PRACTICE

RESEARCH

Animal-assisted therapy in the dental practice

Introduction

Fear of the dentist is a problem that affects many patients and often stands in the way of dental care in the context of preventive, as well as curative treatment. The fear can be acquired through direct conditioning or through the narrated experience of other people in the context of indirect conditioning [3, 14]. To be able to carry out treatment despite dental anxiety, pharmacological techniques are often used to calm or immobilize the patient by means of nitrous oxide, sedation or intubation anesthesia. All these techniques have side effects. An alternative method is the use of "animal-assisted" therapy, which is known as AAT (animal-assisted therapy) in Anglo-American countries [3, 14, 16].

Man's interest in animals stems from the fact that primitive human survival depended in part on animals in the environment. These served as indicators of a safe environment, but also of threats. This is the basis of Edward O. Wilson's biophilia hypothesis (1984). When animals are observed in a peaceful state, it can signal safety, security, and a sense of well-being [6, 10, 16]. Dogs, in particular, are suitable therapy animals because they have developed human-like social skills through domestication that enable them to be sensitive to human posture, attentional states, and emotions [2, 8, 12].

Dogs are increasingly being used as part of animal-assisted therapy in German dental practices. In the following, an overview of the currently available literature on this therapy approach will be given and possible problems will be mentioned.

Statement

A review of the literature shows that most articles on animal-assisted therapy in the context of dentistry have been published in American journals. These are mainly clinical studies, meta-analyses and case reports. The number of studies addressing the benefits of animal-assisted intervention in dentistry is currently small. Increasingly, there is literature on the use of therapy dogs in areas outside dentistry, for example, rehabilitation, geriatrics, and psychiatry.

Methodology for determining the benefits of animal-assisted intervention

Numerical subjective rating scales such as the Corah Dental Anxiety Scale (CDAS) or similar are often used to determine the usefulness of a therapy dog for dental treatment [3, 5–7, 16, 18]. Other criteria include measurement of the patient's pulse and blood pressure [3, 5, 6, 18] as well as oxytocin (happiness or bonding hormone) and cortisol (stress hormone) levels, which reflect the (reduced) fear response [2, 20].

Results of dental studies

According to a 2019 clinical study by Cruz-Fierro, Vanegas-Farfano et al., a therapy dog turns out to be useful in a dental (preventive) treatment of patients with dental anxiety. Thanks to the animal-assisted treatment, there was a decrease in blood pressure and pulse rate, as well as a better evaluation of the treatment using CDAS. Thus, the treatment was somewhat less painful and anxiety-provoking [3].

In 2018, Gupta and Yadav published a study on the acceptance of the use of a therapy animal in the dental office among parents. 41 of 61 parents agreed with the use of a therapy animal [8]. In a study by Vincent, Easton et al. (2020), 90 % of parents reported approving of treatment of their child in the presence of a therapy dog [19].

A study by Nammalwar and Rangeeth (2018) compared the anxiety levels of children with dental anxiety in a private pediatric dental facility in Chennai. A dog-assisted intervention was conducted in the waiting area as well as in the treatment area. The results showed that a 15-minute exposure in the waiting area already reduced the anxiety level [16].

A study by Fox (2019) also exclusively involved patients with dental anxiety. They were divided into two groups. One group had a 10-minute intervention with a therapy dog during dental treatment, and the second group served as a control group. The result was that the use of a therapy dog led to a reduction in physical and psychological anxiety [5]. In a study with a similar design, Thakkar, Naik et al. (2020) used independent t-tests to show that the anxiety reduction from having a dog present during therapy was highly significant (p < 0.001) [18].

University Medical Centre Rostock | Department of Operative Dentistry and Periodontology: Prof. Dr. Hermann Lang, Janna Schnelle

Vincent, Heima et al. 2020 studied children between the ages of 8 and 12 with a known dental anxiety. They were subjected to treatment in the presence of a therapy dog. Saliva was measured for oxytocin and cortisol, which reflect the fear response. In most of the samples, there was an increase in oxytocin as a result of the therapy dog intervention. However, this was not statistically significant. Cortisol levels tended to decrease [20].

General medical studies

In general medicine, a dog-assisted intervention is used in the hospital in psychiatry, geriatrics, pediatrics and psychosomatics [6, 12, 13]. Dog-assisted therapy has a statistically small to moderate (but not significant) effect on psychiatric disorders (e.g., schizophrenia) and cognitive disorders (e.g., Alzheimer's disease) and on various medical interventions in palliative care [12]. Animal-assisted intervention can result in significant pain relief. Objective reports of reduced pain and pain-related symptom relief (especially in physical rehabilitation and in patients with chronic pain) are supported by studies. These measured decreased catecholamine and increased endorphin levels in people who received visits from therapy dogs [13, 15].

Further results show that a 20-minute session with a therapy dog can be an effective intervention to improve well-being and mood, as well as reduce anxiety. This is shown in an exploratory study of students at Heriot-Watt University [7].

Limitations for the use of a therapy dog

As described earlier, animal-assisted dental treatment can be useful for patients with anxiety as well as for children with lack of compliance.

Contraindications include immunosuppression (due to increased susceptibility to infection), allergy to animal hairs, and pregnancy. Animal-assisted intervention is also not indicated for persons with an aversion or phobia towards animals. An existing acute infection, colonization with MRE, open wounds and a lack of compliance with hand hygiene also speak against the use of a therapy dog [4, 9, 11].

Hygiene problems

In Germany, it is not forbidden from a hygiene point of view to use a therapy dog in the dentist's office; in principle, the domestic authority applies [1].

According to Gussgard, Weese et al. (2019), risks to human health and safety during therapy dog intervention are present but low. Compliance with hygiene rules is crucial. The sources of danger can be divided into 4 categories: 1. the dog as a source of both zoonotic and human pathogens, 2. a contact with allergens in case of an existing animal hair allergy, 3. an undesirable animal behavior, 4. a reduced space due to the dog and an increased risk of falling (over the dog) [9].

According to the recommendation of the DGKH, the consent of all parties involved must be obtained before introducing a therapy dog. In addition, liability for damage caused by the dog must be clarified.

Conditions should be established and confirmed by the practice owner. The rooms entered by the therapy dog and the furniture in them must be wipe-disinfectable and a basin for washing hands must be easily accessible from the therapy room [4]. Furthermore, a notification to the health and veterinary office is required. The therapy dog must be labeled as such and must not be fed raw meat [11]. The dog's state of health must be checked regularly, and it requires a certificate of suitability as a therapy dog [4,9]. This is not yet awarded in Germany according to uniform criteria [17].

The personnel must be instructed on how to handle the animal and on the hygiene regulations. The hygiene plan must be written down. Attention must be paid to adequate hand hygiene and the prevention of scratch marks on the patient's skin and furniture [4, 9].

Conclusion

Animal-assisted therapy is increasingly used in medical practices. Before its introduction, some important hygienic precautions are to be taken.

Furthermore, indication or, if necessary, contraindications for the respective patient have to be checked. The advantages lie in the reduction of anxiety, which has been proven in many studies, and which leads to effects such as a reduction in blood pressure, pulse reduction, an increase in oxytocin and a reduction in cortisol. Regarding the subjective sensation of the patients, this is expressed in a better evaluation by means of a numerical evaluation scale. However, there is still no standardized measurement methodology, which limits the significance and comparability of studies.

Overall, the use of a therapy dog as part of an anti-anxiety therapy during dental treatment is an feasible and cost-efficient approach to alleviating dental anxiety and has the potential to improve the therapy of anxiety patients and patients with poor compliance if studies improve in the future [14].

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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Photo: Janna Schnelle

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The Journal Impact Factor 2020

On June 30, 2021, the Clarivate™ media group published the 2020 rankings of scientific journals with impact factor in its Journal Citation Reports. In the year under review, 12,279 of the 20,932 journals considered had a journal impact factor (JIF). The calculation of the JIF is shown in Figure 1. The current JIFs of dental journals are presented below, followed by the scientific journals with the highest JIF. The annual review is complemented by a critical discussion of the JIF.

Included journals and general development

As in the calculation years 2019 and 2020, there are 91 journals with a JIF in the category Dentistry, Oral Surgery & Medicine (Table 1). Included for the first time is the Japanese Dental Science Review; Brazilian Oral Research is no longer listed.

The 2020 JIF values range from 0.125 (the German-language journal Implantologie) to 8.728 (Journal of Clinical Periodontology). The latter value is the highest JIF ever achieved for a dental journal; the peak value of the previous year (7.718, Periodontology 2000) was exceeded by 1.01 points. Only two journals (Periodontology 2000; Journal of Adhesive Dentistry) have an (insignificantly) lower JIFs than in the previous year; for all other journals, the JIF has increased.

The first 3 places are shared by periodontology journals – a first in the history of the JIF ranking. Table 2 illustrates the JIF-related rise of the Journal of Clinical Periodontology; the jump of nearly 3.5 JIF points from 2019 to 2020 is remarkable.

To compare the JIF of dental journals with those of other scientific disciplines, Table 3 shows the 20 scientific journals with the highest JIF values.

JIF rank 2020	Journal	JIF 2020	JIF 2019	JIF rank 2019
1	Journal of Clinical Periodontology	8.728	5.241	2
2	Periodontology 2000	7.589	7.718	1
3	Journal of Periodontology	6.993	3.742	7
4	International Journal of Oral Science	6.344	3.047	12
5	Journal of Dental Research	6.116	4.914	3
6	Clinical Oral Implants Research	5.977	3.723	8
7	Oral Oncology	5.337	3.979	5
8	Dental Materials	5.304	4.495	4
9	Journal of Evidence-Based Dental Practice	5.267	2.426	22
10	International Endodontic Journal	5.264	3.801	6
11	Japanese Dental Science Review	5.093	---	---
12	Journal of Prosthodontic Research	4.642	2.662	17
13	Journal of Periodontal Research	4.419	2.926	13
14	Journal of Dentistry	4.379	3.242	10
15	Journal of Oral Pathology & Medicine	4.253	2.495	20
16	Journal of Endondontics	4.171	3.118	11
17	Caries Research	4.056	2.186	30
18	Clinical Implant Dentistry and Related Research	3.932	3.396	9
19	Journal of Oral Rehabilitation	3.837	2.304	25
20	Journal of the American Dental Association	3.634	2.803	16
21	Clinical Oral Investigations	3.573	2.812	15
22	Molecular Oral Microbiology	3.563	2.905	14
23	Oral Diseases	3.511	2.613	19

Table 1 Journal impact factor (JIF) for 2020 for the 91 journals listed in the category Dentistry, Oral Surgery & Medicine with comparison of the previous year's JIF (n=91)

$$JIF = \frac{\text{Number of citations of publications from journal A in journals in the calendar year x}}{\text{Number of articles published in journal A in the calendar years } (x-1) \text{ and } (x-2)}$$

$$JIF = \frac{\text{Number of citations of publications from journal A in journals in the year 2020 with respect to all publications in journal A in the years 2019 und 2018}}{\text{Number of articles published in journal A in 2019 und 2018}}$$

Figure 1 Formula for calculating the Journal Impact Factor (JIF) of a journal: general principle and, derived from it, calculation for the year 2020.

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JIF rank 2020	Journal	JIF 2020	JIF 2019	JIF rank 2019
24	International Journal of Paediatric Dentistry	3.455	1.993	35
25	Journal of Prosthetic Dentistry	3.426	2.444	21
26	Community Dentistry and Oral Epidemiology	3.383	2.135	31
27	Dental Traumatology	3.333	1.530	57
28	European Journal of Oral Implantology	3.123	2.619	18
29	European Journal of Orthodontics	3.075	2.202	28
30	Gerodontology	2.980	1.339	69
31	Journal of Esthetic and Restorative Dentistry	2.843	1.786	45
32	International Journal of Oral and Maxillofacial Implants	2.804	2.320	24
33	Oral and Maxillofacial Surgery Clinics of North America	2.802	1.554	55
34	International Journal of Oral and Maxillofacial Surgery	2.789	2.068	33
35	BMC Oral Health	2.757	1.911	38
36	Journal of Prosthodontics – Implant, Esthetic, and Reconstructive Dentistry	2.757	2.187	29
37	Progress in Orthodontics	2.750	1.822	42
38	Journal of Applied Oral Science	2.698	1.797	43
39	American Journal of Orthodontics and Dentofacial Orthopedics	2.650	1.960	36
40	Odontology	2.634	1.840	41
41	Archives of Oral Biology	2.633	1.931	37
42	Journal of Periodontal and Implant Science	2.614	1.847	40
43	European Journal of Oral Sciences	2.612	2.220	26
44	Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology	2.589	1.601	51
45	International Dental Journal	2.512	2.038	34
46	International Journal of Dental Hygiene	2.477	1.229	75
47	Implant Dentistry	2.454	1.452	64
48	Operative Dentistry	2.440	2.213	27
49	Dentomaxillofacial Radiology	2.419	1.796	44
50	International Journal of Implant Dentistry	2.384	2.111	32
51	Journal of Adhesive Dentistry	2.359	2.379	23
52	European Journal of Dental Education	2.355	1.050	82
53	Acta Odontologica Scandinavica	2.331	1.573	54
54	Australian Dental Journal	2.291	1.401	66
55	Journal of Dental Education	2.264	1.322	71
56	European Journal of Paediatric Dentistry	2.231	1.500	60
57	Head & Face Medicine	2.151	1.882	39
58	Dental Materials Journal	2.102	1.359	67
59	Journal of Dental Sciences	2.080	1.034	83

Table 1 Journal impact factor (JIF) for 2020 for the 91 journals listed in the category Dentistry, Oral Surgery & Medicine with comparison of the previous year's JIF (n = 91)

Jahr	JIF
2020	8.728
2019	5.241
2018	4.164
2017	4.046
2016	3.477
2015	3.915
2014	4.010
2013	3.610
2012	3.688
2011	2.996
2010	3.933
2009	3.549
2008	3.193
2007	2.678
2006	2.380
2005	2.225
2004	1.644
2003	1.582
2002	1.736
2001	1.641
2000	1.426
1999	1.873
1998	1.679
1997	1.812

Table 2 Development of the JIF of the Journal of Clinical Periodontology between 1997 and 2020.

"The present analysis disqualifies the JIF from adequately representing the citation frequency of a journal or article."

Priv.-Doz. Dr. Tobias Kisslich et al., Salzburg [4]

Criticism of the JIF

Reading and publishing behavior has changed fundamentally over the past few decades. Nestor et al. [6] note: "Apart from any personal subscriptions a researcher might have, performing a primary literature search used to involve a visit to the local library, sorting through each journal's table of contents and indices, finding

articles of interest, and making notes and copies for use. If a library didn't have a local copy of a particular journal, waiting days to weeks after requesting one was the next step. The JIF was quite useful during that era, as a library could best utilize its limited budget to keep a selection of journal subscriptions likely to meet most of the needs of its patrons."

The authors [6] further state: "With the proliferation of computers and the internet, we now can generate thousands of relevant results in a matter of milliseconds. Filtering by year of publication, keyword, authors, and various other options allows for fine-tuned querying. With a few clicks, nearly any article can then be downloaded and saved, although payment for access is often required. The granularity and breadth afforded by the modern literature search have shifted the search mechanics from journal-oriented to article-oriented, and with that shift, the JIF has diminished in value."

The prestigious University College London noted in an August 2020 announcement: "In the pre-digital era, the unit of distribution for science was the physical journal volume. Libraries needed to make decisions on which journals to purchase and retain, and so the JIF was developed with no intention of reflecting research quality – but rather research readership and use. A journal with a high impact factor likely had a large number of potential readers, and the journal was likely to be heavily used. [...] Because the impact factor was for so long the only citation-based metric readily available, it became popular as a metric of quality [...]. But metrics are now easily attributed directly to the individual articles – we can count how many people are reading, downloading, and citing a journal article. This means that we no longer need to estimate the impact of papers when we can get that data directly, more informatively, and more accurately." [10].

General Recommendation

There has been no doubt in the literature for years that the JIF developed by Eugene Garfield [3] has outlived its usefulness (Tables 4 and 5).

JIF rank 2020	Journal	JIF 2020	JIF 2019	JIF rank 2019
60	Angle Orthodontist	2.079	1.549	56
61	Journal of Cranio-Maxillofacial Surgery	2.078	1.766	46
62	Medicina Oral, Patología Oral y Cirugía Bucal	2.047	1.596	52
63	Cranio – The Journal of Craniomandibular Practice	2.020	1.173	78
64	Journal of Orofacial Orthopedics – Fortschritte der Kieferorthopädie	1.938	1.286	73
65	Journal of Advanced Prosthodontics	1.904	1.504	59
66	Journal of Oral and Maxillofacial Surgery	1.895	1.642	49
67	International Journal of Computerized Dentistry	1.883	1.714	48
68	Pediatric Dentistry	1.874	1.594	53
69	Journal of Oral Facial Pain & Headache	1.871	1.260	74
70	Oral Radiology	1.852	0.540	89
71	International Journal of Periodontics & Restorative Dentistry	1.840	1.513	58
72	Orthodontics & Craniofacial Research	1.826	1.455	63
73	Journal of Public Health Dentistry	1.821	1.743	47
74	Journal of Oral Implantology	1.779	1.424	65
75	International Journal of Prosthodontics	1.681	1.490	61
76	Quintessence International	1.677	1.460	62
77	Australian Endodontic Journal	1.659	1.120	80
78	British Journal of Oral & Maxillofacial Surgery	1.651	1.061	81
79	British Dental Journal	1.626	1.306	72
80	Journal of Stomatology, Oral and Maxillofacial Surgery	1.569	1.152	79
81	Journal of Oral Science	1.556	1.200	76
82	American Journal of Dentistry	1.522	0.957	84
83	Cleft Palate-Craniofacial Journal	1.433	1.347	68
84	Korean Journal of Orthodontics	1.372	1.326	70
85	Community Dental Health	1.349	0.679	87
86	Journal of the Canadian Dental Association	1.316	1.200	76
87	Oral Health & Preventive Dentistry	1.256	0.920	85
88	Journal of Clinical Pediatric Dentistry	1.065	0.798	86
89	Seminars in Orthodontics	0.970	0.625	88
90	Australasian Orthodontic Journal	0.226	0.113	91
91	Implantologie	0.125	0.123	90
---	Brazilian Oral Research	---	1.633	50

Table 1 Journal impact factor (JIF) for 2020 for the 91 journals listed in the category Dentistry, Oral Surgery & Medicine with comparison of the previous year's JIF (n = 91)

JIF-Rang 2020	Zeitschrift	JIF 2020
1	CA-A Cancer Journal for Clinicians	508.702
2	Nature Reviews Molecular Cell Biology	94.444
3	New England Journal of Medicine	91.245
4	Nature Reviews Drug Discovery	84.694
5	Lancet	79.321
6	Nature Reviews Clinical Oncology	66.675
7	Nature Reviews Materials	66.308
8	Nature Energy	60.858
9	Nature Reviews Cancer	60.716
10	Nature Reviews Microbiology	60.633
11	Chemical Reviews	60.622
12	MMWR Surveillance Summaries	58.769
13	Journal of the American Medical Association	56.272
14	MMWR Recommendations and Reports	55.857
15	Nature Biotechnology	54.908
16	Chemical Society Reviews	54.564
17	Reviews of Modern Physics	54.494
18	Nature Medicine	53.440
19	Nature Reviews Genetics	53.242
20	Nature Reviews Immunology	53.106
…	…	…
12,279	Sen-I Gakkaishi (Journal of the Society of Fiber Science and Technology, Japan)	0.013

Table 3 The 20 scientific journals with the highest journal impact factor (JIF) and the tail end of the ranking of 2020.

