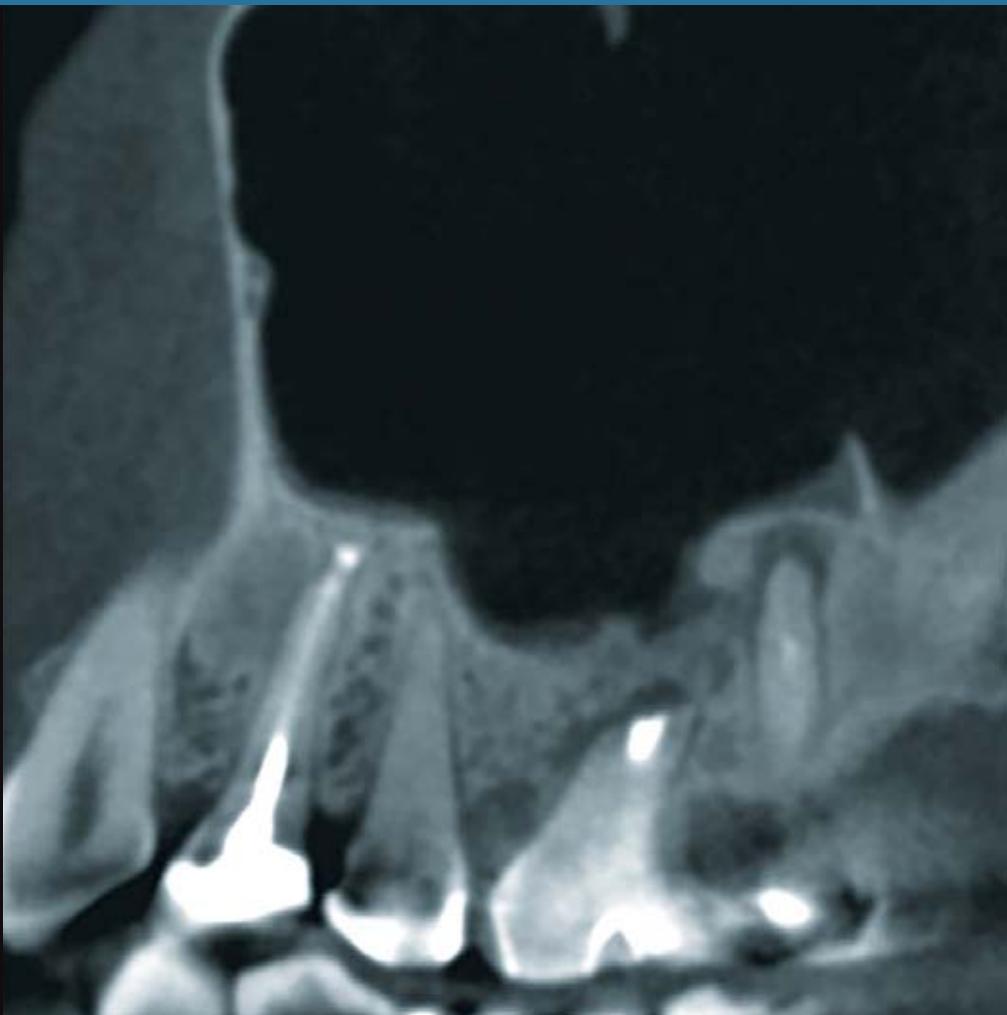
The Journal Impact Factor  
2021

Knowledge and skills of para-medics in handling patients with traumatic dental injuries

Formative e-assessment improves performance in dental education

Are apical lesions visible more often in CBCT than in panoramic radiographs?

From SS-Obersturmbannführer to dentist president: The astonishing career of Gerhardt Steinhardt



This journal is regularly listed  
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**Title picture:** Depiction of an apical lesion in region 27 of the palatal root. Such lesions are often not visible in conventional X-ray technology. (Photo: Ali-Reza Ketabi)

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# The Journal Impact Factor 2021

On June 30, 2022, the Clarivate™ media group published the new rankings of scientific journals with impact factor in its *Journal Citation Reports*. For the 2021 reporting year,

9,588 of the 9,626 journals included have a journal impact factor (JIF).

The dental journals that had a JIF in 2021 are listed below. For

comparison, the 20 scientific journals with the highest JIF are contrasted. The overview is concluded with current critical comments on the JIF.

JIF rank 2021	Journal	JIF 2021	JIF 2020	JIF rank 2020
1	International Journal of Oral Science	24.897	6.344	4
2	Periodontology 2000	12.239	7.589	2
3	Journal of Dental Research	8.924	6.116	5
4	Journal of Clinical Periodontology	7.478	8.728	1
5	Japanese Dental Science Review	6.468	5.093	11
6	Oral Oncology	5.972	5.337	7
7	Dental Materials	5.687	5.304	8
8	International Endodontic Journal	5.165	5.264	10
9	Journal of Evidence-Based Dental Practice	5.100	5.267	9
10	Clinical Oral Implants Research	5.021	5.977	6
11	Journal of Dentistry	4.991	4.379	14
12	Journal of Periodontology	4.494	6.993	3
13	Journal of Endodontics	4.422	4.171	16
14	Journal of Prosthodontic Research	4.338	4.642	12
15	Journal of Adhesive Dentistry	4.309	2.359	51
16	Clinical Implant Dentistry and Related Research	4.259	3.932	18
17	Journal of Prosthetic Dentistry	4.148	3.426	25
18	Molecular Oral Microbiology	4.107	3.563	22
19	Oral Diseases	4.068	3.511	23
20	Journal of Periodontal Research	3.946	4.419	13
21	Caries Research	3.918	4.056	17
22	BMC Oral Health	3.747	2.757	35
23	Journal of Dental Sciences	3.719	2.080	59

JIF rank 2021	Journal	JIF 2021	JIF 2020	JIF rank 2020
24	International Journal of Oral Implantology	3.654	---	---
25	Clinical Oral Investigations	3.606	3.573	21
26	Journal of Oral Rehabilitation	3.558	3.837	19
27	Journal of Oral Pathology & Medicine	3.539	4.253	15
28	Dentomaxillofacial Radiology	3.525	2.419	49
29	Journal of Prosthodontics – Implant, Esthetic, and Reconstructive Dentistry	3.485	2.757	36
30	Journal of the American Dental Association	3.454	3.634	20
31	Dental Traumatology	3.328	3.333	27
32	International Journal of Paediatric Dentistry	3.264	3.455	24
33	Progress in Orthodontics	3.247	2.750	37
34	Journal of Cranio-Maxillofacial Surgery	3.192	2.078	61
35	Journal of Applied Oral Science	3.144	2.698	38
36	European Journal of Orthodontics	3.131	3.075	29
37	Oral and Maxillofacial Surgery Clinics of North America	3.130	2.802	33
38	Journal of Esthetic and Restorative Dentistry	3.040	2.843	31
39	Implant Dentistry	3.000	2.454	47
40	International Journal of Oral and Maxillofacial Surgery	2.986	2.789	34
41	International Journal of Implant Dentistry	2.984	2.384	50
42	Operative Dentistry	2.937	2.440	48

**Table 1** Journal impact factor (JIF) for 2021 for the 92 journals listed in the category *Dentistry, Oral Surgery & Medicine* with comparison of the previous year's JIF.

JIF rank 2021	Journal	JIF 2021	JIF 2020	JIF rank 2020
43	International Journal of Computerized Dentistry	2.923	1.883	67
44	International Journal of Oral and Maxillofacial Implants	2.912	2.804	32
45	Odontology	2.885	2.634	40
46	Medicina Oral, Patología Oral y Cirugía Bucal	2.883	2.047	62
47	Gerodontology	2.750	2.980	30
48	British Dental Journal	2.727	1.626	79
49	International Journal of Dental Hygiene	2.725	2.477	46
50	American Journal of Orthodontics and Dentofacial Orthopedics	2.711	2.650	39
51	Angle Orthodontist	2.684	2.079	60
52	Brazilian Oral Research	2.674	2.203	---
53	Archives of Oral Biology	2.640	2.633	41
54	International Dental Journal	2.607	2.512	45
55	Orthodontics & Craniofacial Research	2.563	1.826	72
56	Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology	2.538	2.589	44
57	European Journal of Dental Education	2.528	2.355	52
58	Community Dentistry and Oral Epidemiology	2.489	3.383	26
59	Journal of Stomatology, Oral and Maxillofacial Surgery	2.480	1.569	80
60	Journal of Oral Facial Pain & Headache	2.457	1.871	69
61	Dental Materials Journal	2.418	2.102	58
62	Pediatric Dentistry	2.378	1.874	68
63	Journal of Orofacial Orthopedics – Fortschritte der Kieferorthopädie	2.341	1.938	64
64	European Journal of Paediatric Dentistry	2.327	2.231	56
65	Journal of Dental Education	2.313	2.264	55
66	Australian Dental Journal	2.259	2.291	54
67	Journal of Public Health Dentistry	2.258	1.821	73
68	Head & Face Medicine	2.246	2.151	57

JIF rank 2021	Journal	JIF 2021	JIF 2020	JIF rank 2020
69	Acta Odontologica Scandinavica	2.232	2.331	53
70	International Journal of Periodontics & Restorative Dentistry	2.227	1.840	71
71	Quintessence International	2.175	1.677	76
72	European Journal of Oral Sciences	2.160	2.612	43
73	Journal of Oral and Maxillofacial Surgery	2.136	1.895	66
74	Journal of Periodontal and Implant Science	2.086	2.614	42
75	British Journal of Oral & Maxillofacial Surgery	2.018	1.651	78
76	Journal of Advanced Prosthodontics	1.989	1.904	65
77	Cleft Palate-Craniofacial Journal	1.915	1.433	83
78	Oral Radiology	1.882	1.852	70
79	International Journal of Prosthodontics	1.785	1.681	75
80	American Journal of Dentistry	1.748	1.522	82
81	Australian Endodontic Journal	1.719	1.659	77
82	Cranio – The Journal of Craniomandibular Practice	1.670	2.020	63
83	Journal of Oral Science	1.630	1.556	81
84	Oral Health & Preventive Dentistry	1.595	1.256	87
85	Journal of Oral Implantology	1.546	1.779	74
86	Korean Journal of Orthodontics	1.361	1.372	84
87	Journal of the Canadian Dental Association	1.348	1.316	86
88	Seminars in Orthodontics	1.340	0.970	89
89	Journal of Clinical Pediatric Dentistry	1.338	1.065	88
90	Community Dental Health	1.330	1.349	85
91	Australasian Orthodontic Journal	0.269	0.226	90
92	Implantologie	0.127	0.125	91

**Table 1** Journal impact factor (JIF) for 2021 for the 92 journals listed in the category *Dentistry, Oral Surgery & Medicine* with comparison of the previous year's JIF (continuation).

Year	JIF
2021	24.897
2020	6.344
2019	3.047
2018	2.750
2017	4.138
2016	3.930
2015	2.595
2014	2.531
2013	2.029
2012	2.719
2011	1.411
2010	0.815

**Table 2** Development of the JIF of the *International Journal of Oral Science* between 2010 and 2020.

### Included journals and general development

The *Dentistry, Oral Surgery & Medicine* category includes 92 journals with a JIF, one more than in previous years due to

- the new inclusion of the *International Journal of Oral Implantology* and
- the journal *Brazilian Oral Research*, which was included too late in the previous year,
- while eliminating the title *European Journal of Oral Implantology* (renamed *International Journal of Oral Implantology* as of January 2019) (Table 1).

The 2021 JIF values range from 0.127 (the German-language journal *Implantologie*) to – almost incredibly for dental journals – 24.897 (*International Journal of Oral Science*), tripling the peak value of the previous year (8.728, *Journal of Clinical Periodontology*; see Table 2 for the evolution of this journal). Although the JIF-related arithmetic mean of all dental journals increased from just under 2.9 in 2020 to just almost 3.4 in 2021, 24 of the 91 journals have a lower JIF than in the previous year.

JIF rank 2021	Journal	JIF 2021
1	CA-A Cancer Journal for Clinicians	286.130
2	Lancet	202.731
3	New England Journal of Medicine	176.079
4	Journal of the American Medical Association	157.335
5	Nature Reviews Molecular Cell Biology	113.915
6	Nature Reviews Drug Discovery	112.288
7	Nature Reviews Immunology	108.555
8	Lancet Respiratory Medicine	102.642
9	British Medical Journal	93.333
10	Nature Medicine	87.241
11	Lancet Microbe	86.208
12	World Psychiatry	79.683
13	Nature Reviews Microbiology	78.297
14	Lancet Psychiatry	77.056
15	Nature Reviews Materials	76.679
16	Nature Reviews Gastroenterology & Hepatology	73.082
17	Lancet Public Health	72.427
18	Chemical Reviews	72.087
19	Lancet Infectious Diseases	71.421
20	Nature Reviews Cancer	69.800
...	...	
9,588	Sen-I Gakkaishi (Journal of the Society of Fiber Science and Technology, Japan)	0.016

**Table 3** The 20 scientific journals with the highest journal impact factor (JIF) and the bottom of the ranking of 2021. Note: Nineteen of the top 20 journals are from the biomedical field.

To “rank” the JIF of dental journals in the overall picture of all scientific journals, Table 3 shows the 20 journals with the highest JIF values.

### Criticism of the JIF

The numerous weaknesses and shortcomings of the JIF have been extensively documented in the literature (e.g., [3, 8]) and in the JIF-specific analyses published annually in this journal and the *Deutsche Zahnärztliche Zeitschrift* since 2015. In the past 12 months, criticisms have included (Table 4):

- The calculation of the JIF as an arithmetic mean,
- the lack of differentiation between the various publication types (research articles, reviews, clinical recommendations, etc.),
- the manipulative-distorting influence of self-citations and citation cartels,
- the misconception that contributions published in JIF journals are

**“The citation frequency is often equated with the quality of a journal. However, this is incorrect. The citation frequency can only be used for statements about the impact of a scientific article, less for the content-related quality of the results.”**

Dr. Jasmin Schmitz, head of publication consulting, Publisco, ZB MED – Information Centre for Life Sciences, Cologne, Germany [6]

Citation	Source
"One of the most commonly noted constraints of the JIF is its calculation as a mean. This mode of data representation has the potential limitation of a small number of highly cited manuscripts disproportionately influencing the JIF. Therefore, if the number of citations per article is a skewed distribution, a metric based on a calculation of a mean could render an evaluation that is not representative of the majority of the articles included in the calculation."	Daugherty et al. [1]
"The other most commonly described constraint of the JIF is an aggregate index encompassing many different types of publications that include not only original research articles but also reviews, guidelines, and statements, which have higher citation metrics."	Daugherty et al. [1]
"For example, a journal (A) scored almost a double increase in its IF during just 4 years. It turned out that in a review published in another journal (B), out of 490 references 445 were citations of articles published by journal A and all of them during 2 years from which the journal's IF was calculated. Incidentally, three of the four authors of that review were on the editorial board of journal A. While self-citations are very easy to identify, citation cartels are difficult to track and can do the most harm to scientometrics based on manipulated data."	Górski et al. [2]
"In view of the above, we can conclude that the evaluation of the quality of publications based exclusively on the impact of the journal in which the article was published is, in addition to being imprecise, unfair in the case of the nursing discipline, given the limited possibility of publishing in this type of journal for our group."	Salamanca Castro [5]
"Although the JIF refers to a journal as a whole and says nothing about the influence or even the scientific quality of individual articles, it is often used to assess the research performance of scientists. This is not the only reason why the JIF is often criticized. It is also highly dependent on the subject area and thus not comparable across disciplines; in addition, it only takes into account the past two years in each case. The calculation is not very transparent and often not independently reproducible."	Open Access Network [4]
"To be able to cite journals by rank, JIFs are given to three decimal places and without confidence intervals or error bars. However, this data accuracy is an illusion. Measuring citation counts is not an exact science, as has been shown in several examples in bibliometrics, e.g., Vanclay, 2012."	University of Zurich [7]

**Table 4** Critical statements on the JIF

Tab. 1–4: J. C. Türp

- automatically of high quality or that only articles published in JIF journals are of high quality,
- the lack of comparability among different disciplines,
  - the misconception that the JIF is a precise value.