Citation	Source
"Despite recognition of many disadvantages and misuses of JIF, it is still prominently used in journal ranking and calculation of research productivity, leading to inaccuracies in these assessments."	Mech et al. [5]
"Journal impact factor may have little to no association with study results, or methodological quality."	Saginur et al. [7]
"The JIF is an extraordinarily poorly used metric, which has led some commentators to suggest it may be the cornerstone of an unhealthy research culture with the potential to distort the scientific process."	University College London [10]
"The average number of citations per paper in a journal over two years sounds straightforward – except that's not quite how the JIF is calculated. Averages are usually calculated by dividing the sum of the values for a sample of observations (numerator) by the number of those observations (denominator). Note simple averages are usually symmetrical – which means the sum of the sample is based only on the observations counted in the denominator. But the JIF isn't calculated in this way. Instead, the numerator – sum of citations – is based on all of the citations received by items in a given journal. This includes articles and reviews, but also letters to the editor, comments, and other front matter that aren't primary research articles – even news and obituaries; while the denominator is based not on the number of cited documents, but only articles and reviews. Hence, a journal's impact factor is driven not only by their research articles, but inflated by the other accompanying material in the journal. While this doesn't always get very heavily cited, it does usually add some extra citations."	University College London [10]
"The JIF is an unreliable, biased, and inherently flawed method of measuring the quality, accessibility, and value of a research journal. While it has played an important and valuable role in helping scientists find and acquire knowledge over the last six decades, our movement into the digital and cross-specialty age has depreciated the value of the JIF as the manner in which we seek and obtain knowledge has fundamentally changed."	Nestor et al. [6]
"The JIF should not be used to assess the quality and impact of individual scientific work."	Asaad et al. [1]

Table 4 Critical statements about the JIF.

Tab. 1–5, Fig. 1: J. C. Türp

Therefore, the first academic institutions have now drawn consequences. The renowned University College London, for instance, has announced that it will no longer use the JIF as an indicator of the quality of an article.

German-speaking universities have also reacted in the meantime. For example, according to the habilitation regulations of the Medical Faculty of the Swiss University of Bern (dated November 2019), neither the journals in which candidates have published their work nor their respective JIF will be taken into account when evaluating their scientific performance [8]. Instead, the evaluation is based "on the scientific content of the work" [9]. Recently, no JIF may be listed in applications to the European Research Council either.

All these institutions are thus following the "San Francisco Declaration on Research Assessment" from 2012, which states as a general recommendation: "Do not use journal-based metrics, such as Journal Impact Factors, as a surrogate

General statements
The JIF is only a limited accurate predictor of journal quality.
The JIF is not a valid measure of the quality of individual publications and/or authors.
The JIF does not account for the skewed citation distribution that results from individual highly cited articles. Therefore, it cannot make reliable statements about how often a published article will be cited in the future.
The JIF misleads readers to reject "low-impact" journals that have no perceived higher "net quality" compared to "high-impact" journals, but may still contain a number of "high-quality" articles.
Validity and reliability of the JIF for cross-discipline comparison are limited.

Calculation of the JIF
The database used to calculate the JIF (Science Citation Index) does not include citations from journals outside its own database.
The selection of journals to be included in the database is not transparent.
The definition of what counts as "citable" in the JIF calculation is unclear.
Numerator and denominator have different contents.
The JIF can be easily manipulated to inflate the values: Editors or peer reviewers send authors articles to include in citations.   The denominator is minimized by removing certain publications from the total number of articles published.   The "type" of an article is changed to increase the likelihood that it will be excluded from the denominator.
Withdrawn articles are still included in the JIF score.
Misreferenced articles can account for up to one-third of references, reducing the chances of correctly counted citations.

Bias due to language and article type
There is a preference for English-language journals published in the United States and the United Kingdom.
Articles published in English or by an author with a conventional English name increase the likelihood of being cited.
There is a preference for review articles.
The JIF encourages self-citation (self-reference) without correcting such a strategy.

Time-related bias
The JIF score is influenced by publication timing.
The measured 2-year window does not account for variance in publication processes among scientific fields.
The measured 2-year window does not account for the variation in citation rates among publication types and favors faster dissemination of "hot topics."

Table 5 Disadvantages of the JIF [5–6, 10].

measure of the quality of individual research articles, to assess an individual scientist's contributions, or in hiring, promotion, or funding decisions." [2].

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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Caries experience in children with Marfan syndrome – a non-interventional case-control study**

Introduction: The Marfan syndrome is a rare connective tissue disorder with autosomal dominant inheritance. The aim of the present study was to evaluate the caries experience in children and adolescents with Marfan syndrome.

Materials and Methods: 31 children with Marfan syndrome (Marfan group; mean age: 8.77 ± 3.72 years) and 31 systemically healthy children (control group; mean age: 9.77 ± 3.72 years) were dentally examined according to WHO criteria. The recorded parameters included the dmft/DMFT (differentiated into dt/DT, mt/MT, ft/FT), the dmfs/DMFS (differentiated into ds/DS, ms/MS, fs/FS), the caries restoration index (CRI), and the hygiene index (HI). Statistical evaluation was carried out using t-test for independent samples and chi-square test ($p \leq 0.05$) using the statistics software program IBM SPSS Statistics 26.

Results: The children of the Marfan group had a significantly lower dmft ($p = 0.040$) and ft ($p = 0.040$) than children in the control group. There were no significant differences between the two groups when considering permanent dentition. However, the Marfan group tended to have a lower DMFT ($p = 0.064$), DT ($p = 0.076$) and FT ($p = 0.059$) than the control group. The HI was significantly higher in the control group than in the Marfan group ($p < 0.001$).

Conclusion: In the present study, children and adolescents with Marfan syndrome did not show a higher caries experience compared to a systemically healthy control group.

Keywords: Marfan syndrome; caries experience; children; adolescents; DMFT; DMFS

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Introduction

Marfan syndrome is a rare connective tissue disease with autosomal dominant inheritance [23]. The incidence of classic Marfan syndrome is reported in literature to be 2–3 per 10,000 inhabitants, regardless of gender or ethnicity [18]. Persons with Marfan syndrome usually have a large, lean stature, long extremities, arachnodactyly (Fig. 1), joint hypermobility, and deformities of the thorax and spine (e.g., scoliosis) [7]. More than 1000 different mutations in the fibrillin-1 (FBN1) gene on chromosome 15 have been identified as the cause of classical Marfan syndrome [26]. Since the clinical picture of Marfan syndrome is variable and the genetic causes are heterogeneous, it is difficult to distinguish it from other diseases of the connective tissue (e.g., Loeys-Dietz syndrome, Ehlers-Danlos syndrome, Shprintzen-Goldberg syndrome, Weill-Marchesani syndrome) [1]. For the diagnosis of Marfan syndrome, the use of the revised version of Ghent-nosology has proven to be of value. In addition to the detection of an FBN1 mutation and a family history, the manifestations of an aortic aneurysm and an ectopia lentis are taken into account [9, 22]. Cardiovascular complications such as aortic dilatation, dissection and rupture were the main reason why patients with Marfan syndrome had a reduced life expectancy compared to the normal population [24]. Although there is still no causal therapy available for Marfan syndrome, drug therapy and, in advanced cases, cardiovascular surgery have significantly increased life expectancy [19, 29].

Characteristic orofacial manifestations such as retrognathia, dolichocephaly, Gothic palate, craniomandibular dysfunctions and oligodontia or hypodontia have been described in people with Marfan syndrome [2, 8, 12]. An increased prevalence of pulp calcifications has also been demonstrated [3]. An increased incidence of periodontal disease is controversially discussed in literature, but could not be confirmed by our research group [30–32]. The dentition of patients with Marfan syndrome often shows crowded teeth, making

	Marfan	**Control**	**Significance (p-value)**
	n = 31	n = 31	
Age [years]	8.77 ± 3.72	9.77 ± 3.72	0.294*
HI [%]	75.36 ± 16.58	89.44 ± 8.59	< 0.001*
Permanent teeth	n = 29	n = 28	
DMFT	0.52 ± 1.64	1.57 ± 2.46	0.064*
DT	0.03 ± 0.19	0.36 ± 0.91	0.076*
MT	0.14 ± 0.74	0.00 ± 0.00	0.326*
FT	0.34 ± 1.05	1.25 ± 2.24	0.059*
DMFS	1.59 ± 6.70	2.61 ± 4.24	0.496*
DS	0.07 ± 0.37	0.46 ± 1.26	0.121*
MS	0.69 ± 3.71	0.00 ± 0.00	0.326*
FS	0.83 ± 3.08	2.18 ± 4.05	0.163*
DMFT = 0	n = 24	n = 15	0.018#
CRI (permanent teeth)	80.00 ± 44.72	76.26 ± 40.71	0.867*
Deciduous teeth	n = 22	n = 20	
dmft	0.41 ± 0.59	1.35 ± 1.84	0.040*
dt	0.23 ± 0.43	0.15 ± 0.49	0.077*
mt	0.00 ± 0.00	0.10 ± 0.45	0.330*
ft	0.18 ± 0.40	1.05 ± 1.73	0.040*
dmfs	0.77 ± 1.15	3.05 ± 4.92	0.056*
ds	0.41 ± 0.80	0.30 ± 0.98	0.693*
ms	0.00 ± 0.00	0.50 ± 2.24	0.330*
fs	0.36 ± 0.79	2.20 ± 4.10	0.063*
dmft = 0	n = 14	n = 10	0.372#
CRI (deciduous teeth)	43.75 ± 49.55	80.00 ± 42.16	0.113*

HI: hygiene index; dmft/DMFT: decayed missing filled teeth Index; dt/DT: decayed teeth; mt/MT: missing teeth; ft/FT: filled teeth; dmfs/DMFS: decayed missing filled surface index; ds/DS: decayed surfaces; ms/MS: missing surfaces; fs/FS: filled surfaces; CRI: caries restoration index; *: t-test for independent samples; #: chi-square-test according to Pearson

Table 1 Clinical parameters differentiated by Marfan and control group

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Figure 1 Example of an arachnodactyly

effective oral hygiene at home more difficult and therefore a higher caries prevalence seems quite understandable. Apart from case reports describing a high incidence of caries [5, 13], there is only one case-control study that has investigated carious lesions in people with Marfan syndrome. In this study, published by De Coster et al. in 2002, 23 people with Marfan syndrome (Marfan group) were examined and compared with 69 randomly selected people (control group) [8]. While there was no significant difference between the Marfan group and the control group when all study participants were examined, the DMFT index in the age group from 0 to 17 years was significantly higher in the Marfan group than in the control group. As a limitation, it must be mentioned here that there was no representative number of cases (n = 8) in the Marfan group and that the DMFT index was only presented as a total value and not in its individual components.

The aim of the present study was therefore to investigate the caries experience in children with Marfan syndrome in a larger number of cases and in a detailed manner. The hypothesis formulated was that children and adolescents with Marfan syndrome do not have an increased caries experience compared to a systemically healthy control group with a comparable age structure and gender distribution.

Materials and Methods

The study was approved by the Ethics Committee of the Hannover Medical School (No. 5113). In children of the Marfan group, the diagnosis of classic Marfan syndrome had to be confirmed by molecular genetic examination. The examinations of these children were carried out at the Department of Conservative Dentistry, Periodontology and Preventive Dentistry of the Hannover Medical School as well as at the annual conferences and parent-child seminars of the self-help group "Marfan-Hilfe (Deutschland) e. V.". The children in the control group were in general medical health and were recruited and examined in a private dental practice. All clinical examinations were performed by a dentist (NW).

The dental examination was performed according to WHO criteria [34]. For this purpose, magnifying glasses, cotton rolls for relative isolation and examination instruments consisting of 2 flat dental mirrors, dental tweezers and a diagnostic probe were used. Ex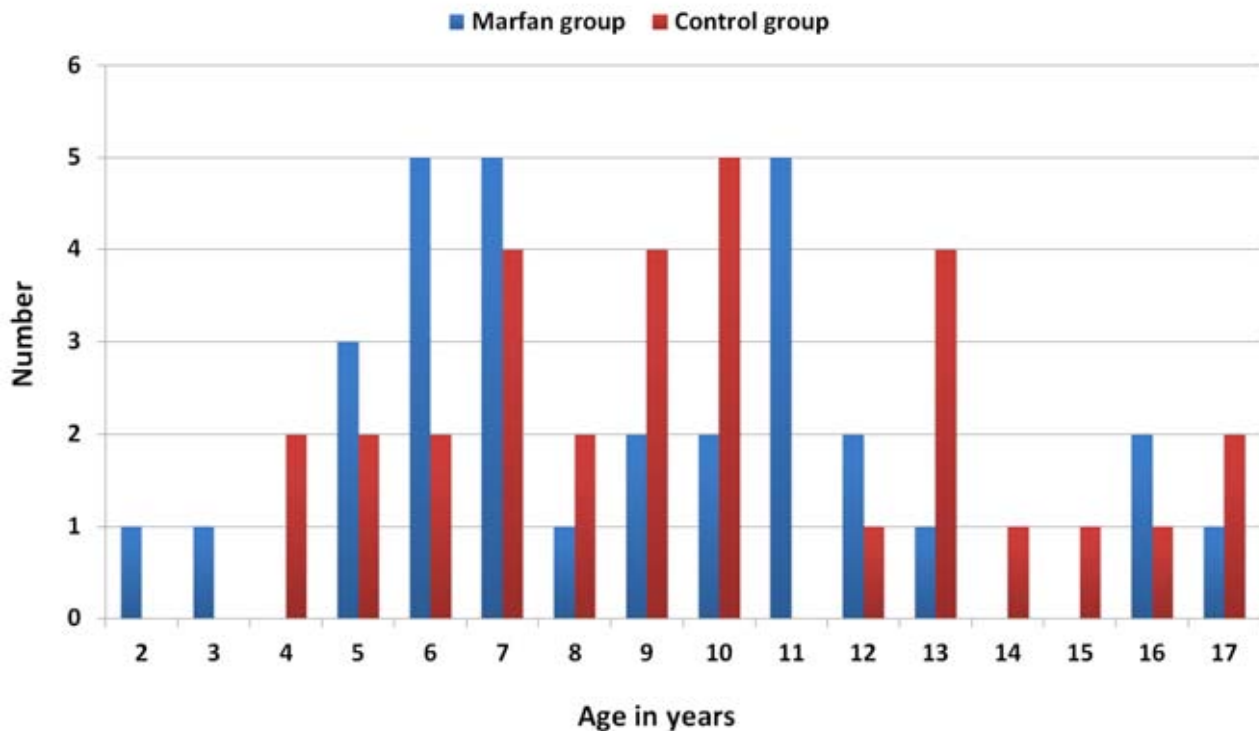aminations, which were carried out at the annual conferences and parent-child seminars of the "Marfan-Hilfe (Deutschland) e. V.", were performed with the help of a chair with head and neck support and a portable LED lamp. With the help of the dental findings, the dmft and dmfs indices for the teeth of the first dentition and the DMFT and DMFS indices for the teeth of the second dentition (decayed, missing, filled, teeth, surfaces) were calculated in order to assess the dental hard tissue [21]. For further differentiation, the dmft/DMFT and the dmfs/DMFS were subdivided into the individual components dt/DT, mt/MT, ft/FT and ds/DS, ms/MS, fs/FS, respectively. For children and adolescents with a dmft or DMFT > 0, the caries restoration index (CRI) was calculated using the following formula: CRI (deciduous teeth) = (mt + ft) / dmft × 100 in percent; CRI (permanent teeth) = (MT + FT) / DMFT × 100 in percent [33].

The hygiene index (HI) was used to assess oral hygiene at home [25]. For this purpose, the teeth were stained with a plaque revelator (Mira-2-tone; Hager & Werken GmbH & Co. KG, Duisburg, Germany) and evaluated at 4 measuring points (mesial, buccal, distal and oral). The HI was calculated using the following formula: sum of plaque-free sites/sum of all sites x 100 in percent.

Evaluation of the data was performed using the statistics program IBM SPSS Statistics 26 for Windows (IBM, Armonk, NY, USA). For the group comparison (Marfan versus control group), the t-test for independent samples and the chi-square test were used. All tests were bilateral with a significance level of p ≤ 0.05.

Results

A total of 62 children and adolescents (26 female, 36 male) with an average age of 9.27 ± 3.73 years (minimum: 2 years, maximum: 17 years) were included in the present study. The Marfan group included 31 children with Marfan syndrome (13 female, 18 male, mean age: 8.77 ± 3.72 years), the control group included 31 children in good general medical health (13 female, 18 male, mean age: 9.77 ± 3.72 years). Detailed information on the

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■ Marfan group ■ Control group

Figure 2 Presentation of the age distribution

Tab. 1, Fig. 1 and 2: A. Rahman and K. Adam

age distribution in the Marfan and control group is shown in Figure 2.

The dmft was significantly smaller in the Marfan group than in the control group (0.41 ± 0.59 versus 1.35 ± 1.84; p = 0.040). The dmfs was also smaller in the Marfan group but did not differ significantly from the control group due to the large standard deviation (0.77 ± 1.15 versus 3.05 ± 4.92; p = 0.056). A differentiated consideration of the dmft and dmfs indices revealed that the number of filled teeth (ft: 0.18 ± 0.40 versus 1.05 ± 1.73; p = 0.040) and filled tooth surfaces (fs: 0.36 ± 0.79 versus 2.20 ± 4.10; p = 0.063) was smaller in the Marfan group than in the control group. The CRI (deciduous teeth) and the number of carious teeth (dt), carious tooth surfaces (ds), missing teeth (mt) and missing tooth surfaces (ms) showed no significant differences between the two groups. Naturally healthy deciduous teeth (dmft = 0) were present in 14 children (63.6 %) of the Marfan group and in 10 children (50.0 %) of the control group. This difference was not statistically significant. The HI was high in the Marfan group but still significantly lower than in the control group (75.36 ± 16.58 % versus 89.44 ± 8.59 %; p < 0.001).

In the second dentition, the DMFT was smaller in the Marfan group than in the control group (0.52 ± 1.64 versus 1.57 ± 2.46; p = 0.064). The proportion of filled teeth (FT) was also smaller in the Marfan group than in the control group (0.34 ± 1.05 versus 1.25 ± 2.24; p = 0.059). In both cases, the difference just missed the level of significance. Naturally healthy permanent teeth (DMFT = 0) were significantly more common in the Marfan group than in the control group (24 versus 15; p = 0.018). All other parameters examined showed no significant differences between the two groups (see Table 1).

Discussion

There are case reports in literature that document increased caries in children and adolescents with Marfan syndrome [5, 13]. The only case-control study on caries experience in patients with Marfan syndrome also demonstrated an increased caries risk, particularly in the age group 0 to 17 years [8].

Classical Marfan syndrome is an autosomal-dominant inherited con-nective tissue disease caused by an FBN1 mutation [23, 26]. Apart from an increased incidence of tooth crowding and the resulting difficulty in oral hygiene, patients with Marfan syndrome do not exhibit any structural features in the area of the tooth crown that promote the development of caries. In a recently published animal study on tooth development, for example, it was shown that FBN1 is not expressed during the development of the crown of the tooth, but only during the development of the root [20]. The hypothesis of the present study was that children and adolescents with Marfan syndrome do not show increased caries experience compared to a systemically healthy control group.

The dmft, dmfs, DMFT, DMFS and the respective individual components of these indices were used to assess caries experience. Representative epidemiological data on caries prevalence in Germany have been published by the Institute of German Dentists (IDZ) and the German Association for Dental Prevention in Children and Adolescents (DAJ) for different age groups [10, 11, 15–17]. In the present study, the children

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with deciduous teeth used to calculate dmft, dmfs and the corresponding individual components showed an average age of 6.95 ± 2.36 years (Marfan group) and 7.60 ± 2.09 years (control group). For these values, a comparison with the data from the DAJ (Epidemiologische Begleituntersuchungen zur Gruppenprophylaxe 2009 und 2016), which provide information on the caries prevalence of 6– to 7-year-olds in specific federal states, is useful. The children and adolescents with permanent teeth used to calculate the DMFT, DMFS and the corresponding individual components showed an average age of 9.21 ± 3.44 years in the Marfan group and 10.36 ± 3.42 years in the control group. This data is subsequently compared with those of the Third, Fourth and Fifth German Oral Health Study (DMS III, DMS IV, DMS V), which present the caries experience of 12-year-olds.

In the first dentition, 14 of 22 children with Marfan syndrome (63.6 %) showed naturally healthy dentition. In the control group, this was the case in only 10 of 20 children (50.0 %). The DAJ data show that 53.9 % (2009) and 56.4 % (2016) of the 6 to 7-year-old children had caries-free, naturally healthy deciduous teeth. The dmft was significantly smaller in the Marfan group than in the control group (0.41 ± 0.59 versus 1.35 ± 1.84). A comparable distribution was also observed for the dmfs (0.77 ± 1.15 versus 3.05 ± 4.92). According to the DAJ (2016), the dmft in the 6- to 7-year-old children ranged from 1.37 in Bavaria to 2.31 in Saxony-Anhalt and the nationwide average was 1.73. These values illustrate that both the children in the control group and, in particular, those in the Marfan group showed above-average dmft values. When the individual components were examined, it was found that the ft was significantly smaller in the Marfan group than in the control group (0.18 ± 0.40 versus 1.05 ± 1.73). Neither the dt nor the mt differed significantly between the two groups. According to the DAJ (2016), 6– to 7-year-old children in Germany had an average of 0.74 decayed (dt), 0.19 missing (mt) and

0.80 filled deciduous teeth (ft). A comparison with this data shows that above-average values were available for all individual components in the Marfan Group.

Regarding the second dentition, 82.8 % of the children and adolescents in the Marfan group and 53.8 % of the children and adolescents in the control group had dentition without caries experience (DMFT = 0). DMS III, IV and V present data from 1997, 2005 and 2014 and show a continuous increase in the proportion of naturally healthy dentition for 12-year-olds (DMS III: 41.8 %; DMS IV: 70.1 %; DMS V: 81.3 %). The mean DMFT was smaller in the Marfan group than in the control group (0.52 ± 1.64 versus 1.57 ± 2.46). However, this difference just missed the significance level. In the DMS III, IV and V, a continuous reduction in caries experience was observed in 12-year-olds with regard to the mean DMFT (DMS III: 1.7; DMS IV: 0.7; DMS V: 0.5) [15–17]. The individual components also showed a positive development in the results of DMS III, IV and V for 12-year-olds. The number of decayed permanent teeth (DT) was reduced from an average of 0.4 (1997) to 0.1 (2014) and the number of filled permanent teeth (FT) from 1.3 (1997) to 0.3 (2014). A comparison with the results of our study shows that the children and adolescents with Marfan syndrome also show values for the individual components (DT: 0.03 ± 0.19; MT: 0.14 ± 0.74; FT: 0.34 ± 1.05) that correspond to the national average.

Overall, the results of our study show that children and adolescents with Marfan syndrome do not have an increased caries experience. The hypothesis formulated in the introduction was thus confirmed. It should be mentioned at this point that the group sizes are quite small, with a case number of 31, and that further investigations are necessary for representative statements. The reason for the low caries experience in the Marfan group is probably the consistent implementation of suitable prophylactic measures. These consist of a healthy diet, effective biofilm management, targeted fluoride application and regular visits to

the dentist [14, 27]. As a limitation, it must be mentioned that these measures for caries prophylaxis were not included in our study. Another reason for the low caries experience could be the fact that a large part of the families affected by Marfan syndrome participated in activities of the self-help group "Marfan Hilfe (Deutschland) e.V.". Studies on the topic of self-help have shown that self-help groups make a significant contribution to the personal development and behavioural change of persons with disabilities through the exchange of experience and the provision of information [4]. This leads to a more reasonable utilization of services of the professional care system (the health care system) and an above-average level of cooperation. For the children and young people of the Marfan Group, it can also be assumed that they have received particularly attentive care from their parents with regard to their dental and oral health.

In conclusion, patients with Marfan syndrome have an increased risk of endocarditis and therefore occupy a special position in dental practice. In order to avoid unnecessary dental treatment, the prevention of caries in the first and second dentition plays a decisive role.

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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Synchronous vs. asynchronous education: Questionnaire-based survey in dental medicine during the COVID-19 pandemic**

Introduction: The rapid establishment of digital teaching in the dental curriculum, which was necessary in the progress of the COVID-19 pandemic, now poses new challenges for both students and teachers. The aim of this study was to assess the impact of the sudden introduction of synchronous and asynchronous online teaching on dental students.

Methods: The evaluation of digital teaching was conducted via online survey using the survey program SoSciSurvey. Dental students at the MHH in the 2nd, 4th, 6th, 8th and 10th semesters were questioned (n = 204, mean age: 23.6 ± 3.7 years, male/female ratio: 28%/72%). By means of a sum value calculation over 21 Likert-type items, as well as the evaluation of core aspects (content, technical quality, interaction potential with the lecturer, clarification possibilities of questions, general orientation on the digital platform) according to school grades, the satisfaction of the students was recorded. The statistical evaluation was carried out with the software RStudio.

Results: The evaluation of the sum scores showed a mean of 66.9 points (median 68.5) for preclinical students (2nd, 4th semester, asynchronous teaching concept) and 79.4 points (median 81) for clinical students (6th, 8th, 10th semester, synchronous teaching concept). The difference of 12.5 points (median 12.5) between both teaching concepts is statistically significant ($p < 0.001$). The grading of the core aspects also showed statistically significant differences with regard to content and orientation on the digital platform.

Conclusion: The questionnaire-based survey of dental students at the MHH revealed that students were more satisfied with synchronous online teaching than with asynchronous teaching. However, whether there is a fundamental superiority of the synchronous teaching format over the asynchronous approach cannot be answered by the data collected.

Keywords: covid-19 pandemic; dentistry; digital teaching; synchronous and asynchronous learning; questionnaire-based survey

1. Introduction

The COVID-19 pandemic, as well as the measures taken to contain it, are showing far-reaching socioeconomic effects [34]. In addition to the currently much-discussed economic cuts, the education sector has also been affected to a considerable extent [55]. General bans on contact and attendance in the sense of "social distancing" prohibit the implementation of "classical teaching approaches" in the form of face-to-face instruction at schools and universities [59]. However, this form of teaching plays an elementary role in the training of future dentists in particular, since a large part of the training takes place in a practical manner at preclinical simulation units and on patients in the clinical treatment courses. This training step, which takes place under the supervision and control of the dental teaching staff, is elementary to the acquisition of manual skills. Theoretical knowledge required to perform dental treatment is taught at Hannover Medical School by "blended learning" [4]. In its basic orientation, this concept consists of a hybrid of conventional face-to-face teaching and teaching content which is available online [7, 15, 38]. This teaching concept allows a clear temporal structuring of the student's daily routine; in addition, the student is comprehensively supported in his self-study by the provision of digital teaching information without time constraints [17, 30]. During the COVID-19 pandemic, the original teaching content of face-to-face courses was completely digitized at short notice at the start of the semester on 20.04.2020 in order to be able to offer the students adequate distance teaching in the absence of practical teaching units. This teaching method is characterized by the use of one and or more technical means to bridge the physical separation between lecturer and students [18, 26]. However, in contrast to medical and dental students in preclinical semesters, this "distance learning" should not be asynchronous for students in clinical semesters, but should continue on a synchronous way for clear organization of the daily routine and continuity of di-

Figure 1 Learning modalities of synchronous and asynchronous teaching in comparison, modified from [12].

Synchronous Teaching		Asynchronous Teaching
synchronous online (online seminar)	**synchronous offline (face-to-face)**	**asynchronous online/ offline**
Advantages		
– lecturer presence (verbal) – real time feedback – everyday structuring – spatial independence – ability to archive – increased question motivation	– instructor presence – real time feedback – everyday structuring – collaborative exchange – real "face-to-face" interaction – lower drop-out rate	– individual time management – arbitrary access/ flexibility – indirect interaction possible – promotion of self-study – learning diversification – self paced study – considered communication
Disadvantages		
– physical isolation – drop-out rate increased – need for: – technical equipment – technical know-how – technical painting functions, if applicable – reduced non-verbal, extra-/paralinguistic signals	– spatial limitations – spatial dependence – travel distance/ mobility costs – one time experience – strict time planning – time window for questions limited – asking questions is not anonymous	– no multilayer interaction – responses delayed – time investment increased

Table 1 Advantages and disadvantages of synchronous and asynchronous teaching, modified from [1, 3, 11, 25, 29, 37, 39, 52, 54].

rect, simultaneous interactivity between students and teaches [12, 44]. An overview of different modalities of synchronous and asynchronous teaching is shown in Figure 1. During the planning process, different providers of web conferencing systems were compared with the aim of finding a practicable, user-friendly and privacy-compliant software that allows online seminars to be espediently used in teaching. The online seminars allow to follow the scheduled timetable, also virtual attendance tools can be used to document student attendance, which is necess-

ary, for example for the acquisition of the qualification in radiation protection [60]. In addition, despite physical isolation, a sense of social cohesion can still be created through interaction opportunities with the lecturer and fellow students. An overview of all advantages and disadvantages of synchronous and asynchronous teaching is shown in Table 1. The basic assumption that students can generally be classified as technology-savvy "digital natives" due to their young age cannot be readily accepted due to the heterogeneity within the student body [5, 50]. Neverthe-

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Figure 2a (Descriptive legend see under Figure 2b)

less, it must be noted that digital technologies are successively opening up all areas of life in a subtle, pervasive and invisible way, making a differentiation between virtual and real spaces increasingly untenable [27]. In addition to "lifelong learning", "ubiquitous learning", which is characterized by the convergence of learning locations and is also referred to as "seamless learning" when using mobile, digital devices, is becoming increasingly important in order to be able to develop new knowledge in a time-efficient manner [10, 56]. The simple exchange of learning locations is, of course, not yet an innovation driver itself, nor are digital teaching methods necessarily superior to conventional ones. However, if digital media are used adjuvantly to traditionally proven concepts, taking adequate, didactic methods into account, it can be assumed that synergistic effects have the potential to sustainably improve teaching [53]. As there are currently no findings on student perceptions of dental teaching preformed only digitally at the time of the COVID-19 pandemic, the aim of this study was to capture student perspectives using a questionnaire. The null hypothesis which was set forth is that there is no difference between the examined teaching formats (asynchronous vs. synchronous) in terms of satisfaction measured by a sum score containing 33 questionnaire items and the evaluation of core aspects using school grades.

2. Methods
During the present study on the qualitative evaluation of asynchronous and synchronous digital teach-

ing at Hannover Medical School (MHH) at the time of the COVID-19 pandemic, 359 dental students were invited by e-mail to complete an online questionnaire. The questionnaire was sent via the MHH e-mail distribution list, and all students received the questionnaire at the same time. In addition to a cover letter, each e-mail contained an individual serial number that allowed for one-time participation. The students were informed about the aim and the procedure of this study, the voluntary nature, as well as the whereabouts and the handling of their data by the participant information preceding the questionnaire. Consequently, informed consent can be assumed when answering the questionnaire. The survey instrument used was the MHH-internally hosted program SoSci-Survey (SoSci Survey GmbH, Munich, Version 3.2.05-i) to increase implementation objectivity. The online survey of students took place over a period of 3 weeks (25.05.2020–15.06.2020). A positive vote of the ethics committee of the Hannover Medical School is available (No. 9192_BO_K_2020).

2.1 Participants and software for online seminars
At the MHH, dental student are taught basic natural science subjects up to the preliminary dental examination after the 5th semester, with minor deviations, analogous to the students of human medicine in the model study program "HannibaL" (Hanoverian integrated professionally oriented adaptive curriculum). As a consequence, the two preclinical semesters (2nd and 4th) were educated with conventional or lectures including sound on the teaching platform "ILIAS" (Integrated Learning, Information and Work Cooperation System) in accordance with the requirements for asynchronous online teaching in medicine. The ILIAS system is the technical basis for e-learning at the MHH since the introduction of the HannibaL model study programme in the winter term of 2005/2006. In contrast to the 2nd and 4th semesters, dental teaching content for the 6th, 8th and 10th semesters was taught synchronously

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Figure 2b Questionnaire with 33 items with closed questions to collect basic information (age, gender, current semester, technical equipment of the home office, disturbing factors) and 21 Likert-type questions to evaluate online teaching, 5-point scale ("I cannot judge" = 1, "do not agree at all" = 2, "rather disagree" = 3, "undecided" = 4, "rather agree" = 5, "fully agree" = 6). The response options to statements 16 and 18 had to be recoded ("strongly disagree" = 6, "strongly disagree" = 5, "undecided" = 4, "strongly agree" = 3, "strongly agree" = 2).

using online seminars. The open source video conferencing application "Jitsi meet" (Emil Ivov; Version 2.10 Build 5550) was used for very few courses, but in direct comparison with "Microsoft Teams" (Microsoft Corporation, Redmond, Washington, USA, Version 1.3.0) it proved to be less suitable for groups of 20 or more participants. Consequently, the open source programm was only used to instruct small groups in the phantom head course of conservative dentistry, but not as a teaching instrument for significantly more participants in lec-

tures within the semester or lectures across all semesters. The program "Microsoft Teams" was used for all other lectures within the Clinic of Dental, Oral and Maxillofacial Medicine (phantom head course of conservative dentistry, course of dental prosthodontics I, integrated clinical course, dental diseases I, clinic of dental, oral and maxillofacial diseases I, orthodontic treatment course II), with the lectures being held according to a timed lecture plan. The students had to log in independently at the respective start time of the course, and attendance was checked using the chat function of the program.

2.2 Questionnaires

In order to assess student perception and satisfaction with asynchronous as well as synchronous teaching at the time of the COVID-19 pandemic, a fully standardized questionnaire (cf. Fig. 2) with 33 items was developed, as existing instruments for assessing learning environments, such as the Dundee Ready Education Enviroment Measure (DREEM), the Dental Student Learning Enviroment Survey or the Dental Clinical Learning Environment Instrument (DECLEI) were not sufficiently satisfactory [21, 28, 43]. Thus, in addition to the literature review, feedback from students and the opinions of two experts from the dental faculty at MHH were relevant for item development. In addition to closed questions to collect basic information (age, gender, current semester, technical equipment, disruptive factors), 21 Likert-type questions for the multifaceted evaluation of online teaching could be answered by means of a 5-point scale ("do not agree at all" = 2, "tend to disagree" = 3, "undecided" = 4, "tend to agree" = 5, "fully agree" = 6) and an additional "don't know" category ("cannot judge" = 1). Based on the coding of these ordinally scaled questions, a sum value was formed, which as a global parameter indicates the students' satisfaction with the online teaching that took place. Out of the 21 question items, two statements (16. I prefer to learn in a team and am now afraid of missing the connection; 18. I feel isolated due to digital

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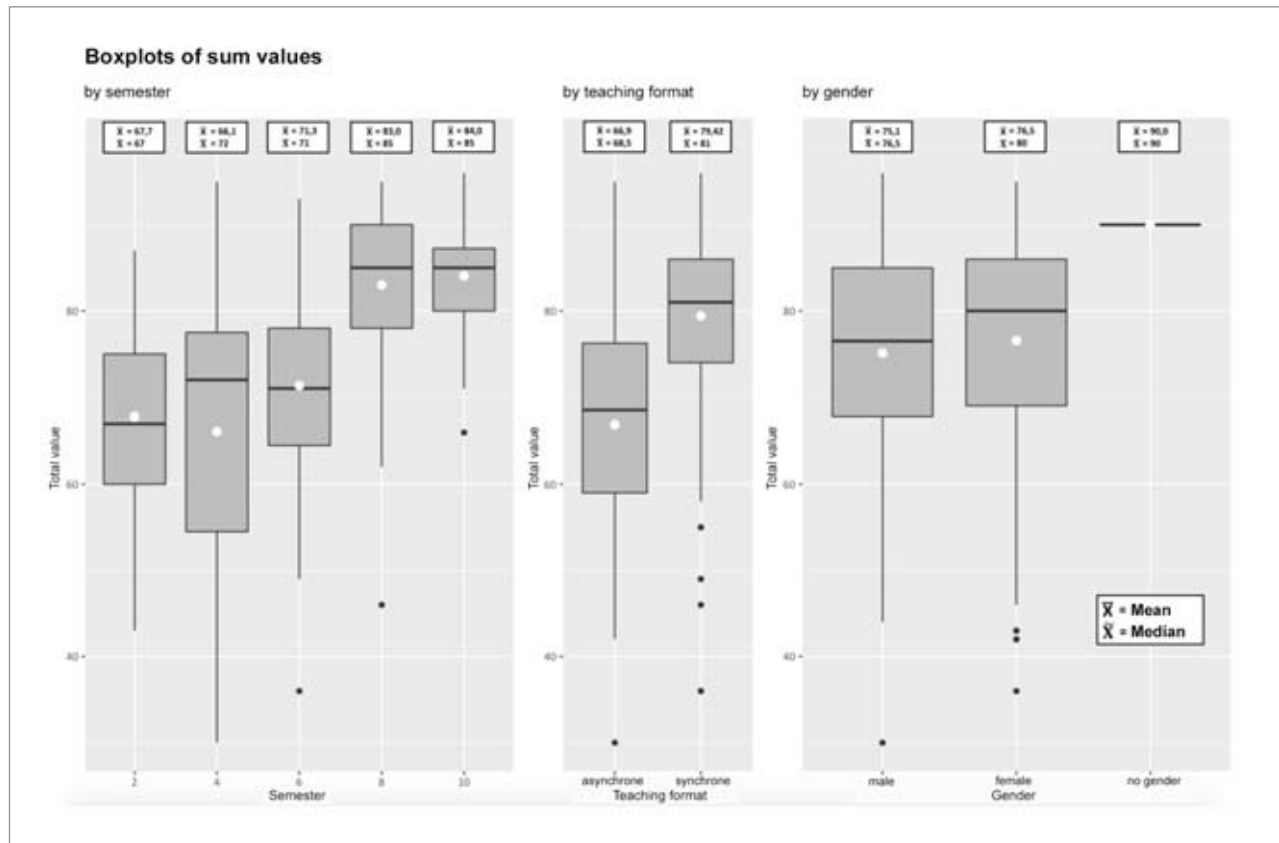
Figure 3 Results of summative value calculation by semester, teaching format, and gender.

teaching) had to be recoded due to their negative connotation ("do not agree at all" = 6, "rather disagree" = 5, "undecided" = 4, "rather agree" = 3, "fully agree" = 2). As a result of the findings of a factor analysis (cf. paragraph 2.4), 5 items (6, 14, 17, 20, 21) were excluded from the sum value calculation. An increased total score in the evaluation was interpreted as meaning that the implementation of digital teaching tended to be perceived more positively by the students. A score of 80 had to be reached ("tend to agree", 16 × 5) to conclude a positive perception. A maximum of 96 points could be achieved ("fully agree", 16 × 6). The final questions allowed the students to evaluate the teaching carried out using classic school grades ("very good" = 1, "good" = 2, "satisfactory" = 3, "sufficient" = 4, "poor" = 5, "insufficient" = 6) with regard to the following aspects: Content, technical quality, interaction potential with the instructor, the clarification options for questions, and general orientation on the digital platform.