### Conflict of interest

The author declares that there is no conflict of interest as defined by the guidelines of the International Committee of Medical Journal Editors.

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Photo: Basilišk, Basel

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# Knowledge and skills of paramedics in handling patients with traumatic dental injuries

**Introduction:** Traumatic dental injuries are sudden and acute events and often require emergency care. Paramedics are very often the first responders on the scene. Through rapid and correct management, they can have a significant impact on the prognosis of the injured tooth. This study aimed to investigate the knowledge and skills of paramedics in the management of dental injuries.

**Methods:** In this cross-sectional observational study, an electronic questionnaire was sent to 541 emergency departments across Germany. The questionnaire contained questions about the characteristics of the paramedics and about their ability to treat dental trauma. For statistical analysis, the Student's t-test, the chi<sup>2</sup> test, the ANOVA test, or a regression model were used, as appropriate.

**Results:** Only 6% of the 690 participants reported having at least a good working knowledge, and only 4.5% reported having good dental trauma management skills. Although 79% of participants felt that an intraoral examination was an essential part of the initial examination of trauma patients, only 15.66% were familiar with this procedure. And although 71.9% of participants had heard of a dental rescue box, only 30.7% carried one as standard equipment on the rescue vehicle.

**Conclusion:** Paramedics have only a basic understanding of the treatment of dental trauma. Initial treatment of dental trauma should become an integral part of paramedic training. Dental rescue boxes should be standard equipment on ambulances. In general, a good long-term outcome should be sought for patients with dental trauma. Paramedics could play an important role in the care of dental trauma patients.

**Keywords:** avulsion; dental rescue box; knowledge; paramedics; skills; traumatic dental injury

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Variable (n)		Number (%)
<b>Age Mean/Median [Min-Max] in years (677)</b>	$32.8 \pm 10.5/30$ [14–62]	677
<b>Gender (673)</b>	Male	501 (74.4)
	Female	170 (25.3)
	Diverse	2 (0.3)
<b>Kind of paramedics (659)</b>	Notfallsanitaeter/Rettungsassistenten*	479 (72.7)
	Rettungssanitaeter**	163 (24.7)
	Rettungsdiensthelfer***	14 (2.1)
	Others	3 (0.5)
<b>Training completed (675)</b>	Yes	598 (88.4)
	No	77 (11.6)
<b>Experience in EM Mean/Median [Min-Max] in months (670)</b>	$111.4 \pm 106.8/72$ [0–480]	670
<b>Amount of Exposure to TDI per month (670)</b>	0	462 (69)
	1–10	158 (23.6)
	11–20	8 (1.2)
	>20	9 (1.3)
	No Information given	33 (4.9)
<b>Family member as a dentist (659)</b>	Yes	19 (2.9)
	No	640 (97.1)

**Table 1** Characteristics of the participants, abbreviations: n = number; EM = emergency medicine; TDI = traumatic dental injury; \* “Notfallsanitäter/Rettungsassistent” = highest nonmedical qualification in the rescue service in Germany with 3 years/2 years of apprenticeship; \*\* “Rettungssanitäter” = emergency service personnel with 520 hours of training, work as a team partner of the “Notfallsanitäter/Rettungsassistent” or in ambulance transport; \*\*\* “Rettungsdiensthelfer” = 320 hours of training, as partner of the “Rettungssanitäter” in ambulance transport or partner of the “Notfallsanitäter/Rettungsassistenten” in emergency service

## 1. Introduction

Traumatic dental injuries (TDI) are sudden and acute events and often require emergency care. Oral injuries account for approximately 5% of all bodily injuries in adults, although the oral region comprises only a small body surface area of 1% [21]. Unfortunately, TDI are still neglected, probably because there are no standardized diagnostic, classification, or registration systems. Properly registered, they rank fifth among the most common diseases and acute injuries [21]. The prognosis of an in-

jured tooth depends on the rapid initiation of proper treatment of dental trauma [2, 17]. Delayed treatment leads to more complications and additional costs [1]. In international studies, emergency physicians have shown little knowledge and inadequate skills in the management of TDI [25]. However, paramedics are usually on the scene before the emergency physician. Their rapid and correct management can have a decisive impact on the prognosis of the injured tooth. The aim of this study was to investigate the knowl-

edge and skills of paramedics in the management of TDI.

## 2. Patients and methods

### 2.1 Participants

This study was submitted to the local ethics committee (No. 28/2/20) and was classified as a survey study of emergency professionals; therefore, no ethical review was required for it.

A total of 541 rescue stations in Germany were contacted by e-mail with a request to participate in this study. All possible available addresses of state, regional and local associations were selected and all major rescue service organizations (434 addresses; Malteser, Johanniter-Unfall-Hilfe, Deutsches Rotes Kreuz, Arbeiter-Samariter-Bund) and professional fire departments nationwide (107 addresses) were contacted. Private companies and volunteer fire departments were not contacted. A cover letter explaining the nature and purpose of the study and clearly emphasizing its voluntary nature was sent to the designated contact person at each rescue station, along with a link to an electronic survey. Distribution of the link to the entire staff was done by this designated contact person. Return of the questionnaire implied informed consent from the participants. Confidentiality was ensured as the questionnaire did not collect names or contact information of the participants. Due to the anonymity of the questionnaires, it is not technically possible to determine a response rate per ambulance station or an overall response rate. All participants were employed in the ambulance service during the study period from November 1, 2020 to January 15, 2021 and belonged exclusively to the non-medical personnel in the ambulance service.

Included as participants were emergency paramedics/rescue assistants (“Notfallsanitäter”/“Rettungsassistent”, in Germany the highest non-medical qualification in rescue services, 3 years/2 years of training). In addition, the participants were “paramedics” (“Rettungssanitäter”, 520 training hours), who work in a team with emergency paramedics/rescue assistants or in patient trans-

port, and "rescue service assistants" ("Rettungsdiensthelfer", 320 training hours), who work together with paramedics in patient transport or with emergency paramedics/rescue assistants in rescue service.

For simplicity, the participants in this study are referred to as paramedics, although the various paramedic professions in Germany cannot be directly compared to this job description worldwide.

## 2.2 Survey

The survey was developed based on previous studies [4, 20, 24, 26]. The electronic questionnaire was created using the program Kwiksurveys®, Problem Free Ltd, Portishead, Bristol, UK ([www.kwiksurveys.com](http://www.kwiksurveys.com)). It was designed so that participants could complete only one questionnaire at a time and duplicate completion was precluded. The questionnaire consists of two parts. Part 1 collected personal information such as age, gender, professional experience, type of emergency service, level of training, self-assessment of one's knowledge and skills in the treatment of dental trauma and intraoral examination, presence of a dentist in the family, interest in learning to treat dental trauma, desired training resources, and approximate TDI cases per month. In the second part, specific questions were asked about the estimated time relevance of TDI care, knowledge and approach to intraoral examination, proper tooth retention medium, and procedures for treating avulsed, dislocated, and fractured teeth. There were 18 questions, which were incorporated into a knowledge score following the study by Yigit et al. [26]. Zero to 8 correctly answered questions indicated an inadequate level of knowledge, 9 to 13 correct answers indicated an intermediate level of knowledge, and 14 to 18 correct answers indicated a high level of knowledge. Some important questions were designed as dependent questions. The participant could only see the follow-up questions if the answer was correct. If the answer was incorrect, the entire set of questions was scored as incorrect. Thus, logical inferences to answers by follow-up questions were avoided.

Variable (n)	Answer	Number (%)
<b>Do you have knowledge about dental trauma management? (Multiple choices possible) 924 answers/689 participants</b>	No	303 (44)
	Yes from books	145
	Yes from training	237
	Yes from advanced training	110
	Yes from clinical experience	68
	Yes from other colleagues	61
<b>How do you rate your knowledge of dental trauma management? (Self-assessment) (686)</b>	Very good	2 (0.3)
	Good	39 (5.7)
	Sufficient	240 (35)
	Inadequate	315 (45.9)
	Have no knowledge	90 (13.1)
<b>How do you rate your practical skills of dental trauma management? (640) (Self-assessment)</b>	Good	29 (4.5)
	Sufficient	198 (31.0)
	Inadequate	324 (50.6)
	Have no skills	89 (13.8)
<b>Are you interested in learning dental trauma management? (688)</b>	Yes	473 (68.8)
	No	26 (3.8)
	Maybe	189 (27.4)
<b>How should the knowledge be conveyed? (686)</b>	Books	31 (4.5)
	Video Demonstration	246 (35.9)
	Oral Training	109 (15.9)
	Hands on Courses	300 (43.7)

**Table 2** Questions about dental trauma management. There were questions asked about the knowledge, self assessment of knowledge and skills in dental trauma management, interest in learning dental trauma management and how new knowledge and skills should be presented. abbreviation: n = number of participants

Whether a question had been answered correctly was assessed in each case using the current guidelines for the management of dental trauma published by the International Association of Dental Traumatology [8, 13, 18].

## 2.3 Statistical analysis

Statistical analysis was performed using SPSS software, version 27.0 (IBM, Armonk, NY, USA). Descriptive analysis including mean, median, standard deviation, minimum and

maximum was performed. Student's t-test, chi<sup>2</sup>-test or ANOVA test, and linear regression models were used, as appropriate. The significance level was set at  $p < 0.05$ .

## 3. Results

A total of 745 questionnaires were received by the Kwiksurveys® program. Due to incompleteness 50 questionnaires and due to a deviating profession of the participant 5 further questionnaires were excluded, so that a total of 690 evaluable questionnaires remained

Question (n)	Answer	Number (%)
<b>Is the intraoral examination an integral part of the examination of trauma patients? (663)</b>	Yes	524 (79.03)
	No	139 (20.97)
<b>Are you familiar with the procedure of an intraoral examination? (664)</b>	Yes	104 (15.66)
	No	188 (28.31)
	Partial	372 (56.02)
<b>Do you know how to detect a) loosened teeth, b) bone fractures in the oral cavity? (666)</b>	Yes a)	230 (34.53)
	No a)	436 (65.47)
	Yes b)	224 (33.63)
	No b)	441 (66.22)
<b>How do you rate your own intraoral examination skills? (665)</b>	Good	22 (3.31)
	Sufficient	225 (33.83)
	Inadequate	370 (55.64)
	Have no skills	48 (7.22)
<b>How do you assess the time relevance for the TDI supply? (680)</b>	High	235 (34.56)
	Medium	322 (47.35)
	Low	80 (11.76)
	I don't know	43 (6.32)
<b>Do you know what a tooth rescue box is? (620)</b>	Yes	446 (71.9)
	No	142 (22.9)
	Not exactly	32 (5.2)
<b>Is a tooth rescue box carried in the ambulance as standard? (618)</b>	Yes	190 (30.7)
	No	428 (69.3)
<b>In general, should patients with dental trauma be presented to a dentist? (613)</b>	Yes	584 (95.3)
	No	10 (1.6)
	I don't know.	19 (3.1)

**Table 3** Questions about the intraoral examination and the tooth rescue box. There were questions asked about the importance and the procedure of the intraoral examination, the self-assessment of their ability to perform an intraoral examination and questions about the knowledge and standard equipment of a tooth rescue box in the ambulance; Abbreviations: n = number, TDI = traumatic dental injury; Note the contrast between the importance and the knowledge and skills of an intraoral examination and between knowledge and the standard on an ambulance regarding a tooth rescue box

from the participating paramedics. The regional distribution of returned questionnaires is as follows: 362 (41.3%) from rural regions, 514 (58.7%) from urban regions (303 [59.0%] small town; 211 [41.0%] large city). Fifteen of

16 states were represented. The mean age of participants was  $32.8 \pm 10.5$  years (median 30 years). With 501 (74.4%) male and 170 (25.3%) female participants, the male-to-female ratio was 2.95:1. Over 70% of participants were

emergency paramedics/rescue assistants. Table 1 provides an overview of the participants' personal data.

Only 6% of participants reported having good or very good knowledge, and only 4.5% reported having good skills in dental trauma care (Table 2). Although 524 (79%) participants believed that an intraoral examination was an integral part of the trauma patient examination, 188 (28.3%) did not know the exact procedure of an intraoral examination at all, and 372 had only partial knowledge (56%). Only 37.14% of participants rated their intraoral examination skills as good or adequate (Table 3).

Only 15 paramedics (3.0%) knew the correct procedure for replanting an avulsed tooth. Only 18% would choose a physiological nutrient medium for temporary tooth storage; only 10.8% chose the second best alternative, milk. Although 71.9% of participants knew about tooth rescue boxes, only 30.7% reported that a tooth rescue box was part of the standard rescue vehicle equipment (Table 3–5). A similar level of uncertainty was evident when dealing with dental luxations and fractures (Table S1). There were also large regional differences within Germany in the equipment of the ambulance with dental rescue boxes (Table S2).

The second part of the questionnaire assessed expertise in the management of dental trauma with 18 questions that were combined into a knowledge score. The mean score was  $10.53 \pm 3.5$  (median 12) and was considered moderate. More than half of the 622 participants (n = 326; 52.4%) scored moderate, but only 139 participants (22.3%) had a high knowledge score. None of the participants had 18/18 correct answers. Table 6 shows the scores for the different categories.

Almost all participants expressed interest in advanced education on the topic of trauma management in dentistry. A total of 68.8% were clearly in favor of continuing education, and 27.4% could perhaps imagine continuing education in this area. Only 3.8% expressed no interest in advanced education. Practical courses (43.7%) and video demonstrations (35.9%) were most frequently desired (Table 2).

#### 4. Discussion

The management of TDI by paramedics in Germany is poor, with about two-thirds having no or insufficient knowledge and another two-thirds having no or insufficient skills. Almost half of the participants (44%) reported having no prior knowledge of dentistry. These results are consistent with other studies examining paramedics and/or physicians [3, 25]. In the study by Lin et al., none of the participating emergency paramedics had received any training on TDI management [19]. Even though dental trauma is often not the primary concern in an emergency situation, but other injuries requiring care and, in some cases, life-threatening injuries need to be assessed and treated, basic knowledge in the initial management of dental trauma, including knowledge of a dental rescue box, is also important for paramedics. This is also reflected in the content of the current AWMF S3 guideline "Polytrauma/Treatment of Severely Injured", which includes procedures for the treatment of dental and facial trauma and provides guidance on first aid [6]. However, not all patients with dental trauma are polytrauma patients, and knowledge and skills in the treatment of TDI would be desirable outside of polytrauma care too.