2.3 Statistical analyses
Statistical analysis of the questionnaire was performed using RStudio software (RStudio PBC; Boston, Massachusetts, USA, version 1.2.5033) and R (version 3.6.3) [41, 46]. Furthermore, the distribution functions of the data were analyzed using the Kolmogorov-Smirnov test and, for non-normally distributed data, the Mann-Whitney-U-test was used to test for differences in central tendency (significance level □ = 0.05). Individual questions were analyzed by Chi-square test. The following R packages were used for data analysis and creation of graphs: "tidyverse" [57], "likert" [9], "HH" [20], "colorspace" [58], "lattice" [47], "lavaan" [45], "psych" [42].

2.4 Factor analysis
An exploratory factor analysis was conducted to investigate the internal structure of the questionnaire. Using principal component analysis with orthogonal varimax rotation, 4 factors were initially extracted in the course of data reduction. Following

the interpretation criteria defined by Schönrock-Adema et al. (point of strongest bend in the scree plot, eigenvalue criterion > 1.5, minimum 3 items per factor, factor loadings ≥ 0.5 per item), one factor as well as 5 questions (6, 14, 17, 20, 21) had to be excluded from the sum value calculation [49]. The first factor describing the seminar structure includes 6 items (1, 2, 3, 4, 5, 19). The second factor includes the items (12, 13, 15, 16, 18) and summarizes extrinsic, person-related characteristics, while the third factor (7, 8, 9, 10, 11) bundles intrinsic characteristics. Overall, the three-factor model can explain 54% of the total variance. Finally, the confirmatory factor analysis applied to validate the given factor structure yielded an acceptable model fit (CFI = 0.94, RMSEA = 0.064) [8, 24].

3. Results
At the end of the survey period (25.05.2020–15.06.2020), the response rate was 56% (response: 204/total questionnaires being send: 359) of the students surveyed (2nd

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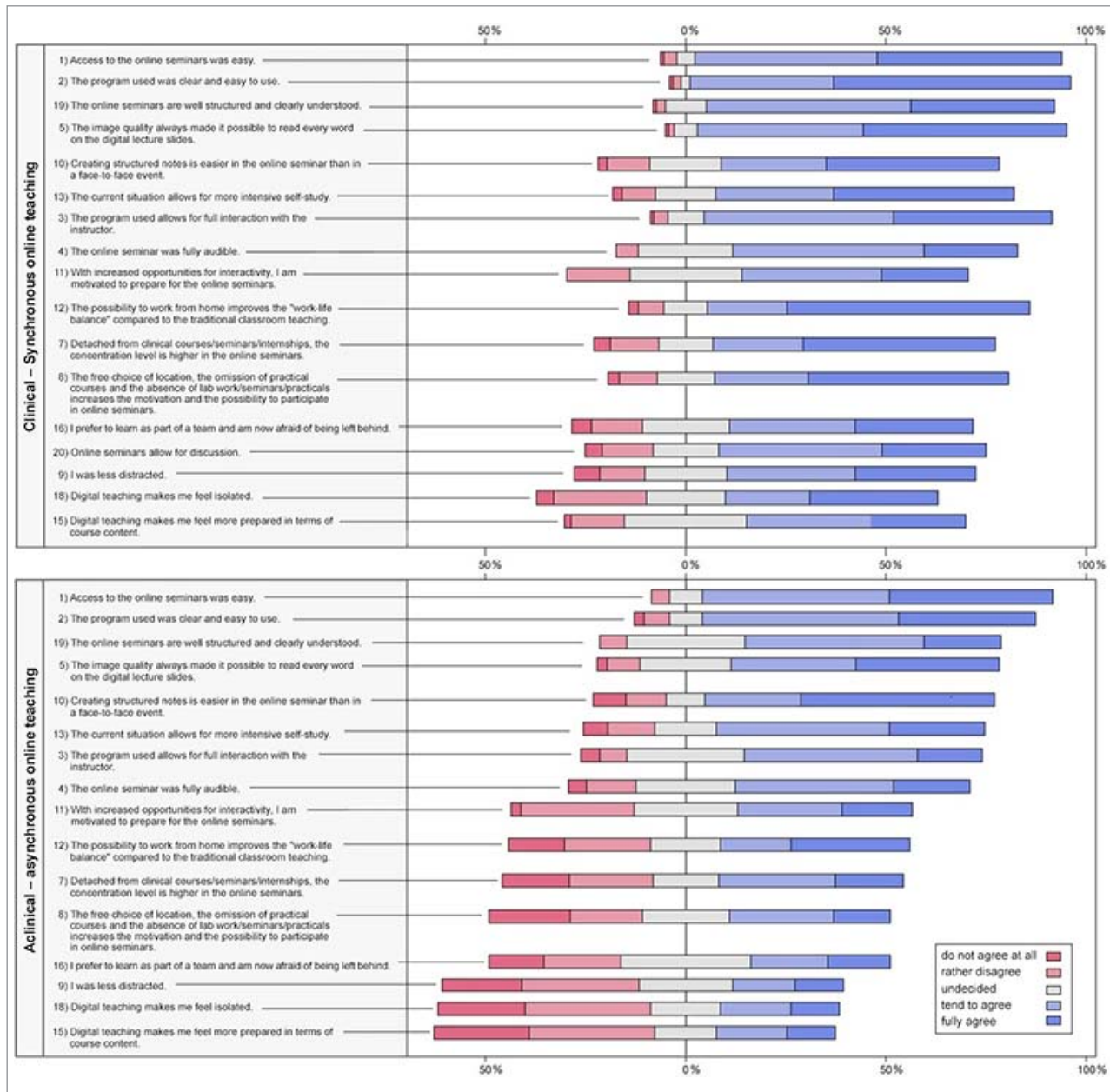
Figure 4 Comparison of online teaching questions in preclinical (asynchronous) and clinical (synchronous) settings.

semester (24/78), 4th semester (29/76), 6th semester (49/66), 8th semester (47/64), 10th semester (55/75)). The participation rate of clinical semesters (6th, 8th, 10th) was higher than that of preclinical semesters (2nd, 4th), namely 73% (151/205) vs. 34% (53/154). Overall, 72% (147/204) of the participants were female, 27% (56/204) male, 0% diverse. One participant did not indicate his gender. The mean age of all participants was 23.6 ± 3.7 years (2nd semester = 21.8 ± 3.6/4th semester = 22.1 ± 4.2/6th semester = 23.8 ± 3.3/8th semester = 24.2 ± 3.0/

10th semester = 26.5 ± 4.5). Regarding the sum value, an average of 66.9 points (median 68.5) could be determined for the preclinical semesters (asynchronous teaching concept) vs. 79.4 points (median 81) for the clinical semesters (synchronous teaching concept). Thus, the difference is 12.5 (median 12.5) points, with a significant difference between the groups (asynchronous vs. synchronous teaching concept; Mann-Whitney-U-test: p < 0.001). The sum score calculation is shown in Figure 3. Twelve students, 9 of them female, indicated that they had to care for children at home in

addition to their studies due to pandemic-related kindergarten or elementary school closures (4th semester: one female student, 6th semester: 3 female students, 8th semester: 4 female and one male student[s], and one unspecified parent, 10th semester: one female and one male student[s]). Due to the small sample size, it was not possible to assess whether there was a statistical relationship between potential stress due to simultaneous childcare and work performance (distraction potential, ability to concentrate). However, evaluated purely descriptively, 10 of the students with

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Teaching format	Content	Clarification of questions	Orientation	Interaction	Technology
Preclinical, asynchronous teaching	2.21 (n = 52)	2.47 (n = 51)	2.42 (n = 52)	2.80 (n = 51)	2.62 (n = 52)
Clinical, synchronous teaching	1.72 (n = 151)	1.74 (n = 151)	1.93 (n = 151)	2.13 (n = 151)	2.14 (n = 151)
Kolmogorov-Smirnov-Test	0.0821	0.0028	0.0929	0.0074	0.0271
Mann-Whitney-U-Test	$p < 0.001$	$p < 0.001$	0.004	$p < 0.001$	$p < 0.001$

Table 2 Grading of online teaching according to the school grading system (mean/n= number of responses evaluated) and statistical evaluation of the comparison preclinical (asynchronous teaching) vs. clinical (synchronous teaching).

children indicated that their work-life balance was improved, and 8 of them also seem to have been less distracted during an online seminar despite the presence of children. Regarding home office conditions, 92 % (188/204) of students had a workspace that allowed them to participate in digital teaching without disruption. Furthermore, 90 % of the respondents also had the necessary technical equipment (headset, microphones, webcam) to participate interactively in the online seminars. Nevertheless, 4 students stated that they had neither an adequate workstation nor communication hardware (2nd semester: 2 students, 8th semester: one student, 10th semester: one student). 87.7 % of the students ("agree" = 91, "strongly agree" = 88) were satisfied with the accessibility of the online seminars, regardless of whether they used an old (>3 years) or a new (<3 years) technical device (PC, tablet, laptop). These conventional devices were used by 98.5 % of participants, with 34.3 % of students also following the online seminars using smartphones. Eight students (3.9 %) indicated that access had not been unproblematic for them. The ability to interact with the lecturer was considered unrestricted by 76.5 % of the students and was rated 2.30 across semesters. Nevertheless, discrepancies in two-way interaction appear to be present, as successful answering of questions was rated 1.74 in the clinical, synchronously taught semesters, whereas the preclinical, asynchronous semesters only rated 2.47. This difference turns out to be significant (compare Table 2). Although only 36 % of the stu-

dents stated that they found it easier to ask questions from the anonymity at home, 62.7 % were in favor of the fact that they achieved a higher depth of concentration in online seminars and were less often distracted (52.4 %). An overview of the responses to questions about online teaching in the preclinical (asynchronous) and clinical (synchronous) settings is shown in Figure 4. In addition, in a direct comparison of the preclinical (asynchronous concept) to the clinical (synchronous concept) setting, a significant difference in central tendency was found in the evaluation of content and orientation (compare Table 2). Looking at the details, there is a statistically significant difference between the presence of equipment (headset, microphones, webcam) and the grading of content, technique as well as general orientation; Mann-Whitney-U-Test: content ($p = 0.00962$), technique ($p < 0.001$), orientation ($p < 0.001$). If equipment is present, significantly better scores were given: Content (mean 1.7 vs. 2.3), Technique (mean 2.20 vs. 2.89), Orientation (mean 1.97 vs. 2.89).

4. Discussion

The purpose of this questionnaire-based study was to assess student beliefs regarding ad hoc, synchronous online teaching compared to asynchronous teaching in dentistry at the time of the COVID-19 pandemic. This revealed that dental students, regardless of gender, generally viewed both asynchronous and synchronous online teaching favorably. Since the statistical analysis of the re-

sults showed that there is significant difference between the two teaching formats, the null hypothesis has to be rejected. In addition to statistically significant differences in the comparison of the total values, differences could also be observed in the allocation of grades with regard to the ability to interact, clarification of questions and technique (cf. Tab. 2). However, it must be taken into account that students from the preclinical phase were compared with those from the clinical phase of dental studies and therefore the setting was not homogeneous. In addition, the participation motivation of students in preclinical semesters was significantly reduced compared to students in the clinical study section ($\Delta = 39$ %). Furthermore, the more critical view of the asynchronously instructed students can possibly be explained by the fact that the questionnaire was intentionally oriented towards synchronous online teaching, in the form of online seminars, which is why the asynchronously instructed participants could not have found themselves fully reflected in the questions. This consideration is supported by the fact that in the preclinical phase 7 % of the questions were marked as not assessable, whereas in the clinical phase the percentage was only 2 %. On the other hand, however, it can be argued that this circumstance is due to the different characteristics of the two forms of teaching compared. For example, asynchronous teaching does not provide for real-time feedback, which is why it seems plausible at first glance that the preclinical students were un-

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able to answer the questions regarding the feasibility of discussions, as well as the unrestricted ability to interact with the lecturer, in the conventional, synchronous sense. However, it must be noted at this point that the students were offered sufficient communication possibilities through the learning platform "ILIAS" or via e-mail, which would have been ideally suited for asking clearly formulated, targeted questions without time pressure [23]. Thus, it is surprising that the Likert-question to elicit the willingness to ask questions from the anonymity at home was not considered assessable by 22.6 % of the students in the preclinical phase, since especially "distance learning" can be advantageous for shy students, among others [32]. Since the questionnaire design deliberately offered an additional "don't know" category in addition to the content-related response option "undecided" as the scale midpoint, so that students without a relevant attitude would not be forced to make a content-related statement, it cannot be conclusively assessed to what extent any satisficing behavior, ignorance of the communicative possibilities, or lack of question comprehension had an effect [16]. The literature review on asynchronous and synchronous online and face-to-face teaching showed that there is no significant difference between the teaching formats in terms of learning success and student satisfaction [22, 40, 33, 36]. This finding could be confirmed for dentistry by a meta-analysis from the field of orthodontic teaching [31], but is not confirmed by the results of this study, as there was a significant difference between the two teaching formats (asynchronous vs. synchronous). According to this, teaching formats are vehicles for transporting knowledge, each with characteristic properties (compare Table 1), which should be selected depending on the circumstances and the content to be taught, so that they can then have a positive effect on learning success in a specific teaching constellation [36]. However, in terms of learning success, the regular and continuous interaction of students with the learn-

ing material is far more important than the chosen teaching format [35]. In this context, oral participation, i.e., direct interaction with the lecturer, but also with fellow students, seems to be closely related to the process of learning [2, 14]. In this respect, this correlation can also be drawn from the evaluation of the preclinical students, where the acquisition of competences was rated worst together with the opportunities for discussion and asking questions. Considering the fact that basic knowledge is taught in preclinical courses, which at most belong to the category of declarative knowledge acquisition, the students' perception seems to be atypical at first glance, since an asynchronous teaching format seems to be beneficial for conveying this content. Thus, just the arbitrary viewing of the content by pausing or rewinding the lectures, completely in the sense of "self-paced-learning", is advantageous [19]. Furthermore, the learning success and the engagement of the students is influenced by the feeling of belonging to a group [6, 13, 51]. This social affiliation is put to the test by the geographical-physical separation during distance learning. Moreover, an asynchronous setting creates a more difficult learning situation due to time delays or a communicative exchange reduced by paralinguistic signals, but the dental students did not consider this particularly isolating. Distraction potential scored significantly worse in terms of evaluation. Why the preclinical students saw themselves significantly more distracted compared to the clinical students cannot be plausibly explained. Similarly, regarding work-life balance, asynchronous online teaching actually still allows students a higher degree of flexibility and convenience compared to synchronous online teaching, as there are no time constraints to adhere to [48]. Interestingly, clinical students taught synchronously according to a strict schedule nevertheless rated their work-life balance significantly more positive than preclinical students did. A possible explanation can be that the students in the preclinical semesters possibly had to invest

more time in their self-study and therefore could not use the time saved profitably, for example, by not having to travel to and from the place of study. On the other hand, students in the clinical semesters also indicated that they would invest more time in self-study, which again puts the explanatory approach into perspective.

5. Conclusion

The necessary restructuring of conventional, presentation-based teaching in dental education at the time of the lock-down during the COVID-19 pandemic was rated positively by students overall. Synchronous teaching approaches were rated significantly better than asynchronous teaching approaches. Nevertheless, based on the results of this questionnaire-based teaching study regarding the overall satisfaction of dental students, the respective teaching format should be selected according to the students' learning situation. However, because the external validity of this work is not comprehensively given due to the chosen setting, the results obtained can only be generalized to dental students at the Medical School.

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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Manifestation pattern of 343 antiresorptive-related osteonecroses of the jaw considering the etiologic factor – consequences for the dental practice

Introduction: Antiresorptives are used in patients with osteoporosis and malignant tumors to inhibit resorption processes in the bone. Antiresorptive-related osteonecrosis of the jaw (ARONJ) is an adverse drug reaction and is associated with a considerable impairment of quality of life. Therefore, prevention and early identification of ARONJ events are crucial.

Methods: The data of 249 patients (mean age: 68.8 ± 10.4 years) with 343 ARONJ events were retrospectively assessed according to etiology (extraction-related, denture-related, idiopathic), risk profile (high, moderate, low), and localization (maxilla/mandible; buccal/crestal/oral). For this purpose, Pearson's χ^2-test and t-test for independent samples were applied. The significance level was set at $\alpha = 0.05$.