Intraoral examination should be routinely performed in trauma patients, especially in the case of head injury. Most (79%) study participants agreed that an intraoral examination is an essential part of the trauma patient exam, but only 15.66% knew the procedure for an intraoral examination. Only one-third knew how to identify tooth loosening or jaw frac-

Question (n)	Answer	Number (%)
<b>Should avulsed teeth be sought out at the scene of the accident? (659)</b>	Yes	529 (80.27)
	No	26 (3.95)
	I don't know.	104 (15.78)
<b>Should an avulsed a) permanent tooth, b) deciduous tooth be replanted? (a) 659; b)653</b>	a) Yes	513 (77.8)
	a) No	19 (2.9)
	a) I don't know.	127 (19.3)
	b) Yes	62 (9.5)
	b) No	349 (53.4)
	b) I don't know.	242 (37.1)
<b>When should an avulsed permanent tooth ideally be replanted? (500)</b>	As quickly as possible	276 (55.2)
	Within 6h	110 (22.0)
	Within 12h	24 (4.8)
	Within 24h	15 (3.0)
	I don't know.	73 (14.6)
	No matter	2 (0.4)
<b>Where would you touch an avulsed permanent tooth? (501)</b>	Not at all	35 (7.0)
	Crown	465 (92.8)
	Root	1 (0.2)
<b>How would you treat a permanent, avulsed tooth prior to replanting? (497)</b>	Not at all	54 (10.9)
	Thoroughly remove dirt and supply to the correct storage medium	119 (23.9)
	Only supply to a correct storage medium	324 (65.2)
<b>Do you know the procedure for replanting a permanent tooth? (495)</b>	Yes	15 (3.0)
	No	442 (89.3)
	Perhaps	38 (7.7)
<b>How do you rate your abilities to replant a permanent tooth yourself? (491)</b>	Very good	0
	Good	0
	Sufficient	14 (2.9)
	Inadequate	86 (17.5)
	Have no skills	391 (79.6)
<b>Should a patient see a dentist after an emergency replantation? (499)</b>	Yes	464 (93.0)
	No	10 (2.0)
	Perhaps	25 (5.0)
<b>When should this presentation to the dentist take place? (457)</b>	Immediately	255 (55.8)
	Within 24h	98 (21.4)
	Within 1 week	23 (5.0)
	If necessary	3 (0.7)
	I don't know.	78 (17.1)

**Table 4** Questions about the knowledge, skills and management of an avulsed tooth. Note the poor results of knowing the procedure and self-assessment of the ability to replant an avulsed permanent tooth; the smaller numbers of participants are caused by the use of dependent questions. Only participants who answered correctly to replant an avulsed, permanent tooth could see and answer the following questions about the further management and their own skills in replanting the tooth. Abbreviations: n = number of participants

Storage media (n=500)	Number	(%)
Hypotone saline solution	10	2.0
Hypertone saline solution	6	1.2
Isotone saline solution	142	28.4
Saliva	53	10.6
<b>Milk</b>	<b>54</b>	<b>10.8</b>
<b>Special nutrient medium</b>	<b>90</b>	<b>18.0</b>
In a bag	45	9.0
In a dry cloth, gauze	22	4.4
No matter	1	0.2
I don't know	76	15.2

**Table 5** Distribution of responses regarding ideal tooth storage media; note the high proportion of "I don't know" compared to the correct answers written in bold (special nutrient medium first choice, milk second choice)

tures. The majority of participants rated their own skills in performing intraoral examination as inadequate or non-existent. This clearly indicates that paramedic training needs to be greatly improved. Participants in this study desired training, preferably in the form of hands-on courses or video demonstrations. This confirms the results of other studies [3, 24], and another study found that 100% of participants stated that this knowledge is important for first aid [11].

Regarding avulsion, the maximum form of dental trauma, the participants of this study showed some basic knowledge. For example, at least 80.27% of the respondents would search for an avulsed tooth at the accident site, and 77.8% would theoretically replant a permanent tooth. Thus, they show much better theoretical knowledge than according to the results of previous studies, in which most participants did not know what a tooth avulsion or a tooth replantation was, or did not even consider replantation as a treatment option [3, 11]. However, the practical skills to perform the replantation of an avulsed tooth are reported to be very poor in all studies (paramedics and/or emergency physicians) [7, 11, 19, 24, 25]. Our results are consistent with these findings, as

89.3% of the participants did not know the replantation procedure and only 2.9% rated their skills to perform replantation as adequate. The remainder rated their skills to perform as inadequate or had no knowledge. No participant reported having good or very good knowledge.

This again shows the urgent need for training or at least support on this topic. A list of local dentists advising paramedics on the proper management of dental trauma, preferably 24/7 by telephone, would be one option that has been suggested previously as a support for emergency physicians [20, 24] and would certainly be useful for the period until the emergency physician arrives on the scene. The very availability of advice on the correct transport medium can dramatically improve the prognosis of the injured tooth. However, this assumes that the dentists involved also have adequate knowledge and skills in the treatment of TDI. Studies have shown that dentists and emergency physicians may lack knowledge [14, 24, 25]. TDI should be considered in the training of first responders, including paramedics. Instruction in the correct diagnosis of TDI coupled with proper skills could lead to a better outcome for the affected teeth [25]. For current practice, tools such

as the "Dental Trauma Guide" ([www.dentaltraumaguide.org](http://www.dentaltraumaguide.org)) or the dedicated app "AcciDent ®" should be available for all first responders, including paramedics. With their help, they could react more appropriately to unknown situations.

Given that paramedics and even emergency physicians are so unsure of how to replant a tooth at the scene of an accident, it is even more important to know the correct storage medium for an injured tooth. Then, safe storage of the tooth is possible until the patient arrives at the dentist for further treatment or the patient's condition permits treatment of the teeth. In the present study, only 18% of the respondents selected the correct specific culture medium for temporary storage of the tooth. And even after adding the second best option, milk, only 28.8% of the injured teeth would be properly stored, while the prognosis for the other 71.2% would deteriorate.

Nearly 30% of our participants chose an inappropriate medium, namely isotonic saline. As in previous studies, saline was generally the (wrong) choice, and most respondents could not name any other options [3, 4, 11]. However, no specific culture medium was given as an option in these surveys. The results of these studies have to be evaluated very critically. In Germany, a recent publication pointed out the importance of correct and timely storage of an avulsed tooth. For this purpose, a special nutrient solution provided in special tooth rescue boxes was clearly suggested as the best storage medium [9]. It has the correct pH and contains electrolytes and keeps the cells of the periodontal ligament alive for up to 24 hours. Cold UHT milk would be the second best choice if a dental rescue box is not available [9, 16]. Sterile saline does not contain metabolically significant ions, does not provide glucose to the cells, and damages the tooth cells quite quickly, but is still much better than dry storage of the tooth [9, 16].

Although 71.9% of respondents knew what a dental rescue box was, only 30.7% reported that it was part of their ambulance's regular equipment. Adequate temporary storage of

Parameter		n	Knowledge score (Median)	p value
<b>Gender</b>	Male	501	11.2 (11.0)	0.464 <sup>§</sup>
	Female	170	10.3 (12.0)	
<b>Experience in emergency service</b>	0 to 24 months	651	10.50 (11)	0.041 <sup>#</sup> 0.279 <sup>+</sup>
	25 to 60 months	133	10.08 (11)	
	> 60 months	164	10.64 (11)	
		343	10.60 (11)	
<b>Work experience</b>	0 to 24 months	641	10.49 (11)	0.065 <sup>#</sup> 0.227 <sup>+</sup>
	25 to 60 months	125	10.02 (11)	
	> 60 months	166	10.53 (11)	
		358	10.64 (11)	
<b>Level of education</b>	Completed	573	10.66 (12)	0.021 <sup>§</sup>
	Not completed	74	9.32 (11)	
<b>Type of training</b>	Notfallsanitaeter/-Rettungssanitär*	479	10.49 (11)	0.071 <sup>+</sup>
	Rettungssanitaeter**	163	10.69 (12)	
	Rettungsdiensthelfer***	14	8.58 (9)	
	Others	3	7.00 (5)	
<b>Amount of exposure to TDI per month</b>	0	462	10.6 (12)	0.557 <sup>+</sup>
	1–10	158	10.4 (11.5)	
	11–20	7	11.3 (13)	
	> 20	9	9.3 (11)	
	No information given	30	9.9 (11)	
<b>Dentist in family</b>	No	640	10.46 (11)	0.357 <sup>§</sup>
	Yes	19	11.2 (12)	

**Table 6** Knowledge score for different parameters; abbreviations: n = number; TDI = traumatic dental injury; \* "Notfallsanitäter/Rettungssanitär" = highest nonmedical qualification in the rescue service in Germany with 3 years/2 years of apprenticeship; \*\* "Rettungssanitäter" = emergency service personnel with 520 hours of training, work as a team partner of the "Notfallsanitäter/Rettungsassistent" or in ambulance transport; \*\*\* "Rettungsdiensthelfer" = 320 hours of training, as a partner of the "Rettungssanitäter" in ambulance transport or partner of the "Notfallsanitäter/Rettungsassistenten" in emergency service; # = linear regression, § = Student's t-test; + = ANOVA

avulsed permanent teeth is therefore more difficult, and inferior alternatives must be used unnecessarily. Adding a dental rescue box to the standard equipment of an ambulance could reduce complications mainly due to incorrect or delayed treatment of injured teeth and save costs with little effort [1, 17].

There were significant differences between the German federal states in the standard equipment of the ambulance with a dental rescue box. However, there was no difference in the score achieved on knowledge about

the treatment of an avulsed tooth whether a tooth rescue box was part of the standard equipment or not. Possibly the reason is that while tooth rescue boxes are known, what they contain is not. When asked about the correct storage medium, there was no alternative answer option to the dental rescue box. Regardless of whether a dental rescue box is available or not, knowledge and skills in handling TDI may be deficient anyway. A recent study among German and international emergency physicians showed similarly poor results with a

lack of knowledge about the intermediate storage of avulsed teeth [24, 25]. The training catalog for emergency physicians changed in 2017 with the new chapter "Oral and Maxillofacial Procedures" in the European Core Curriculum for Emergency Medicine. In addition to the AWMF polytrauma guideline and the AWMF guideline on dental trauma care, there is also information on dental primary care in a new book on clinical emergency medicine in Germany [5, 6, 12, 23]. The content of emergency paramedic training is regulated by the Emergency

Paramedic Act, although the content of the training is more in the hands of each state and training facility [10]. Curricular content for the care of TDI is not explicitly stated for any of the paramedic professions. Training content is not uniform across Germany. However, our results suggest that there is a knowledge deficit nationwide, which may indicate a gap in paramedic training content on this topic.

Previous studies have shown that partnership or family relationships with a dentist can have a positive impact on emergency physicians' knowledge and skills in managing TDI [15, 24]. In the present study, only 2.9% of the participants reported having a dentist in their family. However, there were no differences in knowledge scores due to this fact. Because of the small number of participants with a dentist in the family, no reliable statements can be made about the influence of the knowledge score in this regard.

Surveys of emergency physicians showed a significant influence of the number of dental trauma cases to be treated per month on the knowledge score [20, 22, 24]. In this study, approximately 70% reported not having witnessed dental trauma in their daily work, whereas other studies reported that over 60% of emergency paramedics had witnessed a TDI event during their service [19] and cases of oral and dental injuries did occur, but usually the only treatment was bleeding intervention [3]. It is possible that the focus of our participants has not previously been on dental trauma, and dental trauma has not been noticed or overlooked, which is consistent with the results of the survey on the performance of intraoral examinations. TDI are commonly associated with soft tissue injury and bleeding in the mouth or oral region in injured patients. However, this may also mask dental trauma or tooth loss, which are often overlooked by first responders or paramedics [15]. The level of knowledge in this study did not differ in terms of the number of dental trauma cases treated. However, this should be evaluated critically. It only confirms once again the great unmet need for training of paramedics as first responders in the management of TDI.

Paramedics typically do not receive the necessary theoretical and clinical training to assess and treat TDI. Adaptation of curricula with greater inclusion of dental aspects and first aid measures is necessary to ensure effective teaching and learning of proper management of TDI. The linkage between theory and clinical practice has been mentioned previously [25]. Since the participants primarily desired education/training on this topic via video or hands-on courses, the training could be structured as follows, following Yeng [25]:

- Theory on the FDI (Fédération Dentaire Internationale) dental chart, tooth anatomy, and differences between deciduous and permanent dentition, which would facilitate communication with continuing dentists.
- Likewise, theoretical basics on the types of dental trauma and their initial treatment. At least the use of the tooth rescue box should be made more familiar.
- The practical exercises should focus on the procedure of a structured intraoral examination with assessment of tooth and jaw injuries and on the replantation of an avulsed tooth.

## 5. Limitations

This study has some limitations that we need to point out. First, the number of 690 participants is small compared to all paramedics in Germany. The results presented here may not fully reflect the situation as it would have been reported by all paramedics. However, the participants came from all over Germany, and to our knowledge, this study evaluated by far the largest number of participants in such a study compared with all similar studies worldwide and can therefore be considered representative. Second, participation in this study was voluntary, so only those who were interested in the topic may have participated. Therefore, the results could be biased. Third, there was no control in filling out the questionnaires. Participants might have used books or the opinions of colleagues, friends, or relatives when answering the questions, which could have influenced

the results. Another limitation is the lack of traceability of the number of questionnaires per ward. The results, for example on the proportion of dental rescue boxes carried in the ambulance, could be biased if several participants from the same station gave the same answer. Due to the anonymity of the questionnaires, it is not possible to identify the ward involved in the data collection. This should be taken into account when interpreting the results.

## 6. Conclusion

Paramedics currently have little knowledge and only a basic understanding of how to treat dental trauma. The initial treatment of dental trauma should become an integral part of paramedic training. The willingness to undergo such training is high among paramedics. But the structure and organization of the rescue service in Germany should also be revised. Dental rescue boxes must become standard equipment in ambulances in Germany. Paramedics could make an important contribution to dental trauma care.

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## Conflict of interest

The authors declare that there is no conflict of interest as defined by the guidelines of the International Committee of Medical Journal Editors.

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# Formative e-assessment improves performance in dental education

## Abstract

**Aim of the study:** The purpose of this study was to investigate whether the integration of web-based learning in the form of e-seminars in dental education leads to improved student performance.

**Methods:** In the second semester of the clinical component of dental school, conventional seminars requiring attendance were replaced by e-seminars as part of the dental conservation course. In the control cohort, the theoretical teaching content was taught in the form of lectures as part of the conventional seminar; in the test cohort, this was done via guided self-study and e-seminars. The use of the e-seminars was evaluated with the help of a self-designed questionnaire. To investigate the learning effect, the results of the final exam of two consecutive years were compared.

**Results:** Student acceptance of the e-seminars was positive. Students who attended the e-seminars achieved significantly better results on the final exam than those who attended conventional seminars.

**Conclusion:** E-seminars are an innovative and timely addition to traditional classroom instruction. They can help improve performance while making time management more flexible. They can lead to the relief of teachers and learners and simultaneously to the increase of the education quality.

**Keywords:** dentistry; e-seminars; evaluation; formative e-assessment; gender

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## Introduction

The traditional study of dentistry essentially consists of elements of face-to-face teaching: lectures, seminars, exercises, practical courses and tutorials [4]. These are characterized by the local and timely constraints as well as by the physical presence of the learners and the teaching staff [3]. In this context, the transfer of knowledge is mainly controlled by the teachers. Dental students at Hannover Medical School (MHH), Germany, participate in more than 40 hours of lectures, seminars and practicals per week during the clinical section. In doing so, students report a constant lack of time for pre- and post-processing of the content. During lectures in particular, the amount of content, limited interaction between teachers and learners, lack of feedback from fellow students, and the resulting passivity of learners are major drawbacks [9, 15, 17]. In order to promote learning, new teaching methods therefore rely on greater interactivity between instructors and learners as well as learners among themselves, replacing passive participation in courses [8]. In particular, supplementing face-to-face teaching with electronically supported learning opportunities enables flexibility in terms of time and space in teaching [1, 24] and can effectively support face-to-face teaching.

With this in mind, electronic seminars (e-seminars) have been integrated into the clinical section of dental studies since 2010 as a form of formative e-assessment. The e-seminars are realized with the Learning Management System (LMS) ILIAS (Integrated Learning, Information and Work Cooperation System, ILIAS open source e-Learning e.V., Cologne, Germany), which is the central learning platform at the MHH. Being able to regularly check one's own learning progress should enable students to self-reflect on their own level of knowledge, thus helping them to identify and effectively address learning deficits and consequently improve their knowledge. This offering of e-seminars is still in the development phase and has not yet been tested for effectiveness.

The use of e-seminars in the first semester of the clinical section of dental school was therefore tested by evaluating students. The aim of the study was first to determine the acceptance of this alternative teaching method. Furthermore, one objective was to analyze the effectiveness of the e-seminars. The null hypothesis states that this teaching format does not show a performance-enhancing effect in the form of a better result in the final exam. Additionally, gender differences regarding study load were investigated.

## Methods

### Samples

The study included two cohorts. They were students in the Dental Conservation Science I course from two consecutive years. The cohort that participated in the e-seminars included 54 students out of a total of 55. The study was conducted during the second clinical semester (7th semester) of dental school. The sample consisted of 37 female (68.5%) and 17 male (31.5%) students. Data from the second clinical semester of the previous cohort were used for the comparison sample of the traditional teaching format cohort. This sample consisted of 76 data sets.

The study project was approved by the Ethics Committee (Study No.:1780-2013) of Hannover Medical School.