Results: The majority (88.4 %) of patients received the antiresorptive drug as part of the oncologic treatment and thus exhibited a high risk profile. Extraction-related ARONJ (51.6 %) were most frequently observed, followed by denture-related (30.3 %) and idiopathic (18.1 %). Most ARONJ were located in the mandible (69.4 %). Regarding oro-buccal extension of the ARONJ, the buccal sites were significantly more often affected in the maxilla compared to the mandible ($p < 0.001$), whereas the oral sites were significantly more often affected in the mandible compared to the maxilla ($p < 0.001$). In this context, it should be noted that 75.6 % of idiopathic ARONJ of the mandible extended to the oral sites. Molars were significantly more frequently affected (51.8 %; $p < 0.001$) than premolars and anterior teeth.

Discussion and conclusion: Patients with a high risk profile are known to be susceptible for the development of ARONJ following tooth extractions. The high proportion of denture-related ARONJ underlines that high risk patients wearing removable partial and complete dentures should be closely monitored in the dental practice. Particular caution is required in patients with a thin soft tissue layer and missing keratinization. These anatomical peculiarities seem to predispose for idiopathic ARONJ and may explain the high occurrence in the area of the mylohyoid ridge.

Keywords: antiresorptive-related osteonecrosis of the jaw (ARONJ); etiology; tooth extraction; denture; idiopathic; risk profile; localization

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Introduction

Human bone tissue undergoes continuous remodeling throughout life, with apposition and resorption processes balancing each other under physiological conditions [4, 9, 22]. Osteoporosis and bone metastases of malignant tumors represent common diseases that sensitively interfere with this bone homeostasis. In Germany, the annual incidence for osteoporosis is reported to be approximately 620,000 [8], for breast cancer approximately 69,000, and for prostate cancer approximately 60,000 [28]. Different antiresorptive drugs are used to inhibit the progression of osteoporosis and bone metastases by favoring bone apposition. Bisphosphonates (BP; e.g. Aredia® or Zometa®) are synthetically produced analogues of pyrophosphate and inhibit osteoclast activity [7]. The half-life of these drugs is very long, ranging from 10–12 years [32]. The monoclonal antibody (MAB) denosumab (e.g. Prolia® or XGEVA®) interferes with the signaling pathway of RANK (Receptor Activator of NF-□B) and its ligand (RANKL). In this way, the differentiation of osteoclastic progenitor cells and the activity of mature osteoclasts are inhibited [3]. The half-life of these drugs is 24–26 days [32]. Angiogenesis inhibitors (AI) such as bevacizumab (e.g. Avastin®) exert their antiresorptive effects through specific inhibition of vascular endothelial growth factor (VEGF) in vascular endothelia [35]. The half-life of bevacizumab is comparable to that of denosumab and is approximately 20 days [32].

Previous studies have shown that drug therapy with antiresorptives has reduced the incidence of pain and pathologic bone fractures in both oncologic [26, 32] and non-oncologic patients [13], thereby improving the overall quality of life. However, there is evidence that antiresorptive drugs can cause an adverse drug reaction in the form of osteonecrosis of the jaw (ONJ). This was first described in the 2003 publication by Marx as bisphosphonate-related osteonecrosis of the jaw (BRONJ) and has since presented a new challenge to patients, dentists and oncologists [20]. Since osteonecrosis of the jaw is associated not
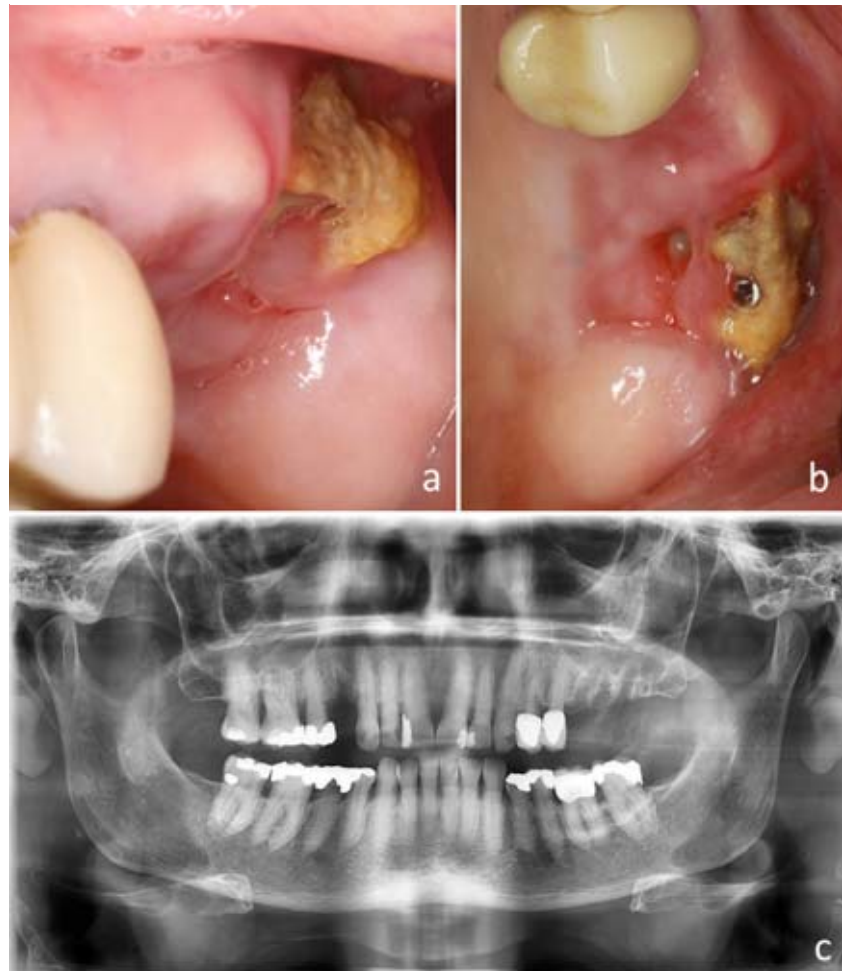
Fig. 1–3: MKG-Chirurgie, Fig. 4 and 5: Knut Adam

Figure 1a–c Antiresorptive-related osteonecrosis of the jaw regio 27 occurring after extraction of the teeth 14, 26 and 27 in a female patient (date of birth: 26.09.1933, primary disease: breast cancer with bone metastases)
1a: extension of the necrosis, buccal view
1b: extension of the necrosis, occlusal view
1c: orthopantomogram recorded at first visit

only with bisphosphonates but also with other antiresorptive drugs, the term BRONJ was replaced by ARONJ (antiresorptive-related osteonecrosis of the jaw). The risk of developing ARONJ depends on the duration of medication, dosage, mode of application, and combination of different preparations [32]. Local microbial ports of entry play a central role in the etiology and pathogenesis of ARONJ. Invasive dental procedures (tooth extractions) as a dentogenic cause are considered scientifically confirmed [36], denture-related and non-reconstructible (idiopathic) injuries are discussed as other etiological factors. Since ARONJ cannot be treated predictably, their early detection and prevention are of crucial im-

portance. Therefore, the present retrospective study aimed to address the following questions:
1. What is the most common local risk factor (tooth extraction, denture pressure area, or idiopathic) for the development of ARONJ?
2. Are there predilection sites (maxilla versus mandible, anterior teeth versus premolars versus molars, buccal versus crestal versus oral) for ARONJ?

Materials and methods

In the present retrospective study, all patients presenting with ONJ at the Department of Oral and Maxillofacial Surgery of the Hannover Medical School (MHH) between 2006 and 2017 were included. For this purpose,

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Figure 2a–c Antiresorptive-related osteonecrosis of the jaw regio 36/37 in a female patient (date of birth: 23.11.1941, primary disease: breast cancer with bone metastases) wearing a removable partial denture
2a: extension of the necrosis, buccal view with denture
2b: extension of the necrosis, buccal view without denture
2c: orthopantomogram recorded at first visit

Figure 3a–b Antiresorptive-related osteonecrosis of the jaw region 47 without recognizable cause (idiopathic) in a male patient (date of birth: 23.11.1946, primary disease: prostate cancer with bone metastases)
3a: extension of the necrosis, lingual view
3b: X-ray of the teeth 45 to 47

the Center for Information Management of the MHH provided a patient list that recorded the following codes using the International Classific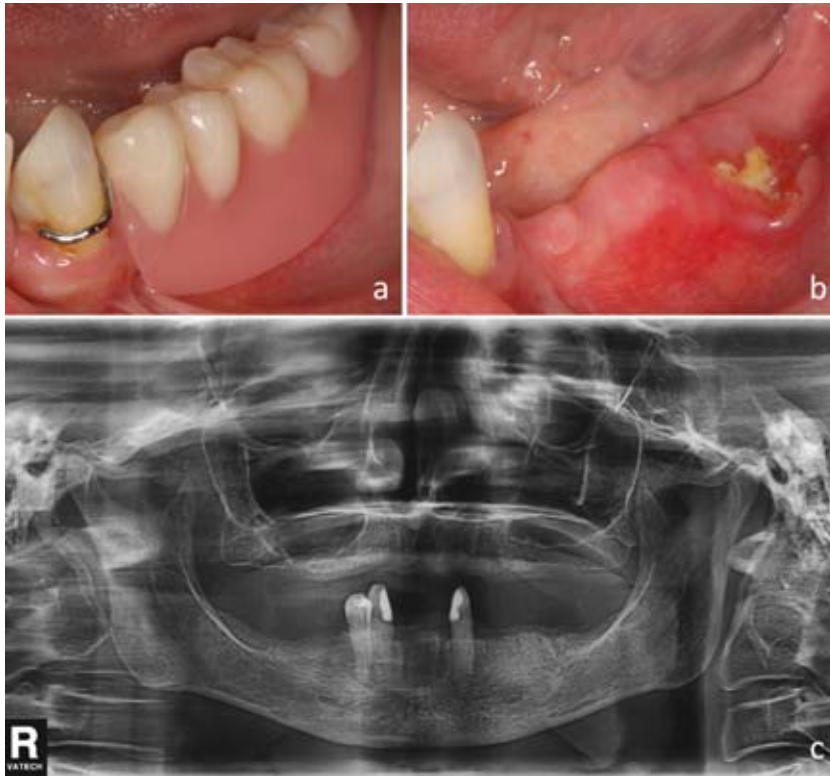ation of Diseases (ICD): ICD-10 code M87.18 (bone necrosis due to drugs: other in neck, head, ribs, trunk, skull, spine) and ICD-10 code K10.28

(other more specifically described inflammatory conditions of the jaws). This list initially included 1256 patients with 2018 treated ARONJ events. In addition, patients were identified from the digital photo archive of the Department of Oral and Maxillofacial Surgery using the

search terms ARONJ and BRONJ. This photo archive contains all patients who had been treated for ARONJ at the MHH since 2007. In addition to the initial findings, the course of the disease, second interventions and the final findings were photo-documented. The data from the different sources were combined into a working list and resulted in 1598 patients. A review of patient records, physician's letters, and radiographs took place for all potential cases. The following inclusion criteria were formulated:

1. Stage 2 or 3 ONJ according to the position paper of the American Association of Oral and Maxillofacial Surgeons [30],
2. Proven use of antiresorptive drugs.

The following exclusion criteria were applied:

1. Concurrent presence of malignant tumor disease in the oral cavity,
2. Radiation in the head and neck region,
3. Tooth extraction under antiresorptive therapy without complications in terms of ARONJ.

There were 249 patients with 343 treated ARONJ events included in the present retrospective study. Initially, 3 etiologic factors were distinguished on the basis of available documents and, in particular, clinical photographs:

1. **Tooth extraction:** In this group, a tooth extraction in the area of the ARONJ could be reliably elicited by the medical history, a referral, file entries and/or radiographs (Fig. 1a–c).
2. **Removable denture:** The second group included patients with denture-related pressure areas as the etiologic factor for the ARONJ. In most cases, pressure areas could be identified from the clinical photographs. Further clues could be documentation of necessary adjustments, such as relining or extension, and instructions not to wear the denture. In addition, tooth extraction and/or other invasive procedures in the area of ARONJ had to be excluded. To determine the type of removable denture, patient records, dental laboratory orders, radiographs, and the comprehensive photo

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| Etiologic factor | Osteonecroses of the jaw [n (%)] | | | | | |
| | Total | Localization | | Risk profile | | |
		Maxilla	Mandible	Low	Moderate	High
Extraction	177	54 (30.5 %)	123 (69.5 %)	9 (5.1 %)	8 (4.5 %)	160 (90.4 %)
Denture	104	30 (28.8 %)	74 (71.2 %)	5 (4.8 %)	8 (7.7 %)	91 (87.5 %)
Idiopathic	62	21 (33.9 %)	41 (66.1 %)	3 (4.8 %)	2 (3.2 %)	57 (91.9 %)
Total	343	105 (30.6 %)	238 (69.4 %)	17 (5.0 %)	18 (5.2 %)	308 (89.8 %)

Table 1 Number of antiresorptive-related osteonecroses of the jaw differentiated according to localization, risk profile and etiologic factor

archive were consulted in addition to the thorough dental examination. Thus, the existing dentures could be identified and assigned both in situ and via the retention elements (clasp rests, telescopes, attachments, bars and implants). In addition, the data collection took into account whether the removable denture was a partial denture (with or without free end) or a complete denture (Fig. 2a–c).

3. **Idiopathic cause:** The third group included all patients in whom ARONJ had occurred spontaneously without any detectable cause (Fig. 3a–b).

In addition to age, sex and date of first presentation, the underlying disease, the drug group(s), the mode of application, the duration of administration, and the intake interval of the antiresorptives were recorded for each patient. According to the currently valid S3 guideline, each patient was assigned to a low, moderate or high risk profile [32]. This risk stratification was instrumental in the subsequent statistical analysis. In order to systematically record the localization of the ARONJ and to identify possible predilection sites, the affected regions were documented according to the FDI dental scheme. Additionally, it was differentiated which areas (buccal, crestal, oral) were affected by ARONJ. Multiple answers were possible.

Statistical analysis was performed using IBM SPSS Statistics 26 software (IBM Corp., Armonk, NY, USA). Pa-

tients were assigned to groups based on etiology (extraction-related, denture-related, idiopathic) and risk profile (low, moderate, high). Pearson's chi-square test and t-test for independent samples were used for group comparisons. The significance level for all statistical tests was □ = 0.05. For the presentation of descriptive data, the patient was defined as the statistical unit. The statistical analysis was performed event-specific and tooth type-specific (anterior teeth, premolars, molars).

Results

A total of 99 men and 150 women were included in the study. The mean age at initial presentation was 68.8 ± 10.4 years, with the youngest patient being 27.9 and the oldest patient being 91.9 years old. The underlying disease was primary or secondary osteoporosis in 29 patients and malignant tumor disease in 220 patients. Here, osseous metastatic breast cancer was most common in women (n = 93) and osseous metastatic prostate cancer in men (n = 66). The different underlying diseases are shown in Figure 4. Most patients (82.3 %) were receiving antiresorptive monotherapy (BP: 70.3 %, MAB: 11.2 %, AI: 0.8 %) at the time of onset of ARONJ. Dual drug therapy was used in 16.1 % of patients (BP and MAB: 10.0 %, BP and AI: 5.6 %, MAB and AI: 0.4 %) and drug therapy with 3 antiresorptives was used in 1.6 % of patients. Patients who were prescribed bisphosphonates received them predominantly intravenously (86.7 %). Fin-

ally, 16 patients could be assigned to a low risk profile, 13 to a moderate risk profile, and 220 to a high risk profile. On average, ARONJ occurred 3.8 ± 3.0 years (minimum: 0.1 years, maximum: 24.0 years) after the start of antiresorptive therapy in the patients studied. In 46 patients (18.5 %), this complication occurred within the first year. The duration of antiresorptive medication until the occurrence of ARONJ showed no significant difference between the different risk profiles. Numerous patients had other general diseases in addition to the underlying disease. Thus, 83 patients (33.3%) suffered from coronary heart disease, 46 (18.5 %) from renal insufficiency, and 44 (17.7 %) from diabetes mellitus. Among the 249 patients, 61 were smokers (24.5 %) and 109 (43.8 %) had radiographically confirmed periodontitis.

Because some patients had multiple ARONJ events, some with different etiologies, the statistical unit was changed for the following analysis. The patient-based evaluation was replaced by an event-based analysis. Among the 249 patients, a total of 343 ARONJ events were identified (Table 1). These were first distinguished with respect to their etiology. Tooth extraction was identified as the etiologic factor in 177 ARONJ events (51.6 %), denture pressure areas were identified in 104 ARONJ events (30.3 %), and no etiologic factor was identified in 62 ARONJ events (18.1 %). The majority of ARONJ events were located in the mandible (69.4 %). This over-

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Etiologic factor		Osteonecroses of the jaw						
		Total	Buccal		Crestal		Oral	
			n (%)	p-value*	n (%)	p-value*	n (%)	p-value*
All	**Maxilla**	105	89 (84.8 %)	<0.001	60 (57.1 %)	0.958	15 (14.3 %)	< 0.001
	Mandible	238	105 (44.1 %)		133 (55.9 %)		114 (47.9 %)	
Extraction	**Maxilla**	54	46 (85.2 %)	<0.001	34 (63.0 %)	0.634	8 (14.8 %)	0.002
	Mandible	123	68 (55.3 %)		80 (65.0 %)		46 (37.4 %)	
Denture	**Maxilla**	30	28 (93.3 %)	<0.001	15 (50.0 %)	0.752	3 (10.0 %)	< 0.001
	Mandible	74	24 (32.4 %)		39 (52.7 %)		37 (50.0 %)	
Idiopathic	**Maxilla**	21	15 (71.4 %)	0.003	11 (52.4 %)	0.166	4 (19.0 %)	< 0.001
	Mandible	41	13 (31.7 %)		14 (34.1 %)		31 (75.6 %)	

Table 1 and 2: Knut Adam

Table 2 Jaw-specific manifestation pattern of antiresorptive-related osteonecroses of the jaw differentiated according to etiologic factor and oro-buccal extension (*: Pearson's chi-square test)

representation of the mandible was present regardless of the etiologic factor. The next step was to assess whether there was a clustered occurrence of ARONJ in the buccal, crestal, or oral region depending on the localization (maxilla, mandible) and the etiologic factor (tooth extraction, denture, idiopathic). This analysis revealed that ARONJ of the maxilla extended significantly more frequently to the buccal jaw sections than those of the mandible. Conversely, the oral regions of the mandible were significantly more frequently affected by ARONJ than those of the maxilla. These phenomena were evident both when all ARONJ events were considered and when differentiated by etiologic factors (Table 2). Known risk factors for the development of ARONJ such as smoking habits, diabetes mellitus, and a history of periodontal disease were subsequently evaluated. Among the 343 ARONJ events, 91 smokers, 62 diabetics, and 162 periodontitis cases were identified. It was investigated whether these risk factors were homogeneously distributed in all 3 etiology

groups. The chi-square test showed an overrepresentation of diabetics with p = 0.007 and an overrepresentation of smokers with p = 0.016 in denture-related ARONJ. When all ARONJ events were considered, the proportion of removable dentures was high at 59.8 % (n = 205). Of these, 75.1 % (n = 154) were partial dentures and 24.9 % (n = 51) were complete dentures. The proportion of complete denture wearers was even higher (32.7 %) in cases of proven denture-related ARONJ. In addition, only three partial dentures (4.3 %) in this group were designed to treat a situation with a tooth bounded gap, whereas the vast majority (95.7 %) were designed to treat a free-end situation.

Since many ARONJ were not limited to one tooth position, the following statistical analysis was performed on a tooth type-specific basis. In total, the 343 ARONJ events covered 602 tooth positions. Molars (51.8 %) were significantly more frequently affected compared with anterior teeth (21.3 %) and premolars (26.9 %) (x^2: p < 0.001). This overrep-

resentation of the molar region was present in both jaws, in all three etiologic factors, and in the presence of the high risk profile (Fig. 5).

Discussion

Osseous metastases of solid tumors lead to a negative bone balance due to osteolytic processes and, in advanced disease stages, to skeletal-associated events (pathological fractures, spinal compression syndrome, hypercalcemia, anemia), which are associated with a significant impairment of quality of life. Given this background, antiresorptives are a blessing for affected patients because they have been shown to reduce the risk of skeletal-associated events and contribute to improved life expectancy [15, 19, 24]. In addition to these beneficial effects, patients with a high risk profile are at particular risk of developing ARONJ. The literature describes highly variable event rates for patients with a high risk profile depending on the study design. In a recently published prospective study with a study period of 4 years, the prevalence of ARONJ was 1.0 % with
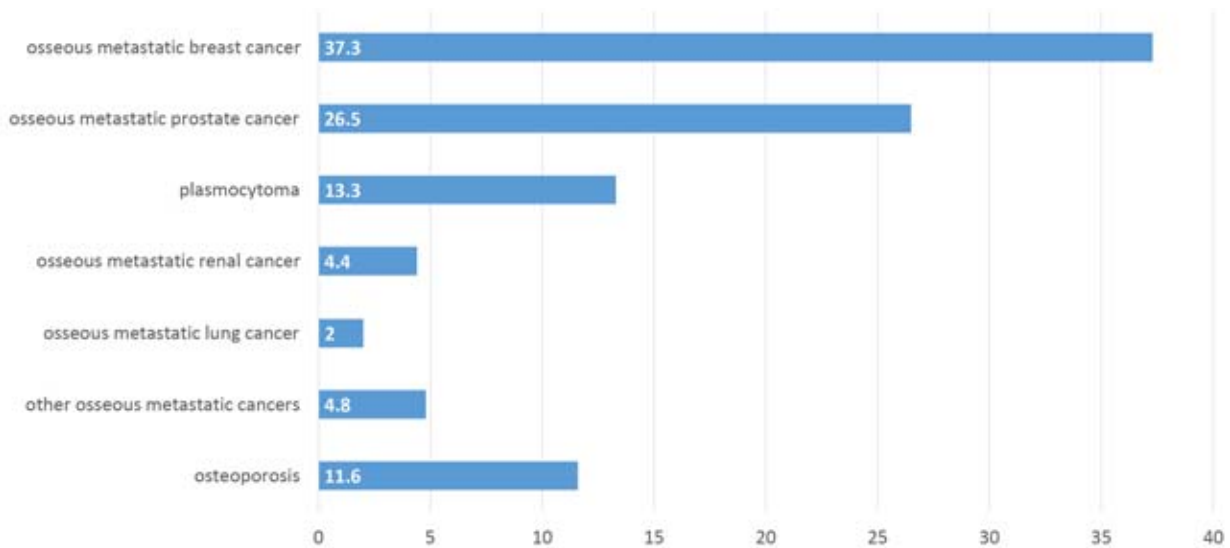
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Figure 4 Percentage distribution of primary diseases
The following tumor entities are summarized under "other carcinoma": urothelial carcinoma, hepatocellular carcinoma, endometrial cancer, malignant neoplasm of vulva, cancer of unknown primary and Non-Hodgkin lymphoma

intravenous bisphosphonate therapy and 3.6% with high-dose denosumab therapy [10]. Another study demonstrated a prevalence of 2.1% in patients with breast cancer, 3.8% in patients with prostate cancer, and 5.2% in patients with multiple myeloma [29]. A significantly lower prevalence has been described for patients with a low or moderate risk profile [29]. Accordingly, in a Brazilian cross-sectional study, 153 osteoporosis patients were treated with bisphosphonates and none of them developed ARONJ within the study period [33]. Consistent with these data, the proportion of patients with a high risk profile in the present study was 88.4%, whereas patients with a low (6.4%) and moderate risk profile (5.2%) were represented in much lower proportions. When differentiated by underlying disease, osseous metastatic breast cancer (37.3%), osseous metastatic prostate cancer (26.5%), and multiple myeloma (13.3%) were most frequently represented. In a paper published by Hoefert in 2012, 195 patients with BRONJ were studied [12]. Again, breast cancer was the most common underlying disease at 39.1%, followed by multiple myeloma at 21.7% and prostate cancer at 14.0%.

In the present study, 51.6% of ARONJ events were due to a previous tooth extraction, 30.3% to a denture pressure area, and 18.1% to an idiopathic cause. In the 2014 American Academy of Oral and Maxillofacial Surgeons position paper, surgical procedures in the dento-alveolar region and specifically tooth extractions are cited as a major local risk factor for the development of ARONJ [31]. In a retrospective study examining 149 patients with ARONJ, 53.7% of cases were associated with tooth extraction, 8.1% with a removable denture, and 36.2% with an idiopathic cause [36]. While the percentage of extraction-related ARONJ was essentially the same as that of our study, the percentages of denture-related and idiopathic ARONJ were significantly different from our results. In this context, it is likely that the comprehensive photographic documentation made it easier for us to reconstruct the cause of the ARONJ and, in particular, to identify denture-related ARONJ compared with other retrospective evaluations.

The stage of ARONJ at diagnosis is a significant prognostic factor for the success of both conservative and surgical therapy. The earlier ARONJ is diagnosed, the greater the chances of successfully treating it conservatively [25]. The extent and success rate of surgical interventions also depend largely on the stage of ARONJ [16].

Therefore, early identification of ARONJ during dental screening examinations is of crucial importance. In this regard, it is of interest to the practicing dentist which areas of the maxilla and mandible are at increased risk for developing ARONJ. In our study, 69.4% of ARONJ events were localized in the mandible and 30.6% in the maxilla. The preferential manifestation in the mandible has been scientifically confirmed [1, 2, 14]. Also, that the ARONJ in both jaws were significantly more frequently localized in the posterior than in the anterior region has already been demonstrated by other research groups [2].

However, no data exist to date as to whether ARONJ in oro-vestibular extension exhibit a jaw-specific pattern. In this regard, it was observed for the maxilla that necrosis showed buccal involvement in 84.8% of cases, whereas the crestal and palatal areas of the alveolar ridge were affected in only 57.1% and 14.3% of cases, respectively. This pattern was observed in extraction-related, denture-related, and idiopathic ARONJ, with denture-related ARONJ showing the highest percentage of buccal involvement (93.3%). Compared with the maxilla, mandibular ARONJ were significantly more frequently localized lingually. This phenom-
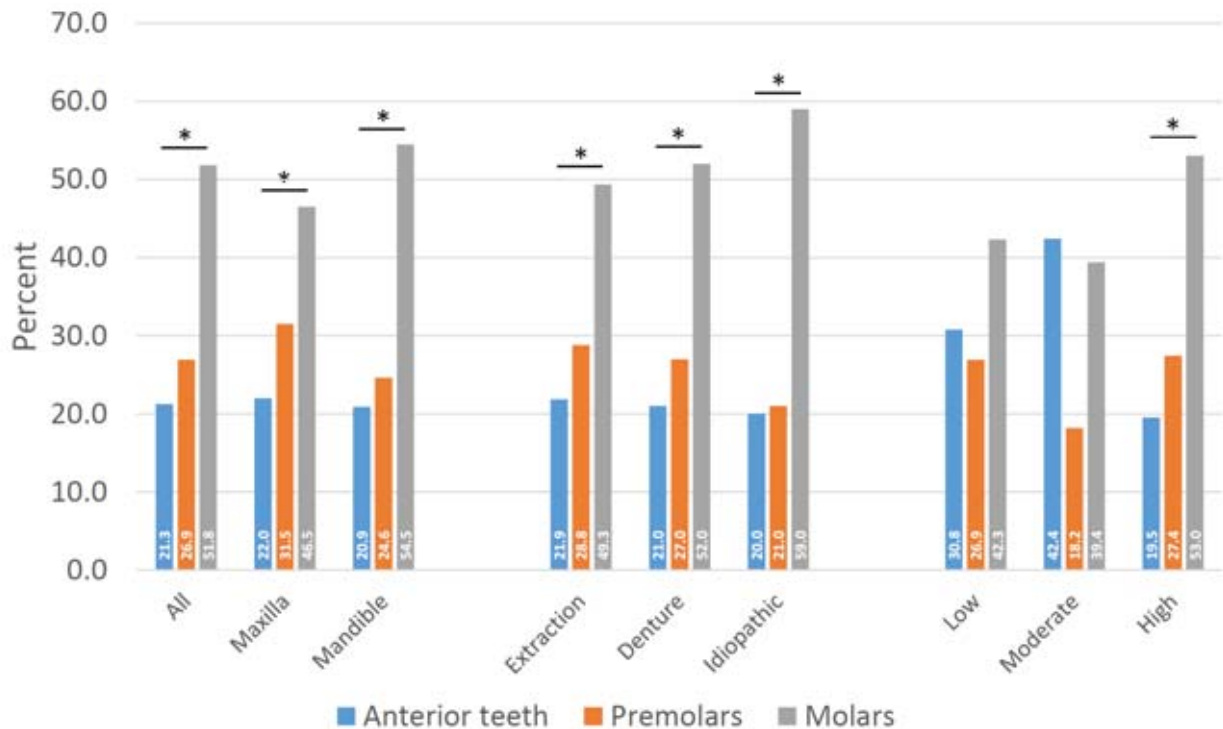
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Figure 5 Percentage distribution of jaw necrosis events in the different tooth regions (anterior teeth, premolars, molars) differentiated by localization (maxilla, mandible), etiology (extraction, denture-related, idiopathic) and risk profile (low, medium, high)
* p < 0.001; chi-squared test

enon was detectable for all etiologic factors, but was particularly striking in ARONJ of idiopathic origin, which appeared on the lingual aspect of the alveolar ridge in 75.6 % of cases. Since the oro-vestibular extension of ARONJ has not been investigated so far, no information exists in the literature on possible causes of the described phenomena. In our opinion, an interplay of traumatic, functional, anatomical, and prosthetic factors is responsible. It is known that continuous medication with antiresorptive drugs leads to an increased accumulation of microcracks in the bony skeleton [17]. Areas of intense stress such as the molar regions of the maxilla and mandible seem to be particularly affected by this [11]. Colonization of microcracks by oral microorganisms may be an explanation, particularly for ARONJ of idiopathic origin. Mucosal ulceration mostly resulting from a local trauma represents another cause for the development of ARONJ [6, 34]. In this regard, areas with a thin mucosa appear to be significantly more susceptible to ulcer-

ation than those with a thick, keratinized mucosa. In the literature, the lingual region of the mandible, and specifically the linea mylohyoidea, has repeatedly been associated with idiopathic ulcers [18, 27]. This area has a very thin mucosal covering and is subject to particular stress due to its exposed position. In contrast, the maxilla is lined with a very thick masticatory mucosa in the palatal region, which appears to effectively protect the underlying bone from traumatic injury. Accordingly, we observed palatal involvement in only 14.3 % of all ARONJ events, and specifically denture-related ARONJ extended to the palate in only 10.0 % of cases.

In patients with removable, tegument-supported dentures, the maxilla and mandible are exposed to pressure loads that lead primarily to centripetal-directed atrophy of the maxilla and centrifugal-directed atrophy of the mandible. This results in altered prosthesis statics and altered loading of the prosthesis bearing. With increasing atrophy, it is known, especially during laterotrusion, that

the maxilla is subjected to increasing pressure loads from the buccal side and the mandible from the lingual side. This is a possible explanation for the fact that denture-related ARONJ are localized predominantly buccally in the maxilla and lingually in the mandible. In addition, studies demonstrate that a large proportion of removable, tegument-supported dentures have a poor fit and thus require relining [21, 23]. Insufficient congruence between the denture base and bearing means that pressure peaks and consequent mucosal injury are likely to occur, leading to the development of ARONJ.

The results of this study underline the importance of eliminating local risk factors in the oral cavity ideally before starting antiresorptive therapy. Consistent with this demand, Bonacina et al. 2011 demonstrated that the identification and treatment of dental risk factors (residual roots, caries, periapical lesions, periodontitis, dentures with insufficient tegumental support) make a decisive contribution to preventing the development of ARONJ [5].

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Conclusion

Every dentist will encounter patients in clinical practice who have been prescribed antiresorptive drugs. It is well known that surgical interventions such as tooth extractions can cause ARONJ in such patients. However, the results of the present study underscore the importance of denture-related ARONJ. Every dental practice can contribute to a reduction of ARONJ events by disciplined follow-up of patients with tegument-supported dentures. This also applies to patients with complete dentures and should include monitoring of static and dynamic occlusion as well as denture fit. Early relining, if necessary with soft-retaining materials, can help to reduce the risk of ARONJ.

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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Till Dammaschke

Facial palsy after dental treatment

Abstract: Facial nerve palsy may occur in rare cases in connection with dental treatment. Its causes have not been entirely clarified so far. If facial nerve palsy sets in immediately after the administration of a local anesthetic, it is likely that the unintended, accidental anesthesia of the branches of the facial nerve has occurred. Once the effect of the anesthetic subsides, the palsy disappears and is completely reversible. Direct damage to the facial nerve with the injection needle seems improbable. Delayed facial nerve palsy, which initially sets in hours or days after dental treatment, must be considered separately. In the past, various causes have been discussed in literature. Presently, it is thought that the most likely cause is the reactivation of viruses (herpes simplex virus type 1 or varicella zoster virus) from nerve ganglia of the facial nerve by dental treatment. This can also occur in cases where no local anesthesia has been used. In addition, this does not have to result in the formation of blisters on the skin (zoster sine herpete), which is typical of herpes labialis or herpes zoster. In order to treat delayed onset facial palsy after dental treatment, drug therapy with glucocorticoids (prednisolone) and antivirals (acyclovir) is the current recommendation. For successful therapy, the drugs should be administered in less than 72 hours after the onset of the first symptoms. Dentists should thus promptly refer patients to a neurologist and otherwise be aware of the potential (irreversible) damage to the facial nerve by the viruses.

Keywords: Treatment complications; Bell's Palsy; facial nerve palsy; local anesthesia; viral infection; dental treatment

The facial nerve

The facial nerve is the 7th cranial nerve and it emerges from the skull via the stylomastoid foramen. Before the facial nerve emerges from the skull, the chorda tympani branches off from it at the level of the petrous bone. It supplies preganglionic secretomotor fibers to the submandibular as well as sublingual salivary glands and carries efferent taste fibers from the front two thirds of the tongue with the exception of the lingual papillae. After emerging out of the skull, the facial nerve divides into 2 main branches – the temporal and cervical – before it enters the parotid gland, where it continues to divide into the temporal, zygomatic, buccal, mandibular and cervical branches, which eventually supply the mimic muscles [6, 31].

In literature, a localized, but very rarely reported neurological complication after routine dental procedures under local anesthesia is the loss of function of the facial nerve (facial palsy). Consequently, no numbers can be derived from literature to determine the frequency of facial palsy after dental interventions. In comparison, the so-called idiopathic facial nerve palsy, in which there is no recognizable cause or triggering moment, is more frequently described. Idiopathic facial palsy affects approximately 7–53 patients per 100,000 persons and year across all population groups [17, 45]. The idiopathic facial palsy is called Bell's Palsy and it is basically defined as a peripheral partial or total loss of function of the facial musculature without an obvious cause. The exact mechanism is still not clear [5, 11, 17, 42, 45]. Five etiological factors are most frequently associated with idiopathic facial nerve palsy: special anatomical structures deviating from the norm, viral infections, ischemia, inflammation and cold stimulation (weather, cold and draft exposure) [17, 45].

Peripheral facial nerve palsy can also occur during dental treatment, either immediately or delayed, depending on the time elapsed from the moment the anesthetic is injected until the onset of symptoms [42]. The occurrence of facial nerve palsy after dental treatment requires a correct diagnosis and immediate, appropriate therapy.

Patients with peripheral facial palsy have characteristic clinical features, which include: generalized muscular weakness of the ipsilateral (same) side of the face, absence of frowning, eyebrow drooping (brow ptosis), incomplete closure of the eyelids, disappearance of the nasolabial fold, drooping of the corner of the mouth and deviation of the mouth towards the unaffected side. Additionally, patients may also complain of pain in the retroauricular region and a reduced sense of taste [6, 17]. Clinically, peripheral facial palsy can be distinguished from central palsy (e.g. stroke) through the involvement of the forehead. If the function of the forehead is intact and the middle and lower parts of the face affected, this indicates a central ("supranuclear") lesion, since the forehead muscles are supplied by nerve fibers from both hemispheres and therefore maintain their function in central lesions. In contrast, peripheral nerve palsy is a lesion of the lower motor neurons and therefore it affects all muscles of the face. The lower nucleus of the facial nerve only receives a one-sided contralateral cortical projection and it supplies the lower facial muscles [6, 17, 22].

Direct nerve injury through injection cannula

In principle, the touching of a nerve with an injection needle during dental anesthesia seems sufficient to cause trauma, which can lead to paresthesia (loss of sensation up to a feeling of numbness) in the area supplied by the sensory nerve. Fortunately, most paresthesias disappear without treatment within a period of 8 weeks. The paresthesia can be permanent only when the damage to the nerve is severe, but this is a very rare occurrence [4]. It has been described in literature that an incorrectly placed injection needle can also lead to facial nerve palsy, e.g. motor neuron failure [2]. However, a direct trauma of the facial nerve due to the injection needle seems very improbable. Nerves have a diameter of about 2–3 mm and consist of a multitude of fascicles. In comparison, an injection needle that has an outer diameter of < 0.5 mm would cause little direct trauma. Additionally, the injection needle can run into the nerve so that it slides between the individual fascicles without cutting the entire nerve. It is unlikely that a needle with a diameter of < 0.5 mm can cause such extensive damage to the entire nerve, so as to result in facial nerve palsy [27]. During the injection, many patients immediately feel an "electric shock" when the needle touches the branch of a sensory nerv. When patients perceive this "electric shock", it does not necessarily mean that it will result in irreversible nerve damage. In the case of 200 dental nerve block anesthesia, 7 patients reported having sensed an "electric shock". Of the 7 patients, only one suffered from a sensory disturbance which completely subsided within 2 weeks [14]. The symptom of an "electric shock" is usually completely reversible without any nerve damage. Therefore, a direct trauma via an injection needle is probably not responsible for facial nerve palsy [27].