### Procedure

In the second clinical semester (7th semester) of the dental program, a mandatory seminar course with a pronounced lecture character was converted into an e-seminar. The introductory lecture on the e-seminar procedure was held in person for all students. In the following eight weeks, the students worked independently or in groups on patient cases from the fields of endodontics, periodontology and restorative dentistry. In addition to the clinical content, students also worked on topics such as the Medical Devices Act, hygiene in the workplace, dental instrument preparation and the handling of hazardous substances. The stu-

dents had one hour per week to work on the content, which was also specified in the timetable. The scope and content thus corresponded to the courses of the previous years.

Each week, the students received a scientific article on one of the topics for independent work and as preparation for the respective seminar lesson. This was made available to the students via the learning platform of the ILIAS learning management system. In each e-seminar, the students completed a multiple-choice (MC) test online with questions on the article provided. This test consisted of five single-choice questions (single selection from five offered answers) and was activated in the learning management system ILIAS, limited in time to this hour. The test could be started at any time within the seminar hour and could be worked on for a maximum of 15 minutes. While working on the test, the students were allowed to discuss the questions. The time allocation was up to the students and was intended to be used to deal with the contents, the questions and problems of the topic.

Participation in the tests was mandatory for the students and was required for admission to the electronic written final exam of the course. The tests were conducted in the e-learning room of the Center for Oral and Maxillofacial Surgery of the MHH for students who were present in the clinic at the time. Any remaining time of the seminar hour was at the free disposal of the participants. They could use this for organizational and administrative activities such as dealing with the patient history, documentation, contacting patients or laboratory activities. It was also possible to perform the test on the road or at home, as there was no compulsory attendance for this seminar hour. Only the time slot was predetermined due to the class schedule. Within the semester, a total of 8 e-seminars with the corresponding short tests of this type took place. At the end of the course, the e-seminars were evaluated with the help of a self-developed, paper-based questionnaire. Statistical validation was not performed. The questionnaire con-

<b>Subject area/question</b>		<b>Evaluation options</b>	<b>N (absolute)</b>	<b>N (relative in %)</b>	<b>M ± SD</b>
<b>1. Gender</b>	Female Male		37 17	68.5 31.5	
<b>2. Study workload</b>	How would you categorize your stress level as a dental student?	high level moderate level low level	49 4 1	90.7 7.4 1.9	
	How many hours per week do you attend formal courses, seminars or lectures?	0–10h 10–20h 20–30h 30–40h >40h	7 0 7 27 13	13 0 13 50 24	
<b>3. E-seminars</b>	Knowledge control in the form of e-seminars is innovative.	1–4			3.28 ± 0.76
	I find the learning effect of e-tests positive and useful.	1–4			3.06 ± 0.86
	I was able to check my learning progress better in this course.	1–4			2.93 ± 0.82
<b>4. What materials did you use to answer the questions?</b>	Professional discussion with fellow students	1–4			3.46 ± 0.79
	Additional professional literature	1–4			2.76 ± 0.87
	ILIAS (literature, pdf files)	1–4			3.28 ± 0.81
<b>5. Was it helpful to work with fellow students to solve the questions?</b>	I do not find it useful to discuss the questions with fellow students.	1–4			2.89 ± 1.3
	I solved the questions myself.	1–4			2.93 ± 0.75
	I have learned by discussing the questions.	1–4			3.37 ± 0.73
<b>6. Alternative form of learning compared to a required course</b>	For me, the alternative learning option with the test questions led to more time freedom.	1–4			3.63 ± 0.59
	The targeted learning based on the test questions was more effective than a mere lecture.	1–4			2.74 ± 0.76
	It would have been better if I could have answered the questions at any time.	1–4			3.09 ± 0.88

Abbreviations: N = sample size, M = mean value, SD = Standard deviation

**Table 1** Evaluation questions

sisted of 29 questions on 10 aspects of investigation (Table 1). The investigated aspects included questions about the general stress situation in the study, the learning effect through the use of the e-seminars, the preparation methods for the e-seminar, the use of communication possibilities in the context of the e-seminar,

the acceptance of the alternative learning form, the independence of the task solution and the use of the provided free time. These were essentially closed questions with rating scales (frequency, intensity and evaluation scales) and questions on personal attitudes (Table 1). The evaluation was based on a 4-point Likert scale with the response categories 4 *completely agree*, 3 *rather agree*, 2 *rather disagree*, 1 *not at all agree*. Furthermore, students were able to give an overall evaluation of the e-seminars using the school grading system and free text comments. In order to assess the effectiveness of the e-seminars, the data of the final

kert scale with the response categories 4 *completely agree*, 3 *rather agree*, 2 *rather disagree*, 1 *not at all agree*. Furthermore, students were able to give an overall evaluation of the e-seminars using the school grading system and free text comments. In order to assess the effectiveness of the e-seminars, the data of the final

exams of the respective years were compared. A maximum of 20 points could be achieved in the written exam. To pass the written exam, at least 60% of the questions had to be answered correctly.

### Statistical analysis

Statistical analysis was performed using SPSS Statistics software (SPSS 26.0 IBM, Armonk, NY, USA). The Kolmogorov-Smirnov test showed that there was no normal distribution of the data. To compare the results between groups, the Mann-Whitney U test was applied. The significance level was set at  $p < 0.05$ . Cohen's d was calculated to represent the effect size. In a further step, an analysis on gender differences was performed. For this purpose, cross-tabulations were made for the relationship between gender and the responses in the questionnaire and possible dependencies were tested using Pearson's chi-square test.

## Results

### Analysis of the evaluation of the e-seminars

The workload in the semester of dental school under study was considered high by 49 individuals (90.7%), medium by 4 individuals (7.4%), and low by one individual (1.9%). The majority of the time invested was 30 to 40 hours per week. 76.1% of the students stated that they had gained more personal time through the e-seminars. Regarding the form of processing, the distribution between group work and individual work was about equal (Table 2).

The evaluation for the e-seminars was assessed in the majority (56%) with the school grade of 10–12 points.

### Analysis of the exam results

The exam scores of the cohort of students who participated in the e-seminars had a mean (M) of 17.24 points ( $86.18\% \pm 1.05$ ). The comparison group cohort scored a mean of 15.25 points ( $76.25\% \pm 1.76$ ). This means that the test cohort achieved significantly better exam results than the comparison cohort ( $p < 0.001$ ) (Table 2). The effect size in this case is

	<b>N</b>	<b>M</b>	<b>SD</b>	<b>95% CI</b>	<b>Range</b>
Point values Cohort e-seminars Cohort comparison	55 76	17.24 15.25	1.05 1.76	[16,95; 17,52] [14,85; 15,65]	[15; 20] [11; 19]
Point values Cohort e-seminars Cohort comparison	55 76	86.18 76.25	5.27 8.8	[84,76; 87,61] [74,24; 78,26]	[75; 100] [55; 95]

Abbreviations: N = sample size, M = mean value, SD = Standard deviation

**Table 2** Examination results of both years

high ( $[d] = 0.963$ ) and therefore the effect is large. Thus, the null hypothesis can be rejected.

### Gender-specific differences

To test for a gender difference in stress perception, a chi-square test was performed. This showed no significant differences ( $\chi^2 = 4.05$ ;  $p = 0.132$ ). In terms of hours invested in the course, there was a trend for gender to matter ( $\chi^2 = 6.81$ ;  $p = 0.078$ ). 25% of male respondents were less likely than their female peers (75% of female respondents) to participate in 40 or more hours of instruction per week, according to the study.

## Discussion

In the present study, the integration of a web-based learning tool in the form of e-seminars into the clinical study section of dental training was investigated. In addition to evaluating the acceptance of the e-seminars, summative performance assessments were also conducted and gender differences were taken into account.

The form of assessment used here is one of the formative assessments. Formative assessments serve to support learners in the learning process, to confront them with their current level of competence, and thus to motivate them to eliminate any learning deficits that may exist. According to Miller [1990], MC questions are suitable for this purpose, as they not only ask for specific technical knowledge, but also test higher levels of competence [18, 22]. The combination of self-study and the previously provided content and the subsequent query of the learning

status by the web-based tests, which could be worked on alone or collaboratively by the students, had a positive effect on the results of the final exam. Thus, the formative assessment not only resulted in an improvement of the previous teaching structure in this semester, but also had a positive effect on the summative assessment in the form of the final exam.

The e-seminars were positively received by the students overall and showed a positive influence on learning success. This is not only illustrated by the direct effectiveness of the seminars in terms of end-of-semester performance, but also by the broader benefits. For instance, the opportunity to independently review learning progress in order to identify one's own gaps in knowledge, and the indirectly positively influenced variables such as increased time efficiency, personal responsibility, and self-discipline point to the consistently positive effects. A superiority of e-seminars compared to a pure face-to-face teaching with lecture character can thus be proven with clear results, with which this study joins the large number of research results on the favorable effects of e-learning [2, 9, 20].

Nearly all students surveyed reported high levels of stress – a finding that has emerged repeatedly from other research [3, 23]. Studies show that female students are more stressed than male students when new courses are introduced [14, 21]. The present study could not confirm this correlation. In terms of content, the primary trigger for this was cited as the lack of time in the daily study routine as a result of the very tightly

scheduled and long day during lecture periods and the resulting impairment of performance, which can come to a head, especially during the phase of entering the clinic [8]. Exactly which factors were responsible for the high score in terms of stress perception in the present study cannot be answered here, as the students were already in their 7th semester, and requires further detailed studies. In the survey conducted, the creation of free time, which the students themselves could decide how to use, was rated positively. It can therefore not be ruled out that the lack of time in the very tightly structured dental studies is also a significant factor for stress in this respect, as the free spaces created have led to a relief for many. Further advantages of the e-seminars, which additionally counteract this stress factor, are the regulated range of knowledge and the possibility of targeted and time-saving learning [2].

Nevertheless, the evaluation found that face-to-face teaching is rated as extremely important by students, as it provides them with structured knowledge transfer as well as personal contact with lecturers. A combination of e-seminars and face-to-face teaching is a promising option for dental education. But the sole statistical comparison of the exam results of the two groups of the traditional face-to-face method or the online equivalent, as conducted here, does not yet support this recommendation with the necessary evidence. However, indications arise from the subjective statements of the students that the fixed face-to-face appointments to discuss the learning material had a positive benefit. Evaluation studies previously conducted showed that the combination of both forms of teaching can lead to valuable synergies [1, 8]. For this purpose, the exact composition of different teaching methods is investigated under the didactic concept of "blended learning".

Today, gender differences are also an indispensable aspect of research in social and cultural sciences. The discipline of dentistry is now predominantly chosen by women [25]. In order to draw correctly differentiated conclusions, differentiation of out-

comes by gender has become indispensable. In the study by Arrenberg and Kowalski, female students were found to be more active in using e-learning services than their male peers [1]. The present study confirms this outcome. The female students rated the e-seminars as more attractive and also performed better in the final exam than their male fellow students. They worked more independently and also spent more time attending classes.

Currently, new learning concepts are to be developed by integrating new projects into dental studies. On one hand they improve teaching, and on the other hand they also relieve the teaching staff and thus create optimized conditions for effective studies [6, 7].

A central aspect that is significant from an organizational point of view is the increase in the efficiency of e-assessment use through an effort-saving application of infrastructures for the acceptance of e-assessments [16]. Recent solutions advocate mobile devices that can be used in an organized manner. In addition, the development effort is very high and the presentation of learning content is often determined by technical rather than didactic factors. In view of the current state of science, further research is needed on didactic, methodological, organizational, and technical aspects of e-assessment to promote the development of appropriate systems [11–13, 19].

Nevertheless, e-assessments are a good supplement to conventional teaching methods, and a development towards digital teaching formats can clearly be seen. It could be observed that more formative e-assessment forms, as opposed to diagnostic examinations, are used in universities and colleges than in the past [5]. At universities, the proportion of formative assessments increased, e.g., "interim tests during self-learning," "quizzes for motivation or review," "follow-up and e-exercises," and "audience response in the lecture hall" [5]. Legal issues also need to be considered [5]. A legal opinion on "Legal aspects of e-assessments at universities" can be used as a guide for this [10].

## Conclusions

Formative e-assessments in the context of e-seminars can be well integrated into dental education as an innovative teaching method. The present study shows that e-seminars have a positive effect on the performance achieved by students in dental education and thus hold great potential for the sustainability of teaching. Acceptance on the part of students is the prerequisite for teaching and learning success.

Further scientific studies on the topic of e-assessment can help to further increase the acceptance and use of e-assessments. In addition, the new licensing regulations for dentists offer many opportunities to integrate online-based teaching right from the start. The importance of this is particularly evident in the COVID-19 pandemic, in which face-to-face teaching had to be largely replaced by online teaching formats.

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## Conflict of interest

The authors declare that there is no conflict of interest as defined by the guidelines of the International Committee of Medical Journal Editors.

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# Are apical lesions visible more often in CBCT than in panoramic radiographs?

## Abstract

**Introduction:** This study compares the accuracy of panoramic radiography and CBCT in detecting and diagnosing mandibular apical lesions, analysing the effect of the thickness of the cortical bone on the radiological visibility of apical lesions.

**Methods:** Digital images of 343 patients who had CBCT scans and panoramic radiographs were inspected for mandibular apical lesions. The dimensions of the lesion and the thickness of the cortical bone in the affected region were measured. Statistical analyses were made using statistical software (IBM SPSS 25, IBM, Armonk, NY, USA).

**Results:** CBCT detected apical lesions around 115 teeth; 77 of these were also visible on a panoramic radiography. The differences between the two methods were statistically significant in the premolar and molar regions (McNemar test;  $p < 0.001$ ) but not in the anterior region ( $p = 0.063$ ). For the size of the lesions no significant differences were found (Wilcoxon test; anterior,  $p = 0.60$ ; pre-molar,  $p = 0.90$ ; molar,  $p = 0.61$ ). In the Mann-Whitney U test, buccal and palatal cortical thickness did not significantly influence the visibility of lesions in CBCT and panoramic measurements (buccal,  $p = 0.93$ ; palatal,  $p = 0.15$ ).

**Conclusion:** Apical lesions seem to be much more readily visible on CBCT scans. The thickness of the cortical bone and the size of the lesions do not significantly influence the representation of apical lesions.

**Keywords:** apical lesions; CBCT; cone-beam computed tomography; cortical bone thickness; panoramic radiography

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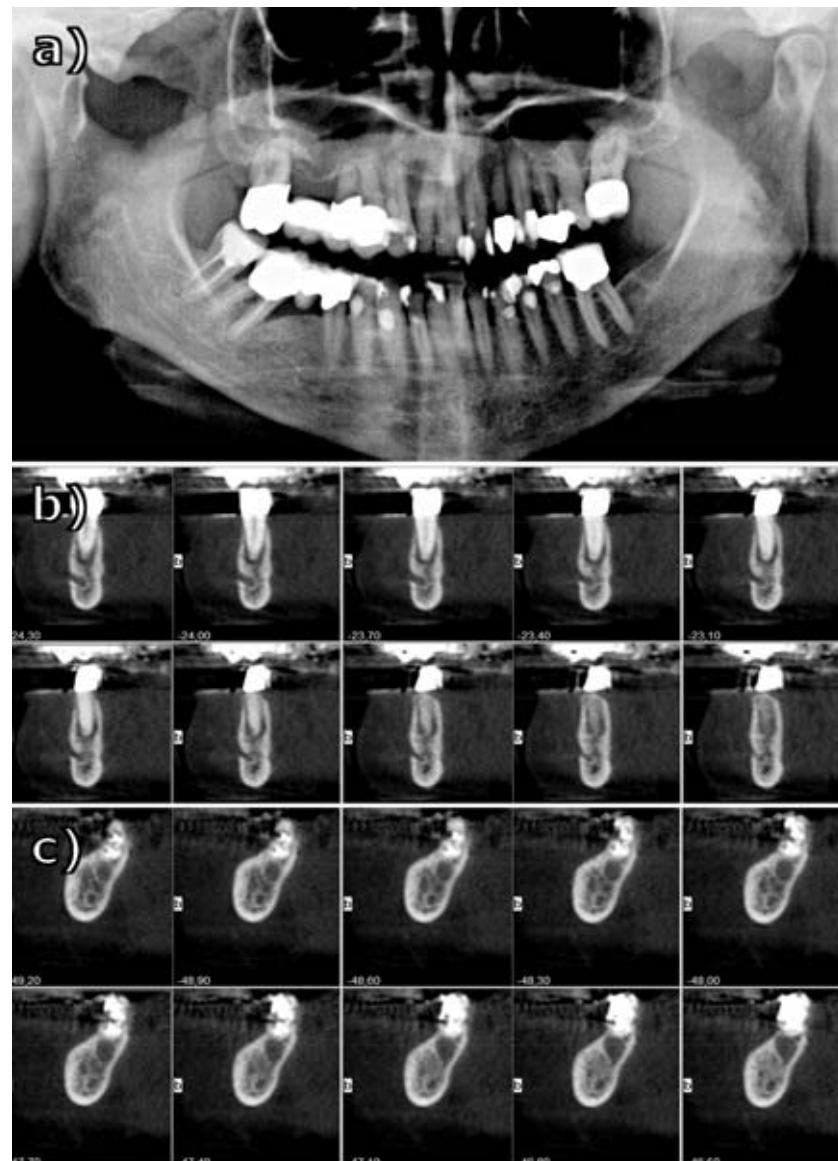
DOI.org/10.53180/dzz-int.2022.0020

## Introduction

Apical bony lesions, usually detected as a radiolucency around the root on radiographs, are a common sequela of endodontic infections [2]. Selecting the appropriate therapeutic approach requires an accurate diagnosis [7]. The diagnosis, assessment and treatment of an endodontic condition is generally accomplished by periapical radiography [2, 8] or panoramic radiography [1]. The current gold standard for detection of periapical lesions is routinely periapical radiography [2, 8]. Practitioners often prefer digital imaging because it requires no time-consuming processing [18, 21, 24] and the results are more accurate. Digital imaging is more sensitive in detecting apical lesion than conventional periapical radiography [9, 10]. However, there have been frequent reports that bony aspects of apical bony lesions were not always detectable on periapical radiographs [31]. If these lesions involve cortical bone (buccal or lingual), this will typically result in reduced radiodensity in some areas, whereas lesions in cancellous bone enclosed by dense cortical bone will frequently remain undetected [7, 12, 14, 28].

The most important factor that determines whether apical bony lesions are visible on intraoral radiographs is the presence or absence of cortical perforation. Van Assche et al. found that approximately 90% of these lesions were detected if the cortex had been perforated, but the examiners detected only 10% of intrabony lesions [27]. A correct diagnosis is also made more difficult by variations in apical morphology, x-ray angulations, bone density and radiographic contrast [11].

Three-dimensional (3D) imaging is an alternative to two-dimensional (2D) panoramic and periapical radiography in detecting apical lesions. The 3D technology most frequently used is cone-beam computed tomography (CBCT). Recent studies have looked at the diagnostic value of CBCT scans in relation to apical lesions [2, 3, 14, 20, 26, 29]. Paula-Silva et al., comparing periapical radiographs with CBCT and histological findings, found that the apical lesions were not detected on periapi-



**Figure 1** By panoramic radiography (a), apical lesions are not visible on tooth 45 and barely visible on the mesial root of tooth 47, whereas they are clearly perceptible on teeth 45 (b) and 47 (c) by CBCT taken 5 days later.

Figures 1-3: Ali-Reza Ketabi

cal radiographs in 22% of cases, while CBCT only failed to detect them in 9% of cases [6]. This was confirmed by studies reporting significantly more accurate diagnoses for CBCT than had been the case for periapical radiographs [2, 7, 14]. It should be noted, however, that most of the studies were either ex vivo or animal studies [2, 6, 14], had small study populations [3, 26] or did not directly compare 2D images and 3D images for specific patients [7, 20, 29]. A systematic review with meta-analysis by Leonardi Dutra et al. yielded no data for comparing panoramic radiography and CBCT [17].

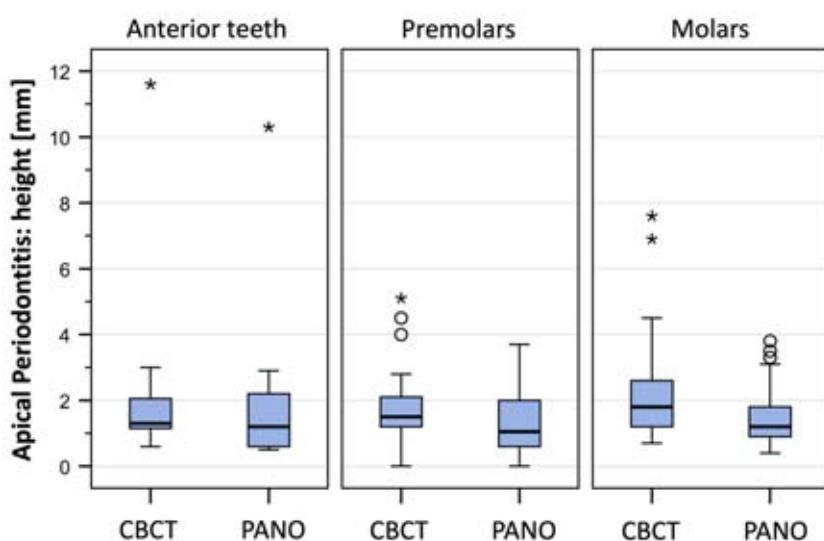
The aim of the present study, therefore, was to compare the visibility of mandibular apical lesions in 2D (panoramic radiography) and 3D (CBCT) radiographs of the same patient and determine whether cortical bone thickness influenced the detectability of apical lesions in a study population of adequate size. Furthermore, it was the authors' intention to measure the size and number of the lesions.

## Material and methods

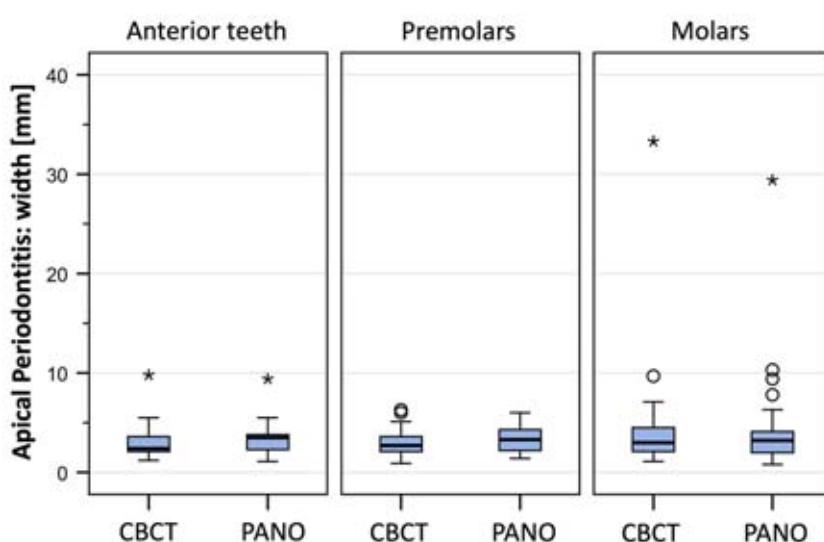
Ethical approval was secured from the Medical Council of Baden-Württemberg, Germany (Register No.

Indication	Gender		
	Female	Male	Total
<b>Endodontics</b>	13 7.5%	10 5.9%	23 6.7%
<b>Periodontology</b>	15 8.7%	8 4.7%	23 6.7%
<b>Implantology</b>	118 68.2%	118 69.8%	236 69.0%
<b>Miscellaneous</b>	103 59.5%	86 50.9%	189 55.3%

**Table 1** Distribution of justifying indications for CBCT



**Figure 2** The measurements of the height AP on the PR and the CBCT.



**Figure 3** The measurements of the width AP on the PR and the CBCT.

F-2014-006-z). The present study was conducted in accordance with the ethical standards of the 1964 Declaration of Helsinki [32]. Imaging records for over 1,000 patients (including panoramic radiography and CBCT) were selected from a data repository at a dental radiological centre. The original examinations had taken place between February of 2010 and January of 2017. Endodontic, periodontal and implant-related diagnoses were included, in addition to some miscellaneous indications (such as a search for cysts, impacted teeth or bone fractures). All patients that were included had had at least one panoramic radiograph and one CBCT scan taken within the previous three months. Patients with an interval between examinations of more than three months were excluded to avoid any distortion potentially caused by changes in the anatomy (such as the development of apical lesions). Data were anonymised prior to analysis.

Digital panoramic radiographs were obtained using an Orthophos D3297 (Sirona, Bensheim, Germany) with 60 kVp and a size of the focal spot of 0.5 mm. Panoramic radiographs were calibrated by reference to objects with a known length (such as implants, metal objects, root canal-treated restored teeth) to eliminate any errors that might have been caused by magnification. Cases without reference objects were excluded. CBCT scans were acquired with a Gendex GXCB-500 (KaVo, Hamburg, Germany) with an 8 × 8 cm field of view (FoV). The exposure was set at 120 kVp/5 mA and 6.0 seconds; the voxel size was set at 0.2 mm. All images were obtained by a dental radiologist. The panoramic images were evaluated with imaging software (DBSWIN v. 5.1.1, Dürr Dental, Bietigheim-Bissingen, Germany). CBCT images were examined using i-CAT Vision software (Imaging Sciences, Hatfield, PA, USA). One examiner with the necessary specialist CBCT competence visually analysed the digital images on a validated computer monitor (Eizo Flex Scan S2000, Eizo Corp., Hakusan, Ishikawa, Japan) in a darkroom after being

specially trained by a dental radiologist.

After the training, inter-examiner and intra-examiner reliability values were calculated for 20 samples. The measurements proceeded for no more than 6 hours per day, with 30-minute periods of rest every 2 hours. All records were reviewed for errors and corrected by a dental radiologist if necessary. Only teeth visible on both the panoramic radiograph and CBCT were included.

The presence or absence of apical lesions was determined for each tooth (Fig 1), with lesion size measured in vertical (Fig. 2) and horizontal (Fig. 3) direction. For CBCT images, the buccopalatal extension of any lesions and the cortical bone thickness (buccally and palatally) in the area of the lesions, if appropriate, were measured.

Data were transferred to individual data acquisition forms for analysis by statistical software (SPSS 25) by a professional medical-statistics provider (medistat, Kronshagen, Germany). The frequency of apical lesions was recorded separately for anteriors/canines, premolars and molars.

The working hypothesis was: "There is no difference in the visibility of apical lesions on panoramic radiographs and CBCT scans."

The CBCT and PR measurements were tested by the Wilcoxon Test for Pair Differences for variations. Two independent samples were compared by means of the Mann-Whitney U test. To examine correlations between quantitative, not normally distributed parameters, a rank correlation analysis was carried out as per Spearman.

The McNemar test and the chi-square test were used for a statistical testing of the working hypothesis (differences between imaging techniques regarding the visibility of periapical lesions). A p-value of  $\leq 0.05$  indicates the presence of a significant difference.

## Results

A total of 343 patients for which mandibular panoramic radiographs and CBCT scans – taken within 3 months – were available were in-

Tooth group			CBCT		
			Negative	Positive	Total
<b>Anterior teeth</b>	Panoramic	Negative	1,043 98.2%	5 0.5%	1,048 98.7%
		Positive	0 0.0%	14 1.3%	14 1.3%
		Total	1,043 98.2%	19 1.8%	1,062 100%
<b>Premolars</b>	Panoramic	Negative	575 92.7%	18 2.9%	593 95.6%
		Positive	0 0.0%	27 4.4%	27 4.4%
		Total	575 92.7%	45 7.3%	593 100%
<b>Molars</b>	Panoramic	Negative	578 91.9%	15 2.4%	593 94.3%
		Positive	0 0.0%	36 5.7%	36 5.7%
		Total	578 91.9%	51 8.1%	629 100%
<b>Total</b>	Panoramic	Negative	2,196 95.0%	38 1.6%	2,234 96.7%
		Positive	0 0.0%	77 3.3%	77 3.3%
		Total	2,196 95.0%	115 5.0%	2,311 100.0%

Computed tomography (CBCT) versus panoramic radiographs in mandible.

**Table 2** Cross-classified comparison of the visibility of apical bony lesions by cone-beam

cluded in the study. Genders were represented approximately equally (174 female/169 male). The patients' age at baseline was  $59.0 \pm 14.5$  (mean  $\pm$  SD; range 19–92) years. The indications for CBCT scans are shown in Table 1; in some cases, there were multiple indications. The inter-examiner and intra-examiner reliabilities were rated as very high (Cohen's kappa 1.0; 95% CI for kappa [0.92; 1.00]).

The prevalence of apical lesions as identified by panoramic radiographs and CBCT is presented as a cross-classified table (Table 2). 67.0% of the lesions visible by CBCT were also visible on a panoramic radiography. The visibility differences were significant in the premolar and molar regions (McNemar test;  $p < 0.001$ ) but not in the anterior region ( $p = 0.063$ ).

The size of the apical lesions was also determined (Table 3). Some teeth were affected by multiple lesions. Hence, the total number of lesions included in the measurements was 123 (115 teeth). The CBCT measurements were: width  $3.38 \pm 3.11$  mm (mean  $\pm$  SD; range 0.90–33.30 mm); height  $1.95 \pm 1.47$  mm; (0.00–11.60 mm); depth  $3.33 \pm 1.48$  mm (1.20–9.00 mm). The panoramic measurements were: width  $3.63 \pm 3.04$  mm (0.80–29.4 mm); height  $1.50 \pm 1.22$  mm (0.00–10.30 mm). The Wilcoxon test showed no significant differences between the two imaging technologies (anteriors/canines  $p = 0.60$ ; premolars  $p = 0.90$ ; molars  $p = 0.61$ ).

		N	Mean	SD	Min.	Max.	25 <sup>th</sup>	50 <sup>th</sup> (Median)	75 <sup>th</sup>
<b>Anterior teeth</b>	CBCT: width	20	3.06	1.92	1.20	9.80	2.10	2.40	3.60
	CBCT: height	20	2.06	2.35	0.60	11.60	1.13	1.30	2.08
	CBCT: depth	20	3.38	1.66	1.80	9.00	2.40	2.85	3.85
	CBCT: buccal cortical bone thickness	20	1.39	0.51	0.00	2.40	1.20	1.50	1.50
	CBCT: palatal cortical bone thickness	20	1.89	0.58	0.90	3.10	1.50	1.80	2.18
	PANO: width	17	3.56	1.90	1.10	9.40	2.10	3.50	4.15
	PANO: height	17	1.89	2.31	0.50	10.30	0.60	1.20	2.25
<b>Premolars</b>	CBCT: width	46	2.92	1.17	0.90	6.30	2.10	2.70	3.60
	CBCT: height	46	1.68	1.01	0.00	5.10	1.20	1.50	2.10
	CBCT: depth	46	2.70	0.96	1.20	5.40	2.08	2.40	3.33
	CBCT: buccal cortical bone thickness	46	1.85	0.57	0.00	3.00	1.50	1.80	2.18
	CBCT: palatal cortical bone thickness	46	2.00	0.52	1.20	3.40	1.50	1.80	2.13
	PANO: width	37	3.34	1.34	1.40	6.00	2.15	3.30	4.45
	PANO: height	36	1.34	0.88	0.00	3.70	0.60	1.05	2.00
<b>Molars</b>	CBCT: width	57	3.90	4.32	1.10	33.30	2.10	3.00	4.50
	CBCT: height	57	2.14	1.39	0.70	7.60	1.20	1.80	2.70
	CBCT: depth	57	3.82	1.60	1.50	8.80	2.65	3.30	4.70
	CBCT: buccal cortical bone thickness	57	2.70	0.89	0.00	4.50	2.15	2.70	3.35
	CBCT: palatal cortical bone thickness	57	2.06	0.71	0.00	3.70	1.50	2.10	2.50
	PANO: width	53	3.86	4.05	0.80	29.40	2.00	3.20	4.20
	PANO: height	53	1.49	0.87	0.40	3.80	0.90	1.20	1.80

**Table 3** Measurements of apical lesion parameters and cortical bone thickness in the mandible

Mean cortical thickness, as measured by CBCT, was  $2.17 \pm 0.71$  mm (mean  $\pm$  SD; range 0.00–4.50 mm) buccally and  $2.01 \pm 0.62$  mm (0.00–3.70 mm) palatally. The results for the thickness of compact bone near apical lesions are given in Table 3. In the Mann-Whitney U test, buccal and palatal cortical thickness did not significantly influence the visibility of lesions in CBCT and panoramic measurements (buccal  $p = 0.93$ ; palatal  $p = 0.15$ ).