However, the injection may lead to the formation of an intraneural hematoma. The needle can increase the tonicity of the small blood vessels that run within the epineurium, producing bleeding in the nerve, which can then lead to the compression and fibrosis of the nerve. This compression may occur relatively quickly (within 20–30 minutes) so that nerve damage arises before the local anesthesia subsides. The patient would not be aware of the increasing pressure on the nerve and the resulting damage [27, 28], but would perceive the nerve damage, and the resulting consequences, immediately after the anesthesia subsides. Moreover, these explanations do not explain the delayed onset of facial palsy hours after the local anesthesia has subsided and/or the involvement of chorda tympani together with the associated impaired taste sensation, described in facial palsy after dental treatment [6, 43].

Immediate palsy of the facial nerve after dental treatment

Acute facial palsy, which occurs during or immediately after a dental pro-
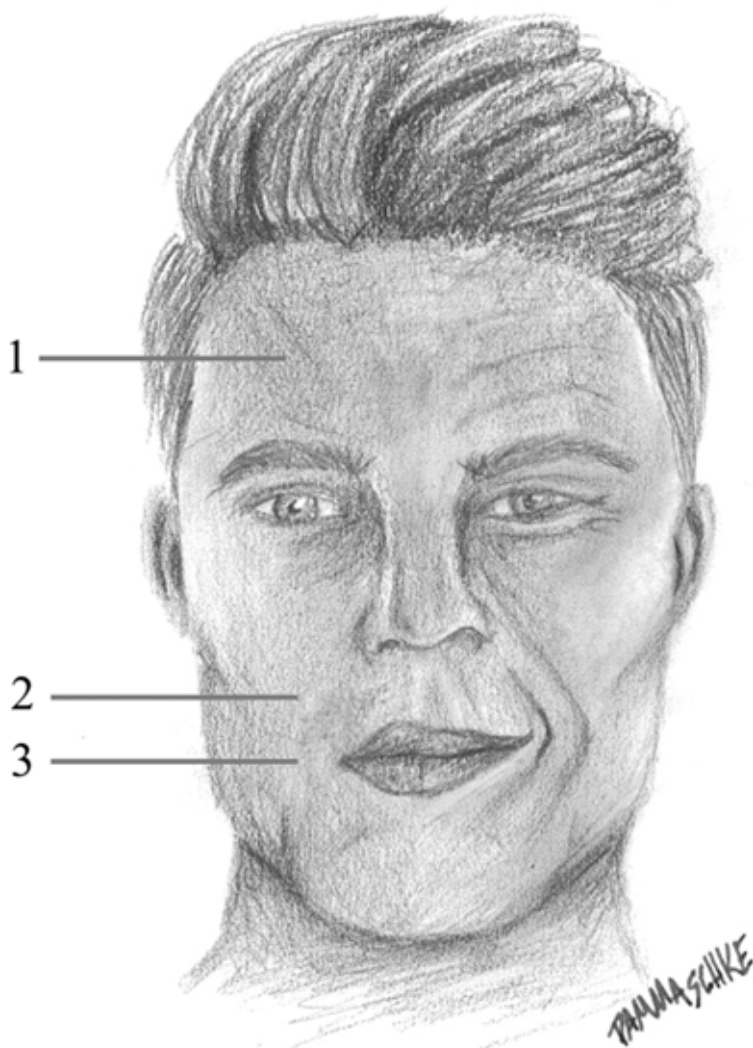
Fig. 1: Sophie Dammaschke

Figure 1 Clinical signs of right-sided peripheral facial palsy: 1. lack of frowning; 2. disappearance of the nasolabial fold; 3. drooping of the corner of the mouth and deviation of the mouth towards the unaffected side

cedure, is usually the direct result of a complication during local anesthesia. It can start immediately after the injection of a local anesthetic and it occurs on the ipsilateral side of the dental procedure. An immediate, direct palsy of the facial musculature thus results from the direct accidental anesthesia of one or more branches of the facial nerve. Normally, in the immediate type, this palsy occurs within minutes of the injection, with a recovery time of 3 hours or less; however, in exceptional cases, it can take 12–24 hours [3, 5, 6, 11, 13, 21, 42, 43]. The visible palsy of the mimic musculature is always temporary, and as the anesthetic subsides, this disappears completely without leaving any permanent damage [20].

Acute facial palsy can occur if the injection is accidentally injected too far posteriorly, thus causing the anesthetic solution to be injected close to or even into the parotid gland. The deep lobe of the parotid gland extends around the posterior ramus of the facial nerve and projects forward on the medial surface of the ramus. In most cases, the parotid gland surrounds the facial nerve and an injection in the vicinity of the parotid gland consequently results in the direct anesthesia of the facial nerve [4, 20, 34].

However, there are also anatomical variations in which the parotid gland does not envelop the facial nerve and its branches [6], or the facial nerve's branches in the retroman-

dibular space appear abnormal [5, 21]. Such deviations from the normal anatomy increase the probability of direct exposure to an anesthetic, even if the anesthesia is correctly performed.

It must be emphasized that some authors believe that it is difficult to anesthetize the facial nerve in this manner through the oral cavity [5, 43]. Moreover, even with these explanations, it cannot be elucidated how a delayed onset of facial palsy occurs hours after the local anesthesia has subsided and/or the involvement of the chorda tympani with the associated taste disturbance [6, 43].

Delayed palsy after dental treatment

In the delayed type of facial nerve palsy, symptoms appear within a few hours to several days after dental treatment, while the recovery period can extend from 24 hours to several months [6, 21, 42]. The pathogenesis of the delayed type is more complex than that of the immediate type and it has not been ultimately clarified. Consequently, the exact cause can only be speculated [27, 42], but in literature, the following theories have been discussed:

Compression edema due to the sympathetic vascular reflex

Facial nerve palsy can possibly be the result of a sympathetic vascular reflex that leads to ischemia in the area of the stylomastoid foramen. The anesthetic solution, its respective decomposition products, or the mechanical action of the injection needle itself stimulates the sympathetic nerve plexus connected to the external carotid artery (vegetative nerve plexus). From the external carotid artery, the fibers of this plexus continue to remain in contact with the stylomastoid artery (a branch of the occipital artery in 66 % of cases and a branch of the auricular artery in the remaining cases) until they enter the parotid gland. Stimulation of the sympathetic stylomastoid plexus leads to a delayed reflex spasm of the vascular nerves of the blood vessels that supply the facial nerve. This leads to ischemic neuritis and secondary edema. These sympathetic

nerve fibers originate in the upper cervical ganglion, from which the lateral, medial and anterior branches arise. From these, it is the anterior branches that follow the common and external carotid arteries and form plexuses that accompany the blood vessels [6, 21, 40]. In short, the anesthesia indirectly leads to a reflex-induced vasospasm of the stylomastoid artery and a retrograde epidural compression edema of the facial nerve in the bone canal of the stylomastoid foramen, and consequently, to ischemia of the nerve [32, 44].

Allergic reaction

The possibility of a localized allergic reaction was also considered. The delayed onset of the reaction and the rather generalized peripheral nerve dysfunction [12] would argue for this. However, in literature, there are no further references to this theory.

Aromatic alcohols

Furthermore, there have been considerations as to whether an alternative reaction path in the chemical decomposition of the local anesthetic could lead to the formation of aromatic alcohols (phenols) around the nerves. These aromatic alcohols could give rise to delayed chemical nerve damage [27, 29, 43].

Prolonged mouth opening

Moreover, prolonged mouth opening during treatment, which results in an overstretching of the facial nerve, has been associated with facial palsy [3].

There is no scientific evidence for any of the theories mentioned above so far. Therefore, it must be emphasized that these are merely attempts at an explanation.

Viruses as the cause of delayed facial palsy

Presently, the most accepted theory that explains why delayed facial palsy can occur after dental treatment is a latent virus infection; dental treatment and/or anesthesia can reactivate viruses such as the herpes simplex virus type 1 or varicella zoster virus [11, 18, 25, 42].

The mechanism leading to viral reactivation in nerve ganglia is known to be caused by varicella zoster viruses in the case of shingles (herpes zoster) for instance. Primary infection with the varicella zoster virus leads to chickenpox in childhood. Even after complete recovery, varicella zoster viruses persist for life in the brain and spinal ganglia. Reactivation of the varicella zoster virus (usually by stress or immunodeficiency for example) leads to shingles that is accompanied by characteristic painful unilateral and dermatome-related skin redness with blistering. The same applies to infection with herpes simplex virus type 1; although the primary infection often goes unnoticed in childhood, reactivation leads to a typical blistering of the lips (herpes simplex labialis) subsequently. However, these skin changes do not necessarily have to occur (zoster sine herpete) or they can be delayed in up to half of patients [18]. Similarly, this applies to facial palsy too. Some patients show no herpetic skin changes neither before nor after the onset of facial palsy [9]. Reactivation of the varicella zoster virus was demonstrated in 29 % of patients with facial palsy without causing skin changes (zoster sine herpete) [10]. For this reason, it is currently believed that zoster sine herpete is the cause of nearly one third of facial palsies that were previously diagnosed as being idiopathic [37].

When facial palsy occurs, the viruses from the geniculate ganglion, which is part of the facial nerve, are probably reactivated. After their reactivation, the viruses destroy ganglionic cells and spread into the endoneurial fluid along the motor branches of the facial nerve. The viruses infect Schwann cells, which leads to demyelination and inflammation of the facial nerve [1, 5, 6, 30, 32, 41]. Inflammation of the nerve initially leads to reversible neurapraxia (dysfunction of the nerve), but ultimately to Wallerian degeneration. Wallerian degeneration refers to a complex molecular process that occurs after damage to a nerve in the peripheral nervous system (PNS) or to fiber tracts in the central nervous system (CNS) and, viewed from the site of damage, it results in the destruction of the nerve component located distally of the perikaryon. The varicella zoster virus shows a more aggressive biological behavior than the herpes simplex virus type 1 because it spreads via satellite cells (= mantle cells, which coat the cell body of the neurons) across the nerve [18].

This theory of the viral etiology of facial palsy was published almost 50 years ago [1, 23] and has been confirmed in various studies [26, 33]. In particular, the herpes simplex virus is suspected to be the causative agent of facial palsy based on investigations in molecular biological [8]. Herpes simplex virus genomes could be detected in facial nerve cell fluid in 79 % of patients with acute facial palsy using polymerase chain reaction (PCR) techniques [25]. Moreover, it has been shown in animal experiments that herpes simplex viruses have the ability to induce facial palsy [7, 15, 35, 38].

Various mechanisms can trigger the reactivation of viruses, despite the fact that the exact mechanism is not always known. At present, though, it is assumed that this can also happen through dental treatment. In cases where viruses are reactivated by dental treatment, this is not necessarily related to the administration of a local anesthetic. It is important to note that in 1/3 [8] to 1/2 [11] of cases, where delayed facial palsy occurred after dental treatment, no local anesthesia was used. Even comparatively less invasive dental treatment measures that do not require local anesthesia, such as professional tooth cleaning, caries excavation, filling therapy and the fitting of dentures, have been shown to reactivate viruses, and consequently, lead to facial palsy [8, 11].

Differential diagnoses

Besides the already mentioned central facial palsy that results from a stroke for instance, peripheral facial palsy should be distinguished from a number of diseases that have similar clinical features, but which are clearly not related to dental treatment. The list of differential diagnoses includes, for example, anatomical variations in the path of the nerve, ischemia (inadequate blood flow), trauma (fractures of the petrous bone), surgical in-

juries, acoustic neuroma, otitis media, malignant parotid tumors, Lyme disease, various infectious diseases (Rickettsia-, HIV, mumps, cytomegaly, rubella infections), syphilitic or tuberculous basilar meningitis, sarcoidosis (Heerfordt's syndrome), Ramsay-Hunt's syndrome, Guillain-Barré's syndrome, Sjögren's syndrome, Melkersson-Rosenthal's syndrome, Miller-Fisher's syndrome, meningeosis carcinomatosa [17, 24, 40, 42, 45].

Therapy and healing

There is hardly any data on the prognosis of delayed peripheral facial palsy in connection with dental treatment in literature. In principle, it can be assumed that the prognosis of idiopathic facial palsy is good even without therapy. A complete recovery can be expected in circa 70 % to 94 % of patients after 6–9 months [17–19, 45]. Full recovery can take up to 24 months (or longer) [11]. Yet, in a few patients, facial palsy does not heal if left untreated [18].

The evidence-based therapy of choice for idiopathic facial palsy is the oral administration of glucocorticoids (prednisolone). The therapy should begin as soon as possible after the onset of symptoms (< 72 hours) [17, 36]. The hypothesis that dental treatment can reactivate viruses, which then result in the development of facial palsy, suggests that glucocorticoid administration should be supplemented by virostatic therapy (acyclovir). Thus, prednisolone in combination with acyclovir should improve the probability of a complete recovery. In this manner, the healing rate of patients treated with prednisolone combined with acyclovir was 95.7 %, which is higher than that of patients treated with prednisolone alone (88.6 %) [16]. Nonetheless, the available studies on idiopathic facial palsy are relatively heterogeneous. In particular cases, a treatment that combines glucocorticoids and antivirals can be considered after discussing the findings with the patient [17]. Especially if there is suspicion that the dental treatment could have reactivated viruses, additional antiviral therapy is absolutely necessary. Prophylactic antiviral therapy prior to dental surgery can be helpful for preventing recurrent facial palsy in patients who have had prior facial palsy or who complain of recurrent herpes infections [11].

In addition to oral drug therapy, symptomatic therapy can be recommended if necessary; for example, in cases of insufficient eyelid closure, artificial tears, dexpanthenol eye ointment and nocturnal watch glass dressing can be used [17, 44]. Conversely, a recent meta-analysis on physical therapy (physiotherapeutic exercises, mimic exercises, electrotherapy) showed neither a significant benefit nor a significant harm [39].

Principally, the exact diagnosis and therapy of delayed facial palsy is the responsibility of a specialist physician. A referral to a neurologist for further therapy should be made as soon as possible after the first signs of facial palsy appear. The physician should be informed about the possible reactivation of viruses through dental treatment.

Conclusion

A delayed onset of facial palsy after dental treatment can possibly be related to the reactivation of viruses (herpes simplex virus type 1 or varicella zoster virus) from nerve ganglia. Dentists should be aware of the potential for irreversible damage to the facial nerve by the viruses and the need for early drug therapy, which is the neurologist's responsibility. An immediate referral to a specialist is therefore necessary.

Acknowledgements

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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Recognition and prevention of cognitive biases and judgment errors in diagnostics and dental therapy

Introduction: Cognitive biases affect perception, memory, thinking and judgment. Mostly, they are the result of heuristics, i.e. mental shortcuts accelerating the decision-making process. In medicine, several biases can be recognized in both patients and practitioners such as choosing between treatment options and making errors in diagnostics and therapy, respectively.

Methods: In order to synthesize this review, the literature in psychology and medicine was analyzed for the purpose of elucidating various biases and describing their relevance in dental practice.

Results: Several cognitive biases were found to be relevant for diagnostics, decision making, treatment and practice management: the tailored framing of the communication content changes the perception of risks and influences the placebo and nocebo effects. The status quo bias may explain why patients tend to avoid undergoing reasonable treatment due to loss aversion. Affect heuristics shows the dependence of decision making on current emotions, which are rarely beneficial for the patient. Both the confirmation bias and attribution error affect diagnostics; facts supporting the initial diagnosis are given preferential consideration and the symptoms of patients who are perceived as difficult characters may be ignored or conveniently classified as psycho-somatic. The anchoring effect demonstrates why initial information has a disproportionate influence on the diagnosis. The overconfidence bias results in the practitioner's distorted self-perception, which can result in errors in diagnostics and therapy. Priming can direct the patient's perception towards a more positive outcome. The peak-end rule states that the recollection of a treatment is mainly influenced by the most aversive and final stimulus. The hindsight and outcome biases illustrate the tendency to remember a past experience in a distorted manner after events occur, thus underlining the importance of detailed patient records. The perception of the dentist's competence depends not only on dental skills, but due to the halo and nocebo effects, also on the environment, circumstances and style of communication.

Discussion and conclusion: Cognitive biases affect both patients and dentists and this leads to errors in diagnostics, decision making and treatment. Dentists can try to use debiasing strategies in order to reduce those effects. Visual images such as pie charts and bar graphs help to reduce the effects of framing, especially in patients who are not mathematically inclined. The strategic use of cognitive biases by practitioners can be used to direct patients' perceptions towards more positive treatment experiences.

Keywords: biases; heuristics; psychology; diagnostics; decision making; treatment; practice management

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1. Introduction

For centuries, a general consensus existed that humans are rational beings who make deliberate and utility-maximizing decisions. Yet, over time, it has become increasingly clear that various influences affect the decision-making process.

Biases are universally detectable cognitive distortions in perceiving, remembering, thinking, and judging. They usually arise due to the use of heuristics, i.e. mental shortcuts that accelerate decision-making processes through unconscious judgments [19]. Also, in medicine, diverse biases exist. These affect both patients when they weigh treatment options, as well as, physicians who can make diagnostic and therapeutic errors [38].

The aim of the article is to describe some of the systematic errors which are particularly relevant for dental practitioners with regard to diagnostics, the interaction between dentist and patient, therapeutic decisions, but also for dental practice management. This is intended to enable dental practitioners to better reflect on and control their behavior as well as to understand patient actions more thoroughly. In addition, specific strategies may help to reduce the effects of practitioners' cognitive biases (debiasing).

2. Diagnosis, therapeutic decision and treatment

At the start of every dental treatment, the anamnesis as well as the extraoral and intraoral findings are collected. This is followed by the diagnosis, the presentation of treatment options, informed decision making and potential treatment. The inherent cognitive biases in this process are explained below.