The cortical bone was significantly thicker both on the buccal and on the palatal aspect (Mann-Whitney U test;  $p < 0.01$ ) for molars on which apical lesions were visible on both

CBCT and panoramic radiographs. The visibility of the apical lesions showed no correlation with bone thickness in the anterior (buccal  $p = 0.65$ ; palatal  $p = 0.59$ ) and premolar regions (buccal  $p = 0.68$ ; palatal  $p = 0.11$ ).

### Discussion

The results show that apical lesions were 1.5 times more visible on CBCT scans than on panoramic radiographs. Furthermore, the diameters of the apical lesions were almost equivalent for both imaging methods.

This result agrees with a study by Nardi et al., who investigated the ac-

curacy of panoramic radiography in detecting apical lesions on asymptomatic root canal-treated teeth and found higher positive predictive values for lesions located in the mandible in canine/premolar and molar areas [19]. Furthermore, Nardi et al. found negative predictive values for panoramic radiography if the lesions were smaller than 4.6 mm and did not affect the cortical bone [19]. In the present study, discrepancies were highly evident. A possible explanation in the anterior region is that the anterior imaging quality is often poor in the latter due to a possible superimposition of the spine or blurring caused by a position out of

focus. Hence, this value is significantly higher than the visibility of anterior maxillary lesions, of which only 13.6% were detected via panoramic radiography. This discrepancy is caused by the roots in the mandible being more orthograde to the x-ray beam. Furthermore, disturbances by superimposition of anatomical structures are less common in the mandible [19]. Not once was a lesion found on a panoramic radiograph if not on the corresponding CBCT. However, not least because of radiation protection requirements in accordance with the ALARA/ALADA principle [13] ("As low as reasonably achievable/as low as diagnostically acceptable"), panoramic radiography is not the diagnostic method of choice for apical lesions [19].

The present study is of limited validity because histological material could not be acquired for ethical reasons. False-negative/false-positive results may have been present. However, histopathologic studies reached comparable results and showed high diagnostic accuracy for CBCT and apical lesions compared with panoramic radiography [2]. Other human clinical studies used CBCT as reference, [4, 5, 7, 22, 23] with possibly biased results [25, 30]. Recently, Kruse et al. found that the diagnostic accuracy of CBCT depends on the endodontic status of the tooth. The diagnostic accuracy of CBCT was high for non-treated roots, whereas the diagnosis of apical lesions on root canal-treated roots was less accurate [16]. This aspect had not been known when the present study was implemented and was therefore not considered.

For this study the researcher was briefed by an expert in the field of dental radiology prior to commencement of the study. To verify the reliability of radiographic measurements and evaluations, multiple ratings were carried out of 20 randomly selected patients. Since a selected patient population was included here, a possible risk of spectrum bias cannot be ruled out. However, the high intra- and interrater reliability (Cohen's kappa 1.0) of the study also indicates the reliability of the results.

A systematic review and meta-analysis by Leonardi Dutra et al., on

the other hand, found high levels of accuracy for CBCT (0.96) compared to the already good results obtained by periapical radiography (0.72–0.73) in detecting apical lesions. The present results combined with current published research allow us to conclude that CBCT is more accurate in detecting apical lesions than panoramic radiography [17].

The thickness of the cortical bone and its influence on the visibility of lesions on CBCT and panoramic radiography has not been investigated previously for the mandible. Our results do not show any significant correlation between the thickness of the cortical bone and the visibility of lesions on CBCT and panoramic radiography. The cortical bone in the molar area was significantly thicker in cases where apical lesions were detected, as compared to cases where no such lesions were visible. It is conceivable that the thicker cortical bone compensates for the loss of cancellous bone in the maxillary molar region with its typically lower bone density. However, this would need to be verified in further studies.

There was no correlation between cortical bone perforation and lesion visibility in the mandible, contradicting previous results [27].

The results show that panoramic radiographs are not a reliable diagnostic tool for detecting apical lesions. Small apical lesions seem to be much better visible on CBCT scans. Cortical thickness does not seem to influence the visibility of apical lesions on panoramic radiographs or CBCT scans.

## **Authorship declaration**

Dr Ali-Reza Ketabi had the idea for the study and collected the data. Dr Sandra Ketabi evaluated the radiographs and was responsible for the data analysis. Prof Dr Hans-Christoph Lauer substantively revised the manuscript. Prof Dr Andree Piwowarczyk substantively revised the manuscript. Dr Martin Brenner wrote the manuscript and provided support in the conception of the study. All authors are in agreement with the manuscript.

## **Conflict of interest**

The authors declare that there is no conflict of interest as defined by the guidelines of the International Committee of Medical Journal Editors.

## **Availability of data and materials**

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Photo: A.-R. Ketabi

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Dominik Groß

# From SS-Obersturmbannführer to dentist president: The astonishing career of Gerhardt Steinhardt\*

**Introduction:** Until 2022, Gerhardt Steinhardt has been the only university lecturer to be elected both President of the DGZMK and the DGMKG. At the same time, he is the only DGZMK president with an SS membership in the Third Reich. This paper looks at Steinhardt's life and work, and in particular clarifies how these seemingly irreconcilable findings fit together.

**Material and methods:** The central basis of the study are primary sources from the Schleswig-Holstein State Archives and various file collections from the Federal Archives in Berlin. In addition, a critical reanalysis of secondary literature by and about Steinhardt was carried out, with special reference to a dissertation on the life and work of Gerhard Steinhardt published in 2004.

**Results:** Steinhardt was one of the leading professors in the Federal Republic of Germany, especially with his contributions to the physiology and pathology of the temporomandibular joint (TMJ) and his clinical expertise as a maxillofacial surgeon. He was also regarded as an assertive professional politician. During the Third Reich, he joined the NSDAP (National Socialist German Workers' Party), the SS (Schutzstaffel) and other Nazi organisations, resigned from the church in accordance with Nazi ideology and took on various political tasks. After 1945 he was enacted for political reasons but managed a return to the university in the 1950s.

**Discussion and conclusion:** Steinhardt was extraordinarily well connected both during the Nazi era and in the Federal Republic. He also impressed with his broad education and professional versatility. Politically, he showed himself to be strongly adapted in both systems. In the Third Reich he appeared as a convinced National Socialist and used his political network to establish a career. After 1945 he tried to construct a distance to Nazi ideology through a series of deliberately false statements. In the end, he was able not only to continue his university career, but even to expand it considerably. He also achieved high social honors.

\* In 2022, the DGZMK Board unanimously passed a resolution to posthumously revoke the honours awarded to Gerhard Steinhardt (Honorary Fellowship, Golden Badge of honour) due to his political entanglement in the Third Reich.

**Keywords:** maxillofacial surgery; National Socialism; SS (Schutzstaffel); temporomandibular joint; Würzburg

## Introduction

Gerhardt Steinhardt's career offers two striking features: On the one hand, he was the only university lecturer until 2022 to be elected both president of the "Deutsche Gesellschaft für Zahn-, Mund- und Kieferheilkunde" (German Society for Dental and Oral Medicine, DGZMK) (1965–1969) and president of the "Deutsche Gesellschaft für Mund-, Kiefer- und Gesichtschirurgie" (German Society for Oral and Maxillofacial Surgery, DGKG, today: DGMKG) (1969–1971), which clearly shows his broad professional recognition in dentistry and maxillofacial surgery. On the other hand, he is the only DGZMK president with SS membership and extensive contacts with influential Nazi officials..

This paper deals with Steinhardt's life and work. In a first step, Steinhardt's academic and political work will be analysed and classified. Then it will be clarified how Steinhardt was able to achieve such success despite the aforementioned political burden. In this context, it is also necessary to look at the only biography of Steinhardt to date. In 2004, Wencke Fischer wrote a dissertation on his life and work and explains Steinhardt's loyalty to the regime under National Socialism with the statement: "People in high and important positions, like Prof. Dr. Dr. Steinhardt, had no other option than to join the NSDAP and SS" [12].

But is this assertion accurate? And how did Steinhardt himself see and outline his role in National Socialism? These questions are discussed in detail in this article. Accordingly, a strong focus is placed on Steinhardt's political stance in the Third Reich and on his denazification procedure.

## Material and methods

The study is based on a variety of primary sources from the Schleswig-Holstein State Archives, the Federal Archives in Berlin and the Cologne University Archives. In addition, Steinhardt's publications were evaluated – with special attention to his writings during the Third Reich.

Furthermore, a critical analysis of the secondary literature on Steinhardt's places of work and the afore-

mentioned biography was carried out. The same applies to the laudations and necrologies published by and about Steinhardt.

## Results and Discussion

### 1. Gerhard Steinhardt: Central stations in his life

Gerhard Friedrich August Wilhelm Steinhardt (Fig. 1; [9]) was born on May 24, 1904 in Damerkow in Pomerania [7, 12, 14–16, 33, 36–41, 46, 47, 50, 52, 76, 77]. He was the son of the farmer and farm owner [4] Wilhelm Friedrich Steinhardt and his wife Berta Pauline Ernestine, née Hapke, and had three younger siblings [12].

Gerhard Steinhardt graduated from the Realgymnasium Belgard (today Białogard, Poland) in 1923. In the same year he enrolled in Heidelberg to study chemistry but changed to dentistry after two semesters at the same university. Here he passed the dental examination in November 1927. At that time, the Heidelberg Dental Institute was headed by Georg Blessing (1882–1941) [13]; the other authoritative teachers were the titular professor Gerhard Weißenfels (1890–1952) [13] and Elsbeth von Schnizer [13, 28], who habilitated under Blessing in those years.

Steinhardt took up an assistant position with Blessing after his studies. In 1928 he received his doctorate (Dr. med. dent.) with the thesis "Zur Pathogenese der zirkulären Karies am Milchgebiß" (On the pathogenesis of circular caries in the milk dentition) [53]. His doctoral supervisor was the Heidelberg pathologist Siegfried Gräff (1887–1966) [12]. At that time Steinhardt studied medicine – parallel to his part-time work in the Heidelberg prosthodontics department. In 1931 he passed the medical examination in Heidelberg. He completed the mandatory practical year at the Medical Clinic of the University of Heidelberg with Richard Siebeck (1883–1965) [12] and at the Pathological Institute of the Katharinenhospital Stuttgart with the oral pathologist Herbert Siegmund (1892–1954) [43, 51]. In June 1932 he received his licence to practise medicine and in December 1932 he com-



Courtesy of "Deutscher Ärzteverlag".

**Figure 1** Portrait of Gerhard Steinhardt [9]

pleted his medical doctorate (Dr. med.). This second dissertation, "Über besondere Zellen in den alternden Mundspeicheldrüsen (Oncocyten)" (On special cells in the ageing oral salivary glands [oncocytes]), was again a pathological study. It was supervised by Siegmund and submitted in Heidelberg [54]. The starting point of Steinhardt's study were the "oncocytes" described by Herwig Hamperl (1899–1976) in 1931, which made Hamperl famous within a very short time [32].

After his second doctorate, Steinhardt worked for another year as an assistant at the Stuttgart Institute of Pathology: there he now devoted himself to his habilitation project – namely "Untersuchungen über die Beanspruchung der Kiefergelenke und ihre geweblichen Folgen" (Studies on the strain on the temporomandibular joints and their consequences for the tissue) [55]. From 1933 he was also an assistant at the Dental Institute of the University of Cologne under Karl Zilkens (1876–1967) [13], where he soon became head of the prosthetic department.

In September 1933, Steinhardt married the factory owner's daughter Elisabetha Gutermann. Their only child together, a daughter, was born in 1934 [12].

The next career step followed in the same year: in November 1934 he submitted the above-mentioned ha-

bilitation thesis in Cologne [55], with Zilkens and the pathologist Ernst Leupold (1884–1961) [43] acting as reviewers. The formal route via the Cologne medical faculty and via Karl Zilkens was necessary because the Katharinenhospital in Stuttgart did not have university status and therefore had no habilitation rights. Steinhardt was able to complete the procedure in July 1935 and was appointed Privatdozent. During that period, there was a change of head in Cologne dentistry: Zilkens – a member of the Catholic “Deutsche Zentrumspartei” (German Centre Party) – was considered politically suspect by the Nazis; he had already been dismissed in 1934 and was officially forced to resign in 1936. Steinhardt, however, remained unaffected by this measure: in 1935, he was able to move to the Surgical University Clinic in the Bürgerspital in Cologne as an assistant to Hans von Haberer (1875–1958) [43], where he expanded his general surgical knowledge; he worked there until February 1937 [12].

In March 1937 Steinhardt took up a visiting professorship at the State Dental School in Tokyo. For three years he lectured there on oral pathology and worked as an assistant at the surgical department [4]. In November 1939, while still in Tokyo, he was appointed associate professor in Cologne. After his return to the German Reich in May 1940, he then took up a position as senior physician at the University Clinic of Maxillofacial Surgery in Berlin. This clinic, directed by Otto Hofer (1892–1972) [40, 62], was considered leading in the German Reich. There Steinhardt also got to know the senior physicians Heinrich Hammer (1891–1972) [13] and Ewald Harndt (1901–1996) [13, 18, 66]. Steinhardt's time in Berlin also saw an important private change: after his first marriage had been divorced in July 1942, he married the dentist Annemarie Jänicke (\*1915) in August 1942. Jänicke had been acting as ward physician in the surgical department headed by Hofer since March 1941 [5]. Three children were born of this second marriage [12].

Steinhardt was dismissed from university service in 1945. He left

Term of office	Name	NSDAP Membership	Life data
1906–1926	Otto Walkhoff	+	1860–1934
1926–1928	Wilhelm Herrenknecht	+	1865–1941
1928–45, 1949–54	Hermann Euler	+	1878–1961
1954–1957	Hermann Wolf	+	1889–1978
1957–1965	Ewald Harndt	+	1901–1996
<b>1965–1969</b>	<b>Gerhardt Steinhardt</b>	+	<b>1904–1995</b>
1969–1971	Eugen Fröhlich	+	1910–1971
1972–1977	Rudolf Naujoks	–	1919–2004
1977–1981	Werner Ketterl	+	1925–2010

**Table 1** The presidents of the CVDZ (from 1933: DGZMK) who experienced the Third Reich as adults and their party-political orientation

Berlin and arrived in Satrup near Flensburg. There he worked as a self-employed dentist from August 1945 to December 1949, with his wife acting as a “dental assistant” [12]. However, he was temporarily detained in Neuengamme near Hamburg from December 1945 to February 1947 [48].

In 1950 Steinhardt obtained a lectureship at the University of Kiel: his former colleague Heinrich Hammer had in the meantime become director of the Kiel Dental Institute and was able to arrange that (minor) teaching position for him [12].

With effect from April 1, 1952, Steinhardt was appointed head of the newly founded jaw clinic of the (non-university) “Städtische Krankenanstalten Bremen” (Bremen Municipal Hospitals). There he soon gained professional recognition, especially in the field of therapy of temporomandibular joint disorders [12]. In July 1956 he obtained a civil servant position there and was promoted to department director. Nevertheless, he retained his lectureship in Kiel.

In 1957, the next step in his career followed: Steinhardt was appointed (non-tenured) associate professor and clinic director at the Uni-

versity of Würzburg, succeeding Karl Peter (1896–1959), who was seriously ill. After Peter's death in 1959, he was appointed tenured associate professor there [12, 42, 44].

At the beginning of 1961, Steinhardt then took the opportunity of another guest professorship – this time at the Medical Faculty of the University of Alexandria in Egypt, where he worked as a lecturer and surgeon for several months.

Once again, the return from abroad was followed by a promotion: in March 1962, Steinhardt was able to take up a full professorship at Erlangen University; at the same time, he was appointed Director of the Clinic and Polyclinic for Dental Diseases there. Steinhardt had thus climbed the last rung on the career ladder as a university lecturer. From the winter semester of 1969/70 to the summer semester of 1972, he also acted as provisional head of the Department of Orthodontics in Erlangen [12].

Steinhardt formally became emeritus professor on September 30, 1972, but remained provisional director until October 1, 1973. He then moved with his wife to Feldafing on Lake Starnberg. During this period, he suffered from the late effects of a

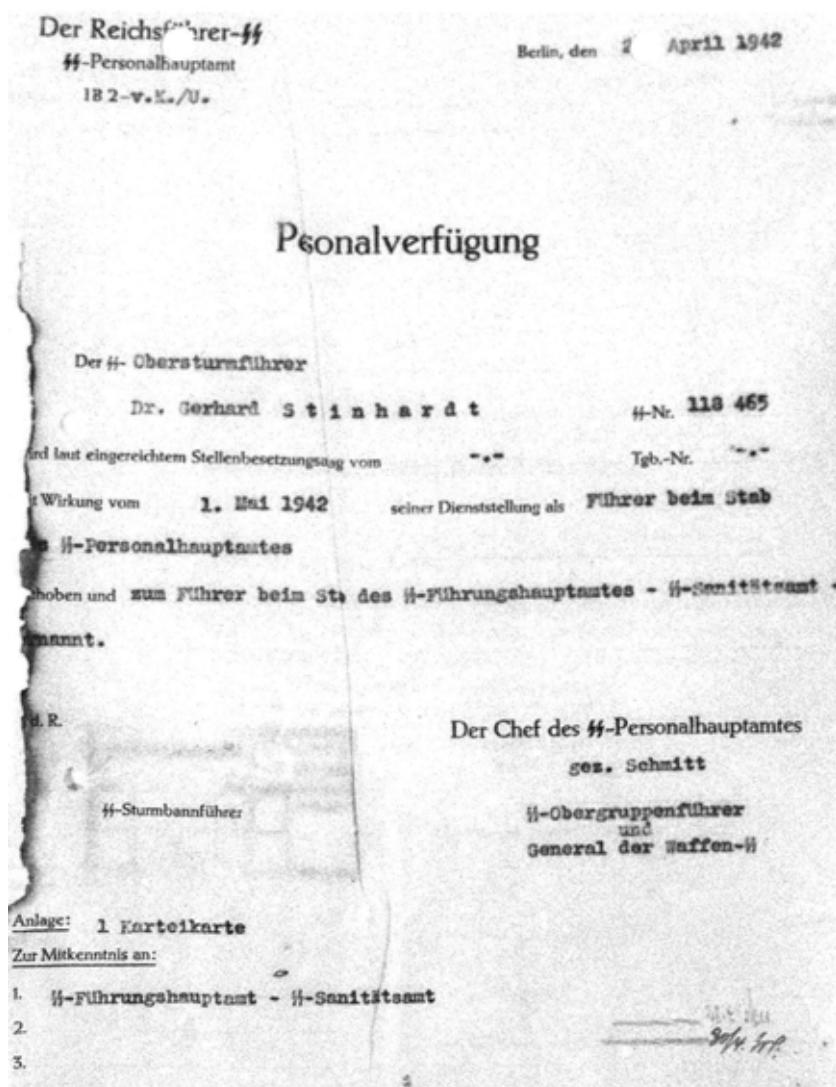
self-experiment: as a young researcher he had infused a colloidal solution of the then new X-ray contrast medium Thorotrast into the ductal system of his parotid gland [12, 71]. The agent had the desired effect, but later nodules formed in the tissue and the cells eventually degenerated. Thus, a parotidectomy had to be performed, which resulted in peripheral facial paresis.

Steinhardt died on June 18, 1995 in Feldafing and was buried in the local mountain cemetery (section A, grave no. 16). His widow subsequently moved to Rottach-Egern (Rupertihof) [12].

## 2. Steinhardt's scientific and professional status in German dentistry

Steinhardt's career was impressive: already at a young age he had gained experience abroad and held leading positions in both prosthodontics and oral surgery. He had acquired profound expertise in pathology and was also trained in internal medicine and general surgery. He was able to publish basic studies (in the field of temporomandibular joint disorders), but was also considered an accomplished clinician. In addition, he had a track record in university and professional politics: He was Dean of the Erlangen Medical Faculty in 1965/1966 and was also, until 2022, the only university lecturer to chair both the DGZMK and the DGKG (today: DGMKG) [10, 12, 16, 33].

It was precisely the professional versatility described above that was appreciated by contemporaries. Erwin Reichenbach (1897–1973) [19] and Eugen Fröhlich (1910–1971) [30] emphasised: "The range of his training is unusually wide. Apart from working as an assistant in prosthodontics and surgery at the specialist dental clinics in Heidelberg and Cologne [...] we find him [...] as an assistant physician at the internal clinic in Heidelberg, the surgical clinic in Cologne and at the pathological institute of the Katharinenhospital in Stuttgart, where Siegmund was instrumental in determining his later main direction of work" [50]. Indeed, Siegmund laid the foundation for Steinhardt's career. Konrad Thiele-



**Figure 2** Document concerning Gerhard Steinhardt's SS membership (1942) [6].

mann (1898–1985) [13] was also part of Steinhardt's early network: he met him around 1932 at the Katharinen-hospital in Stuttgart. Together they investigated the connections "between occlusion and temporoman-dibular joints". Both later also worked together in the field of focal infection [49].

The early studies on the temporomandibular joint conducted with Siegmund are still considered Steinhardt's most important contributions and it was no coincidence that one of the research papers from this period was awarded a prize by the Adolf Witzel Foundation in 1934 [56]. Ewald Harndt particularly highlighted Steinhardt's habilitation thesis on this topic [37]. Karl Häupl (1893–1960), international pioneer of

orthodontics [20], also paid tribute to Steinhardt's studies on the temporomandibular joint [35]. Even decades later, Steinhardt showed his commitment to this field: in 1989, in collaboration with Albert Gerber (1907–1990), he wrote a textbook entitled "Kiefergelenkstörungen – Diagnostik und Therapie" (Temporoman-dibular joint disorders – diagnostics and therapy) [72].

As clinic director in Erlangen, Steinhardt then established a "De-partment for Functional Dentition Analysis" – the first institution of its kind in the German-speaking world; Oskar Bock (1915–1979) became head of the department in 1964.

Steinhardt's scientific focus [76] also included salivary gland research [57, 64, 71], the management of

mandibular and temporomandibular joint fractures [68, 70, 74], tumour therapy [67, 69, 71], the therapy of bite anomalies and jaw malpositions [60, 61, 73], prosthetic treatment of the gap dentition or the role of the temporomandibular joints in prosthetic planning [59, 63, 65] and focal infection [58]. No scientific, but clinical fields of work were root tip resection and the therapy of cleft lip and palate.

Steinhardt was not a "prolific writer". In terms of quantity, his œuvre of around 90 publications remained significantly behind that of other DGZMK presidents. Werner Ketterl, for example, published well over 300 papers [31], Hermann Euler over 240 [25, 34] and Hermann Wolf [29] wrote more than 180 publications.

Notwithstanding the basic research-oriented contributions to TMJ, Steinhardt was considered a good clinician and surgeon [15]. Steinhardt's student Ferdinand Sitzmann (\*1939) noted: "He was able to single-handedly translate scientific pretension with technical operative skill into practice [...] He [...] was able to make the right decision at the right moment. Through his performance and example, he was a natural, self-evident authority" [52].

Steinhardt, who continued to play golf into old age [52], was regarded by his colleagues as sociable and eager to debate. Harndt noted: "Steinhardt prefers 'uncomfortable' colleagues; he loves sharp, objective discussion [...]" [37]. Sitzmann also confirmed this characteristic: "He loved sharp, factual discussions [...]. Tolerance towards dissenters was an important maxim" [52].

Steinhardt's trainees found in him a committed mentor, which Martin Herrmann (1895–1976) [13] also emphasised in a laudation [38]. In addition to the aforementioned Ferdinand Sitzmann, his academic students included Manfred Straßburg (1930–2014) and Hans-Dietrich Mierau (1930–2019).

A critical undertone, on the other hand, can be found in Carl-Heinz Fischer (1909–1997) [34], who as Rector of the University of Düsseldorf (1970–1972) was also one of the

powerful protagonists of the discipline. He stated in his memoirs that Steinhardt had "done everything" to become DGZMK president in 1965 and to prevail against the opposing candidate Ulrich Rheinwald [11].

The fact that Steinhardt was highly respected and well networked among his colleagues becomes clear from the large number of offices, awards and honours he received [10, 12, 78]: In addition to the two presidencies in the DGZMK and the DGKG (DGMKG) mentioned above and the office of dean, he served as press officer of the then DGKG as early as the 1950s. In 1960 he was appointed honorary member of the Italian Dental Society. In 1970 and 1971 he served as conference president of the DGMKG. In May 1973 he was appointed honorary member of the Swiss Dental Society and in the same year he received the Badge of Honour of the "Deutsche Zahnärzteschaft" (German Dental Association). In 1974 he was awarded the Golden Badge of Honour of the DGZMK, in 1977 he became an honorary member of the DGZMK and in 1980 an honorary member of the DGMKG on the occasion of the 30th annual conference in Zurich. The "Arbeitsgemeinschaft für Funktionslehre" (Working Group for Functional Theory, DGFDT) also appointed him as its honorary member.

### 3. Gerhardt Steinhardt and National Socialism

Steinhardt joined the NSDAP shortly after the Reichstag elections of March 3, 1933 (admission May 1, 1933; membership no. 2,117,571) and also decided to join the SS as early as summer 1933 (admission August 1, 1933; no. 118,465). He also became a member of the "NS-Ärztebund" (Nazi Medical Association). Furthermore, he joined the "NS-Volkswohlfahrt" (Nazi People's Welfare) and the "NS-Dozentenbund" (Nazi Lecturers' Association) (admission January 1, 1940) [1, 4, 6].

In the archive files Steinhardt repeatedly describes himself as "gottgläubig" (God-believing). This term had been introduced by the Nazis for those believers who had renounced the institutionalised Chris-

tian churches for ideological reasons and was therefore regarded as a sign of particular closeness to National Socialism. Steinhardt had left the Protestant Church in 1935 [5, 6]. Steinhardt's second wife Annemarie Jänicke was not a party member, but also classified herself as "gottgläubig" [5].

Whether Steinhardt was convinced of the Nazi ideology or acted opportunistically is difficult to assess retrospectively. What is certain is that he supported the Nazi regime with his various memberships and by leaving the church. His stay in Tokyo from May 1937 to May 1939 must also be placed in this context: In the Third Reich, research stays in the partner country Japan [45] were always carried out in close coordination with political decision-makers. Only representatives loyal to the regime were considered for exchange with Japan. This was also evident in the Steinhardt case. For example, the files of the Federal Archives contain the minutes of a meeting that took place on September 3, 1936 between the Japanese host and rector of the Tokyo university, Professor Thol Shmanine, the dental "Reichsdozentenführer" Karl Pieper (1886–1951) [23] and the "Reichszahnärztführer" Ernst Stuck [24]. It was decided that Hermann Groß (1899–1979), who was in Tokyo at the time, would return to Germany in the spring of 1937 and that Steinhardt would take his place [4]. Groß – also an avowed National Socialist – was to leave early to replace Zilkens, who had been forced to resign, as head of the Dental Clinic of the University of Cologne [13]. Only one day after the meeting, Pieper then officially proposed Steinhardt as Groß's successor to the head of the NS-Dozentenbund – Hermann Hiltner – pointing out that Steinhardt had been an NSDAP member since 1933 and was thus politically reliable and that there were no other noteworthy candidates [4].

Before Steinhardt left for Japan, he was "honorably discharged" from the SS; his reinstatement was envisaged for the time of his return. In the first year of his stay in Tokyo, however, Steinhardt then received information that "former members of

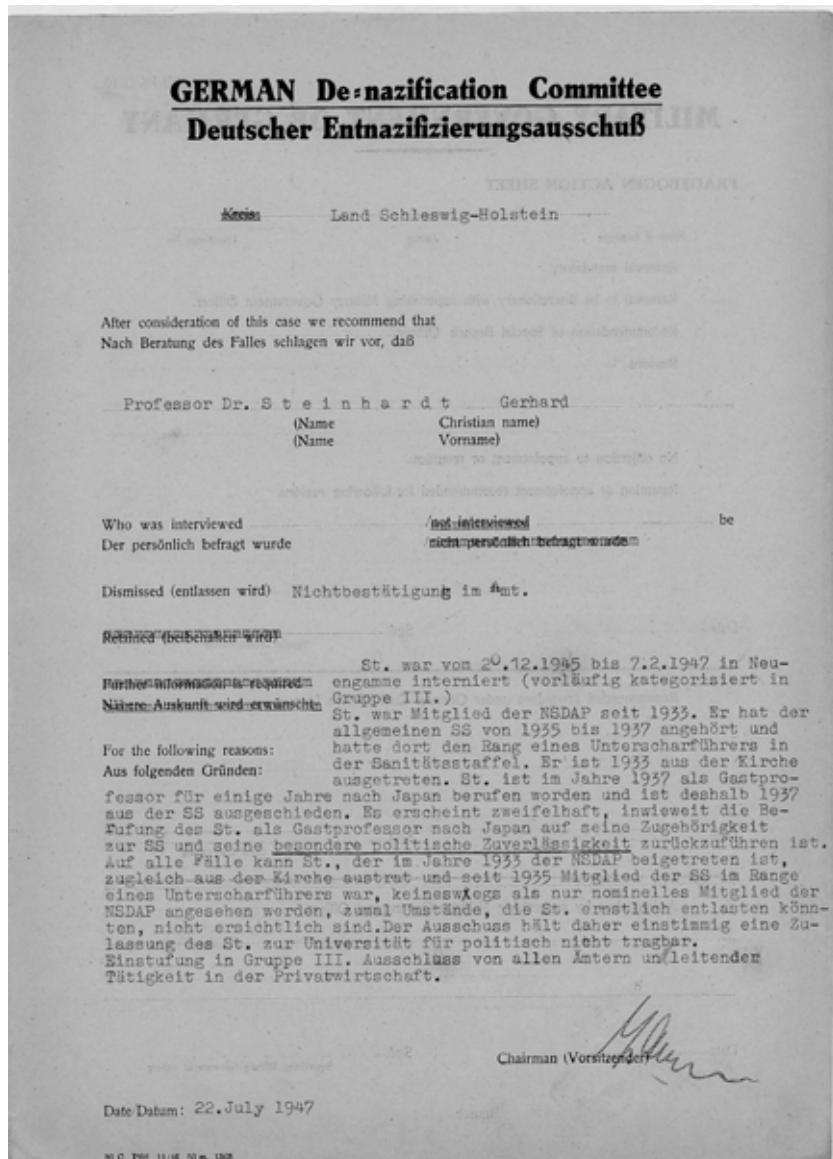


Figure 3 Denazification notice for Gerhard Steinhardt dated July 22, 1947 [48].

the SS who are abroad can remain in the SS on application for the duration of their stay abroad". Steinhardt took this information as an opportunity to proactively apply for instant reinstatement in the SS. The local group leader in charge supported Steinhardt's application. On October 27, 1938 Steinhardt received the message that his application had been granted: "You are reinstated in the Schutzstaffel with effect from September, 20" [6].

Steinhardt's demonstrative zeal had an effect: only a few months later – on January 30, 1939 – he was appointed SS-Untersturmführer. In addition, his stay in Japan, originally scheduled for two years, was ex-

tended by one year. This success message was sent to Steinhardt by Pieper by telegraph after Otto Koellreutter (1883–1972) had given Steinhardt a positive report. This information is found in a correspondence between Pieper and Steinhardt dated 4 May 1939 [4]. Koellreutter, a professor of law, was, like Pieper, a convinced National Socialist. He had already come to prominence in 1934 as the author of "Der deutsche Führerstaat" (The German Führer State) [43]. Koellreutter was in Japan during those years and had apparently got to know Steinhardt in Tokyo.