2.1 Framing

The concept of "framing" refers to the specific framework in which the content in communication is conveyed, as the form of presentation influences the reaction to the content [44]. A well-known study of the phenomenon of different reactions to a situation, which is the same in terms of content, but presented differently in terms of communication, includes the example of a fictitious illness formulated by Tversky and Kahnemann [44]. In the study, 600 people were told that they might have been infected during the outbreak of a disease and then asked to evaluate programs for dealing with the disease: by applying Program A, 200 people would be safely saved, while Program B would save all 600 people with a probability of 1/3 and nobody with a probability of 2/3. Although both programs had the same expected value of survivors, 72 % preferred program A, the risk-avoiding alternative. Other participants received the following alternatives: by applying program C, 400 people would die, while the application of program D corresponded to a 1/3 probability that nobody would die and a 2/3 probability that 600 people would die. Only 22 % of the participants chose program C in spite of the fact that its content contains the same risk-avoiding scenario as program A.

People thus prefer a risk-avoiding option in the case of a potential gain, but make riskier decisions when losses are anticipated. Accordingly, the way a therapy is presented will lead to different decisions depending on whether the option is in the context of a gain or loss. A systematic review showed that patients are 1.5 times more likely to choose a riskier treatment alternative if the expected outcome is presented as a survival rate rather than a death rate [27]. Framing can also enhance the placebo effect and weaken the nocebo effect [12]. Yet, not only patients are affected by framing: physicians likewise interpret data, such as drug efficacy, differently depending on how the data is presented [33].

If the findings pertaining to framing are applied in dentistry, there is the presumption that patients will evaluate the possibility of tooth preservation more positively when it is framed as a gain. This includes, for example, the phrasing that 9 out of 10 teeth will be saved by root canal treatment. When framing a loss, such as the possibility that one tooth out of 10 teeth will not be saved, the judgment is expected to be less positive.

2.2 Denominator neglect

The way probabilities are presented also influences the decision. Subjects had the choice between an urn containing 10 balls, one of which was red, and another urn containing 100 balls, 8 of which were red [29]. The study participants were then asked to select the urn from which they would like to draw a ball, knowing that a prize would be offered for drawing a red ball. Although the first urn should have rationally been preferred, 30–40 % of the study participants chose the second urn because of the higher nominal numerator value. They neglected the influence of the denominator. Applied to dentistry, this means that patients evaluate therapeutic outcomes more positively if, for the same probability, the representation with a larger numerator is selected, e.g. 90 out of 100 teeth instead of 9 out of 10.

A variation of this phenomenon is evident in another study in which the same probabilities led to different estimates due to different representations: forensic psychologists and psychiatrists were asked to decide whether a patient could be discharged from a hospital. The probability of committing a violent crime within 6 months after discharge was estimated at 10 % for similar patients. Other participants were told that, from 100 similar patients, 10 would commit a violent crime within 6 months of discharge. Despite equal probabilities, only 21 % of psychologists and psychiatrists were against discharge in the first presentation, compared with 41 % in the second, nearly twice as many [41]. This means that a higher probability of occurrence is assigned to absolute frequencies than to percentages when they represent the same value.

Conversely, when numbers are compared directly, a relative description such as a 100 % increase has a more dramatic effect than an absolute comparison involving an increase from one to two cases per 1000 patients. The representation of results in absolute numbers is thus considered to be the format least influenced by bias [33].

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2.3 Status quo bias

It is not uncommon for therapeutic proposals to be prepared for patients and discussed with them, but ultimately not be carried out. Causes for this include the fear of treatment [16], on the one hand, and financial aspects, on the other hand [14]. However, even patients for whom these factors do not apply sometimes wait until the onset of complaints. The reason for this may be the "status quo bias," i.e., the preference to maintain the current condition. If an existing status quo alternative exists, it is chosen disproportionately often [37]. In dentistry, this implies that patients tend to want to avoid treatment in order to maintain the current condition, especially if there are no acute complaints.

One of the explanations for the status quo bias is "loss aversion". This describes the tendency to avoid losses if there is an equal chance of a gain [21]. Some studies suggest that losses are perceived twice as negatively as gains of the same magnitude [22].

Despite today's massively changed living environment compared to earlier developmental times, one conceivable explanatory approach is of an evolutionary nature: if the loss of a unit of food might have been fatal, the gain of an additional unit yielded little advantage in relation to it. In connection to dentistry, this effect means that, in the absence of complaints, the risk-benefit ratio of treatment is shifted in the direction of the risk of possibly experiencing pain after treatment. The above-mentioned factors can then result in the status quo bias of tending to avoid treatment.

2.4 Affect heuristics

Affect heuristics describes how people generally tend to make decisions depending on their current, prevailing emotional state. Like the status quo bias, it can influence patients' treatment decisions. If the feelings towards a situation are positive, the risks are assessed as being lower and the potential benefits as being higher. On the other hand, if negative feelings predominate, the assessment is reversed [6].

Current emotional states can influence treatment decisions in dentistry. The "fight-or-flight" reaction is particularly pronounced in anxious patients. As originally described by Walter Bradfort Cannon [4], the body automatically reacts with fight, flight or freeze in moments of fear. In these conditions, it is more difficult for a patient to make rational decisions. In relation to elective treatments, it has been shown that anxiety leads to the rejection of certain dental treatments [24]. Thus, the practitioner should be aware of the patient's emotional state. This awareness can occur intuitively or through the acquisition of additional knowledge for analyzing facial expressions [5], body language, voice, etc.; it represents a demanding and central task of the dentist.

2.5 Confirmation bias

The confirmation bias describes the tendency of people to interpret, select, and favor information in ways that fit their own expectations [30]. Attempts to revise these assumptions are rarely made. This is because maintaining two opposing opinions at the same time creates cognitive dissonance, which can lead to mental stress or even physical discomfort [11]. In diagnostics, this mental bias can ensure that, once practitioners are convinced of the correctness of a diagnosis, they will selectively search for facts supporting the respective theory.

2.6 Attribution error

The attribution error states that the reason for complaints is searched for in a patient's personality traits, and consequently, symptoms may be overlooked. This is particularly true if dealing with the patient is strenuous due to their personality type, and the causes of the symptoms of discomfort are unclear [9]. Mentally taking a step back in order to objectively check if the correct diagnosis has actually been made or a premature ending to the diagnostic process is being aimed for is worthwhile.

2.7 Illusion of truth

Patients do not generally know whether the information presented by the dentist is factually correct. Hence,

they rely on the trust placed in their practitioner. Whether a true statement is judged as being true or false depends on various factors which can be influenced to some extent.

The frequency with which a piece of information is perceived tends to determine whether it is believed to be correct or false. In one study, different statements were presented at two-week intervals for a total of three times and it was assumed that the subjects did not know the correct answers. The content that was repeated all three times was assigned a higher degree of truthfulness [15]. Thus, it is advantageous for the success of the practice when consistent communication with the patient is used by all employees.

"Processing fluency" also contributes to the assessment of a statement. Information that is conveyed using clearly legible lettering and color is easier to process mentally. Consequently, a higher degree of truthfulness is attributed to it [34]. The same applies to the use of language: content has a more credible effect when it is presented with words that are easy to understand [32]. When conveying information to the patient, the practitioner should attempt to make it as comprehensible and discernable as possible by using, for example, medical decision aids such as decision boards [23].

2.8 Anchoring effect

In a study, Tversky and Kahneman manipulated a wheel of fortune so that it could only stop on the numbers 10 and 65. After spinning the wheel, the subjects were asked how high they thought the share of African states in the United Nations was. Mean estimates were 25 % in the group that had been shown the number 10 on the wheel of fortune, and 45 % in the other group [43]. A number that is completely independent of the outcome therefore significantly influences estimates and serves as an anchor to which further mental steps are attached.

The anchoring effect is also present in medicine, for instance in diagnostics, where it ensures that the first piece of information mentioned influences the subsequent analysis, and

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it can thus lead to an incorrect result [38]. If a physician has made a tentative diagnosis, for example, it serves as an anchor that influences the next physician's diagnosis [18].

2.9 Overconfidence Bias

The overconfidence bias describes the fact that most people perceive themselves and their abilities as above average [25]. The overconfidence bias can also lead to incorrect diagnostic outcomes, as already established diagnoses are no longer questioned [2]. Especially beginners overestimate their abilities in the profession [8]. Together with framing, the overconfidence bias is one of the most common cognitive biases among physicians and it may be the cause of treatment errors [38].

2.10 Priming

The priming effect states that input from a particular stimulus influences the processing of subsequent afferent input. This has to do with the fact that implicit memory content is activated for the most part unconsciously by the first stimulus [28]. For example, if one reads the word "eat", one will subsequently complete the word fragment "so_p" as "soup" rather than "soap". The contrary would probably be the case if the word "wash" is read before [31].

In an investigation in which patients were shown a list of mentally, or physically, threatening as well as neutral and positive words prior to root canal treatment or extraction, it turned out that anxious patients remembered significantly more threatening words than those who were not anxious [3]. Dentists should be aware of the fact that certain words increase anxiety, and that anxiety in turn can also affect the perception of aversive stimuli. By intentionally applying this knowledge, patients' perceptions can be steered in a positive direction through the use of words that are not associated with pain or anxiety.

2.11 Negativity dominance and the peak-end rule

Negativity dominance states that when positive and negative stimuli are of equal magnitude, negative stimuli have a greater impact on the

psychological well-being [36]. Therefore, the methodical avoidance of aversive stimuli in dental treatment should generally be pursued.

A distinction is also made between what patients feel during treatment and what they remember after it, where the latter is decisive for the final assessment. In a study assessing pain during colonoscopy – performed with no narcotics and amnestic drugs at that time – patients were asked once per minute about the pain they felt at a particular moment and the pain intensity was plotted against time [35]. The scale of pain intensity ranged from "pain-free" (grade 0) to "unbearable pain" (grade 10). Subsequently, the patients were asked to provide an overall retrospective assessment of the pain they had experienced during treatment. Theoretically, the results should have correlated with the area under the curve of the recordings, but this was not true. The grading was well predicted by the pain intensity at the peak and at the end (peak-end rule), while the duration of the unpleasant sensations was neglected.

Relating to dentistry, this means: if the goal is to ensure that the patient remembers the treatment as being the least unpleasant as possible, the dentist must first try to keep the peak of aversive stimuli as low as possible during the entire treatment period. On the other hand, the treatment session should be planned to end positively, for example, through the use of empathetic communication or by performing the final treatment steps in a particularly gentle manner.

2.12 Hindsight and outcome biases

The human brain's ability to reconstruct past beliefs after a change of opinion is inadequate [20]. This leads people to assess previous events as having been more predictable than they actually were before they occurred, which is then referred to as hindsight bias.

The outcome bias refers to the assessment of the quality of decision making based on the influence of currently known outcomes. Actions which may have seemed thoroughly

thought out at the time of the decision may now be considered negligent under the impression of events occurring differently than expected. Therefore, in the legal evaluation of medical negligence, the hindsight and outcome biases play a role because both pose a risk to the realistic judgment of a situation that occurred in the past [17].

In dental practice, the dentist should be aware of the effects of the aforementioned cognitive biases. The need for accurate records of all findings and procedures is particularly clear in cases where dentists are required to prove exactly how they arrived at certain therapeutic steps in the event of an accusation by the patient, thus avoiding the negative consequences of the hindsight and outcome biases.

3. Practice management

There are also some biases and misconceptions when it comes to practice management and dealing with employees; knowledge of them can potentially improve success and employee satisfaction.

3.1 Fundamental attribution error

Attribution is the process of assigning causes to behaviors. External attribution is characterized by seeking reasons not related to the self, but rather, to the difficulty of the task or the influence of other people. Internal attribution refers to searching for causes related to the self, e.g. individual abilities, personality, or motivation. The fundamental attribution error states that strange behavior is mostly explained by the traits of the respective person. In contrast, attribution varies when self-performance is assessed: in the case of negative events, the influence of the situation is more likely to be emphasized, whereas in cases of positive events, mainly dispositional factors of the person are seen as the cause of success [13]. Practitioners should be aware of this bias in order to achieve satisfactory communication with their staff. If a mistake is made, knowing that the situation and not necessarily the lack of skills or lack of motivation is potentially decisive; this allows the practitioner to solve problems more empathically.

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Bias	To be considered in practice	Example
Affect heuristics	Establishing an emotionally positive setting	e.g. "take a deep breath in and out" vs. "you do not need to be afraid"
Anchoring effect	In diagnostics, ensuring that the initial information does not disproportionately influence the subsequent analysis	e.g. patient: "my family dentist has said that the tooth can no longer be preserved"
Attribution error	In case of unclear complaints, do not search prematurely for a diagnosis based on the patient's personality structure	e.g. in cases where patients are receiving psychological therapy, do not directly assume that the causes for the complaints are psychosomatic
Availability bias	Question diagnoses so that recently acquired knowledge regarding a possibly rare disease does not influence the current diagnosis through its mental presence	e.g. considering the possibility of bone metastasis of a carcinoma for apical ostitis
Confirmation bias	Diagnostics: do not only search for facts that confirm the initial assumption	e.g. suspicion of "symptomatic apical periodontitis" after positive percussion test. Nevertheless, consider and check other diagnoses (e.g. sinusitis maxillaris)
Denominator neglect	A higher numerator increases the perceived probability	e.g. "90 out of 100 teeth are retained by treatment" vs. "9 out of 10 teeth are retained by treatment"
	Absolute frequencies increase the perceived probability	e.g. "90 out of 100 teeth are preserved by treatment" vs. "90 % of teeth are preserved by treatment"
Framing	Present treatment options using positive framing	e.g. "9 out of 10 teeth are preserved by treatment" vs. "One out of 10 teeth cannot be preserved"
Fundamental attribution error	Being aware of dispositional and situational influences on oneself as well as on others	e.g. in patients with a small mouth opening, do not directly assume that a lack of willpower might be the cause
Halo and horn effect	Factors not related to the dental performance per se also influence the patient's judgment	e.g. paying attention to friendliness, cleanliness, etc.
Hindsight and outcome biases	Complete recording of the findings and treatment procedures	e.g. clarification of the treatment procedure and recording the participatory decision making of the patient
Illusory truth effect	All employees consistently communicate the same information to the patient	e.g. regular team meetings in order to discuss and coordinate communication with patients
	Patient information clearly legible (color, font), use of easily understandable words	e.g. written information for patients should be easy to understand
Loss aversion	Might lead to the avoidance of treatment, especially when no pain is present	e.g. patient has no complaints. Thus, no subjective gain is likely achieved through treatment, but only a potential loss of freedom from pain
Overconfidence bias	Critically scrutinize own diagnoses and performance	e.g. discussing cases with colleagues
Peak-end rule	Minimize the magnitude of aversive stimuli during treatment and end the treatment procedure on a positive note	e.g. performing the final treatment steps in a gentle manner, concluding discussion should take place in a positive atmosphere and at eye level with patients
Priming	Using positive words to describe the treatment	e.g. treatment of children: "We'll put the tooth to sleep now" instead of "There is a sting now"
Status quo bias	Might lead to the patient's avoidance of treatment due to the tendency to want to maintain the current condition	e.g. patient no longer comes for treatment after the therapy has been proposed

Table 1 Overview of the above-mentioned biases listed in alphabetical order and their significance in dental practice
(Tab. 1: O. Rehder)

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3.2 Perceived competence of the dentist

The patient's image of the dentist's competence is not only determined by dental skills. The "halo effect" states that the positive impression of a person, company or brand in a certain area has a favorable effect on its judgment in another unrelated area [1]. The opposite of this is the so-called "horn effect" [40], in which a negative factor influences the judgment in areas that are not actually associated with it. If these findings are transferred to dentistry, it can be assumed that both the halo and horn effects unconsciously influence the judgment of the dentist's competence. This is because factors such as friendliness, attractiveness and equipment of the practice, all of which do not correlate with the actual quality of treatment, have an effect on the formation of the patient's opinion.

The individual's own prediction about how a task will be accomplished has an influence on perceived competence as well: in one study, participants were presented with a task and were required to make a prediction about the outcome that would be attained before beginning to solving it. After the results were evaluated, the observers assessed the competence of the participants. Not only did the actual outcome matter, but also the prediction: participants were evaluated positively if good self-assessments were followed by congruent performance, or if the quality of the latter remained unknown; conversely, participants with negative self-assessments were evaluated adversely even if their assessment was accurate [39]. Practitioners should therefore be aware of the fact that their own prognosis about the treatment has an impact on the perception of their competence, especially since patients cannot ultimately judge the actual quality of the treatment. In this regard, practitioners should not create unrealistic hopes, but should show confidence which is justified.

4. Summary and prospects

Cognitive biases and the associated misjudgments can affect both patients and physicians. The aim of this review article is to explain a selection of systematic errors which appear to be particularly relevant with regard to diagnostics, the interaction between dentist and patient, treatment decisions and practice management. An all-encompassing presentation of all biases affecting dentistry is beyond the scope of this review article. For this reason, this article has focused on the most important biases and it presents an overview of this information (Table 1).

Various studies indicate that practitioners' errors in diagnosis and therapy can be possibly attributed to cognitive bias [38]. However, the decisions of patients may also be modified by the effects of framing, denominator neglect, status quo bias, anchoring effect, and confirmation bias.

There is also the possibility of using mental biases for the therapeutic advantage of patients: through priming, it is conceivable to channel patients' perceptions in a favorable direction, for example, by using words with positive connotations so that the current experience is not dominated by ideas with negative connotations. Understanding the peak-end rule may put the dentist in the position to prevent situations where the patient experiences severe discomfort and to end the treatment session on a pleasant note, thereby positively influencing the patient's recollection of the treatment.

Knowledge of the hindsight and outcome biases illustrates the need for having good patient records. In cases of negative treatment outcomes, it then becomes possible to comprehend how decisions and treatment procedures were made. In this regard, the records serve as a basis for positive communication with the patient while also providing reassurance should legal disputes ever arise.

Moreover, by knowing about the effects mentioned above, the practitioner becomes aware that it is not exclusively the dental performance per se that determines the practice's success, but, for example, that the halo and horn effects and own prognoses influence the patient's judgment to a certain extent.

Studies aiming to reduce the negative influences of mental biases have shown that it is not possible to eliminate patients' biases by simply pointing out their existence, and then asking the patients to avoid being influenced by them [7]. Accordingly, visual representations in the form of pie charts and bar graphs can help to reduce the effects of framing. It is noteworthy to mention that patients with low mathematical competence benefit more from such visual images than patients with good skills in this domain [10].

The "debiasing" approach can be used in order to minimize the influence of biases on physicians' diagnoses and decisions. This includes the questioning of the initial diagnosis by seeking evidence that rejects and confirms it, before making a final diagnosis [26]. Moreover, the use of checklists can reduce the influence of overconfidence, the anchoring effect, and framing [38].

Mental biases are probably ubiquitous in medicine. However, their true influence on treatment errors and outcomes has not been conclusively examined so far due to the insufficient number of studies [38]. Nonetheless, in the best interest of patients, it makes sense to use these findings in order to give patients the opportunity to make better decisions for themselves and to provide a more positive treatment from a psychological point of view.

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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