In view of his promotion to Untersturmführer, Steinhardt wanted to

adapt his uniform in Tokyo to the new SS grade. Therefore, on June 9, 1939, he requested the "sending of the [matching] sleeve stripes as well as the collar insignia" for a fee, in order to be able to wear the uniform in a correctly adapted form at meetings of the NSDAP local group Tokyo-Yokohama [6]. Steinhardt had joined the aforementioned local group in Tokyo and functioned there as a "Blockleiter" (block leader); this emerges from a letter dated November 5, 1939 [4].

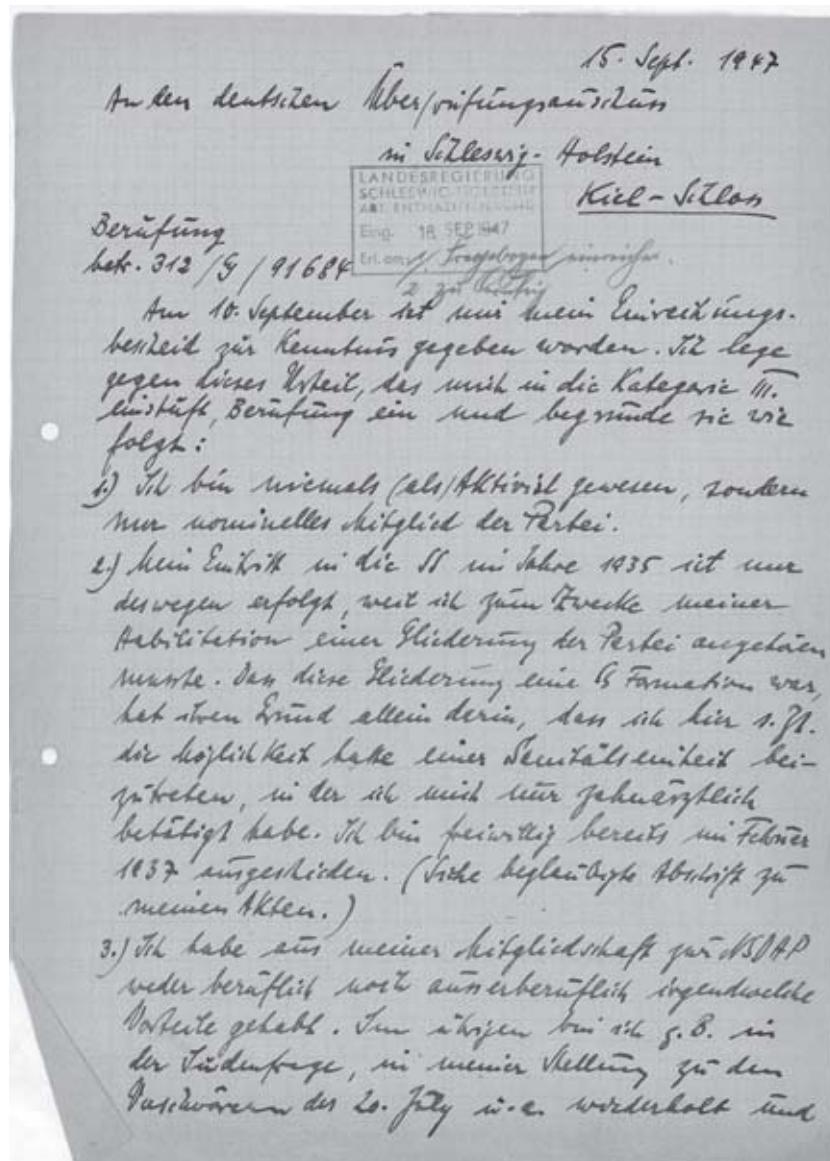
Steinhardt was in regular correspondence with Reichsdozentenführer Pieper during his stay in Japan. He made no secret of his attitude to Nazi politics. On December 1, 1939, for example, he wrote to Pieper: "We have followed the victory of our armies in Poland with enthusiasm. Now our eyes turn to our brave navy, which we all hope will continue to deal such considerable blows to the British fleet in conjunction with the Luftwaffe that proud England will soon fall to its knees [...]. For Führer and people may it bring victory over presumptuous England and her mean methods of war leaders and propaganda. With heartfelt greetings and Heil Hitler!" [3].

At the end of April 1940, Steinhardt began his return journey to Germany. Already in 1939, it had been explored in the German Reich how and where Steinhardt could continue to be employed after his return. Karl Friedrich Schmidhuber (1895–1967) [27] – director of the Heidelberg Dental Clinic, leader of NS-Dozentenbund in Heidelberg and also a member of the SS – announced as early as 1939 that he would make a position available for Steinhardt at his institution [75]. At the same time, however, there were efforts to get him into position as a lecturer at the Charité. This proposal came from none other than Max de Crinis (1889–1945), prominent ministerial advisor for medical matters in the Berlin Ministry of Science and full professor of neurology at the Charité [43]. It was explicitly supported by Pieper.

It was precisely against this background that Steinhardt was appointed professor in November 1939 – in absentia [75]. This titular profes-

sorship was formally conferred on him at his last university location: in Cologne. By doing so, Steinhardt was able to take up his post at the renowned University Clinic for Maxillofacial Surgery at the Charité in Berlin as professor (and senior physician) (May 1940). This clinic was considered a career springboard and was also timely from a professional point of view: since Steinhardt had previously worked mainly in prosthodontics (and oral surgery) at the dental clinics in Heidelberg and Cologne, he was now able to gain important clinical experience in maxillofacial surgery.

In 1942, the dental chair at the University of Tübingen had to be filled. The Tübingen Medical Faculty put Steinhardt [13] on its list of three favourites, in addition to the much older colleagues Walter Adrion (1891–1960) [13] and Karl Greve (1897–1942). All three were party members. In addition to professional assessments, it was customary at the time to obtain expert opinions on the political views of each list candidate. One of the opinions on Steinhardt came from Reichsdozentenföhrer Pieper: on February 24, 1942, he praised Steinhardt in the highest terms and stated that he had “worked to a very significant extent for Nazi Germany in Japan scientifically, practically, but also politically”; he also pointed out that Koellreutter was of the same opinion [4]. Gustav Borger (1899–1989) [13, 43], temporary head of the Department of Science in the Nazi Lecturers’ Association, came to the same conclusion on March 30, 1942 [4]. The Tübingen chair ultimately went to Adrion, who was 13 years older and far more experienced. All the experts involved according to the files – Erwin Reichenbach, Otto Hofer and Eugen Wannenmacher (1897–1974) [43] – had assessed Steinhardt positively, but also indicated that he was still in the process of gaining in-depth surgical experience. Wannenmacher stated: “It can be assumed that his development in maxillofacial surgery will soon be completed, so that he will be able to fully represent this field” – implying that this point in time had not yet been reached [4].



**Figure 4** Letter from Steinhardt to the Review Committee dated September 15, 1947 [48].

Shortly before the end of the Third Reich, another appointment opportunity seemed to arise: There was a professorship to be filled at the German University in Prague, where Steinhardt was again counted among the favourites in 1944 [2]. But the end of the war got in the way: instead of filling the position of clinic director, the entire German University was dissolved in 1945 and the clinic was “handed over” to the local maxillofacial surgeon František Kostečka (1893–1951).

When comparing Steinhardt’s attitude and activities in the Third Reich with other dental university teachers covered in this series, it is

striking that he was much more politically involved – not only at the level of memberships, but also through personal networking with influential Nazi officials.

Steinhardt’s network ranged from the central functionaries of the dental profession (Ernst Stuck, Karl Pieper) to the responsible representatives in the Nazi lecturers’ association (Gustav Borger, Hermann Hiltner) to the “Theorist of the Führer State” [43] Otto Koellreutter and the powerful ministerial advisor Max de Crinis. Steinhardt sought and cultivated these contacts. Therefore, Wencke Fischer’s statement that “people in high and important positions, such as

Prof. Dr. Dr. Steinhardt was," had "no other option" at that time "than to join the NSDAP and SS" [12] is clearly inadequate: Steinhardt's actions, unlike those of the majority of university teachers [17], went beyond "purely nominal" memberships. Joining the SS and holding the position of SS-Obersturmführer (cf. Fig. 2) were also by no means typical. This is shown by the fact that not even one in ten of the approximately 400 dental university lecturers in the Third Reich had SS membership, as a still unpublished study by our research group shows. Among the SS members, practitioners and rather insignificant scientists predominated. At most, the professors Karl-Friedrich Schmidhuber (1895–1967) [27] and Eugen Wannenmacher (1897–1974) [13] attained similar career positions – but even they did not come close to Steinhardt in academic terms.

Steinhardt had also established a network beyond the aforementioned Nazi functionaries, which already proved useful in the Third Reich, but also after 1945: Hans von Haberer [43] had hired Steinhardt at the Cologne Surgical University Hospital in 1935 – at a time when its previous head Karl Zilkens had been suspended and was thus no longer eligible as an academic mentor. At the beginning of 1942, von Haberer then gave Steinhardt a positive reference – in the context of the Tübingen appointment procedure – as Pieper mentioned in his letter of February 24, 1942 [4]. Von Haberer was a university-political "heavyweight": as Rector, he was at the head of the politically centralised University of Cologne from 1935. Heinrich Groß – Zilkens' successor in Cologne – also exerted a supportive influence on Steinhardt's career: in 1940, as the responsible expert at the University of Cologne, he supported Steinhardt's appointment there as a titular professor; it took place in absentia because Steinhardt was still in Tokyo [75]. Heinrich Hammer in turn provided him with a lectureship at the University of Kiel in 1950 and thus enabled him to make his first connection to the university in the post-war period. Ewald Harndt, who, like von Haberer, Groß and Hammer, was a party

member before 1945, supported Steinhardt in his career within the DGZMK: under Harndt's presidency Steinhardt moved up to the DGZMK board, and after Harndt's retirement Steinhardt became his successor [33]. The fact that the two cultivated a friendship was shown, among other things, by the fact that they honoured each other with laudations and also referred to their personal relationship [8, 36, 37, 66].

The questions of how Steinhardt's denazification proceeded and whether he critically reflected on his relationship to National Socialism after 1945 still require an answer:

The denazification procedures pursued the goal of determining the political burden of those affected. In the end, they were to be classified in one of five categories (I main culprits, II incriminated [activists], III lesser incriminated, IV followers and V exonerated). Steinhardt was initially held in the British internment camp Neuengamme at the end of 1945, as he had been "provisionally" classified in group III (cf. Fig. 3; [48]). He was not allowed to leave the camp until February 1947.

In the denazification proceedings, it was established practice that those affected procured character references – popularly known as "Persilscheine". The name was derived from the detergent "Persil", because the certificates were intended to cleanse the person concerned of any accusation of political incrimination. In Steinhardt's case, too, the statements – including a statement by Karl Zilkens – were intended to "prove" his political distance from National Socialism. Thanks to the practice of character references, the trial chambers increasingly developed into "Mitläufefabriken" (follower factories). In the end, even obviously incriminated National Socialists were mostly denazified as followers (group IV) or even exonerated (Group V) – at the latest in the revision proceedings [17].

In the case of Steinhardt, however, the denazification committee came to the conclusion in July 1947 that he was to be classified in Group III (cf. Fig. 3; [48]). The reason given was that Steinhardt "could by no means be regarded as only a nominal

member of the NSDAP, especially since circumstances that could seriously exonerate Steinhardt are not apparent. The committee therefore unanimously considers an admission of St. to the university to be politically unacceptable" [48]. The last sentence was of decisive importance, because it meant that Steinhardt's desired university career would be blocked.

The latter submitted a revision request on September 15, 1947, which was common practice (cf. Fig. 4; [48]). But Steinhardt's objection mainly contained false statements – which was rather unusual in this form and obviousness. Steinhardt's statement about his SS membership was particularly brazen: he claimed, on the one hand, that his entry into the SS had only taken place in 1935 – at the time of his habilitation and exclusively against this background – and, on the other hand, that he had left the SS "voluntarily as early as February 1937". Both were untrue: he had already joined the SS in 1933. Above all, however, he had not finally left the SS in 1937 as Unterscharführer. He had only suspended his membership "in honour" for purely formal reasons because of his stay in Japan, in order to rejoin on his own initiative the following year and subsequently achieve the rank of SS-Obersturmführer. Steinhardt had apparently withheld this crucial fact from the committee in the first proceedings – for in the denazification decision of July 1947, it was erroneously stated that he had already left the SS in 1937 on his own initiative as a Unterscharführer, which he was given credit for.

In his appeal, Steinhardt also emphasised that he had disapproved of anti-Semitism. In doing so, he wrote on an attached sheet under the heading "Einstellung zur Rassenfrage" (Attitude to the question of race) the (incomplete) sentence: "Gelegentlich der Berufung nach Japan durch das dortige Kulturministerium Austritt aus der SS, 1937" (On the occasion of the appointment to Japan by the Ministry of Culture there, resignation from the SS, 1937) [48]. This remark was apparently intended to suggest that he felt prompted by Nazi policy

on the “racial question” to “resign” from the SS and saw the appointment to Japan as a suitable opportunity to do so.

Furthermore, Steinhardt claimed to have been “only a nominal member of the party”; moreover, he stated that he had had “neither professional nor non-professional advantages of any kind” due to his membership in the NSDAP [48]. These two statements also did not correspond to the facts – in more ways than one: his research stay in Tokyo would have been inconceivable without his membership and without political protection. In addition, there is evidence that he acted as a “Blockwart” in Tokyo and appeared in SS uniform – this also does not fit the picture of a purely nominal party membership. The same applies to his (unmentioned) promotions in the SS (1939, 1940), his appointment as titular professor in absentia (1940), initiated by Max de Crinis and Pieper, and to the two list placements in the aforementioned appointment procedures for professorships (1942, 1944). The provision of the position of senior physician at the Charité (1940) was also the result of party-political protection.

Thus, the question of whether Steinhardt critically reflected on his relationship to National Socialism after 1945 can be answered with a clear “no”. The opposite was the case: he suppressed incriminating facts and glossed over his own role.

Unfortunately, there is no explicit paper in Steinhardt’s denazification files that could shed light on whether his aforementioned revision request of September 15, 1947 was successful. However, there is a document dated October 4, 1947, which again notes the classification in Group III. Another letter showing the same classification is not dated [48]. Thus it is most likely that the original classification (III) was retained. This is also indicated by the fact that Steinhardt actually only returned to the university in a roundabout way and with considerable delay (a mere lectureship in Kiel in 1950, a non-university management function in Bremen 1952–1957). And yet he ultimately managed to pass through all the stages of a successful university career.

## Conclusions

Steinhardt showed remarkable scientific and professional achievements. He was medically broadly trained, acquired several sub-specialties within the field of dental medicine and achieved recognition both in basic research and in the clinic. He was also an excellent networker; this is shown by the numerous offices and functions Steinhart attained.

In the Third Reich, he clearly served the Nazi regime, joined several Nazi organisations and used his contacts to Nazi functionaries and party comrades for his own career development. Some – other university teachers such as the aforementioned Karl Pieper [23], Fritz Faber (1887–1961) [22], Heinrich Fabian (1889–1970) [21] or Hans Fliege (1890–1976) [26] – also derived considerable professional advantages from their proximity to National Socialism, but the latter would hardly have been able to achieve a university career without political protection, while Steinhardt was also far above average in purely professional terms.

Ultimately, of all the DGZMK presidents who experienced the Third Reich as adults and who are examined in more detail in this series, he exhibited the strongest political commitment. It should also be pointed out that Steinhardt constructed a distance to Nazi ideology in the denazification proceedings through a series of very obvious, blatant false statements. Although euphemistic claims can also be identified, for example, in the proceedings of DGZMK presidents Harndt [18] or Fröhlich [30], these were less misleading than in Steinhardt’s case. So, despite the political commitment described above, Steinhardt found his way back to success in post-war Germany.

## Conflict of interest

The author declares that there is no conflict of interest within the meaning of the guidelines of the International Committee of Medical Journal Editors.

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