



# Peri-implantitis, periodontitis, endodontics: Dental market analysis and future trends

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## Abstract

**Background:** The ageing of the population and the importance of aesthetics put pressure on the delivery of dental care. Bacterial infection in intra-oral cavities can develop into a pathogenic biofilm, which then induces inflammatory processes. One of the necessary dental treatment steps is the disinfection of the infected area, whether it is in the root canal, or in the periodontal, periapical, or peri-implant regions. The objective of this review is to assess the actual situation and trends in the treatments for three of the most important areas of dental health: peri-implantitis, periodontitis, and endodontics.

**Methods:** Results from clinical studies, reports from dental associations, national health insurance records, and market reports are used to quantify the number of treatment needs. For peri-implantitis, the number of inserted implants and the prevalence of peri-implantitis build the basis for the computation. For periodontitis and root canal treatments (RCTs), health insurance figures, and reports on dental instrument orders are the data sources for the estimations.

**Results:** The data show that the number of performed periodontitis and RCTs increase linearly over the year, mainly driven by demographic changes, i.e., increase in size and age of populations. The computed values show that the treatment need for peri-implantitis follows an exponential growth and may surpass that of periodontitis by 2023 in Europe and in the USA.

**Conclusion:** Where dental implantology is growing, the rapid development of peri-implant diseases will burden the health systems. This should be addressed at different levels. At the practitioners' level, this includes continuous training of staff and (re)investment in adequate material and infrastructures. At the governmental level, it includes policy development and reimbursement strategies as well as information dissemination in health insurance and dental associations. Last, but not least, R&D efforts in the public and private sectors should be implemented/boosted.

**Keywords:** Peri-implantitis, Periodontitis, Endodontics, Dental care, Dental implantation

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## Introduction

Dental implants are the crown of today's dentistry. The need for dental implants can be expressed in one exemplary statement: "In the world's largest market, the United States, more than 36 million Americans do not have any teeth, and 120 million people in the United States are missing at least one tooth."<sup>1</sup> Although dental implants are becoming a standard solution to dental loss, they come with the risk of bacterial-related complications. Peri-implantitis is an inflammatory, usually irreversible process induced by a pathogenic biofilm in the tissue surrounding the functional osseointegrated implant, leading to the loss of the supporting bone and, often, of the implant. At a preliminary stage, mucositis in the peri-implant soft tissue is a reversible inflammatory change without bone loss. Peri-implantitis is to a dental implant what periodontitis is to a natural tooth.

According to the World Health Organization, oral disorders are the most common causes of the global burden of disease, and periodontal diseases are the second most common oral disease worldwide after dental decay.<sup>2</sup> According to the European Federation of Periodontology (EFP), periodontitis is the "most common chronic inflammatory disease," with 6 out of 8 people showing some degree of periodontal inflammation.<sup>3</sup> However, treatment need not necessarily lead to therapy.<sup>4</sup> Therefore, this data from the EFP is not an indication of how many periodontal treatments are performed on a daily basis in a dental practice.

Endodontics focuses on the treatment of root canals and tooth pulp to keep the natural tooth in a healthy state. In endodontics, as for periodontitis and peri-implantitis, the control of the bacterial burden is essential, and a complete disinfection of the site is the overarching aim of



the respective therapies.

The objective of this review is to assess the actual situation and trends in the number of performed treatments for three dental procedures that include a disinfection step: peri-implantitis, periodontitis, and endodontics. The regions in focus are Germany, Europe as a whole, and the United States.

## Methods

### Peri-implantitis

Peri-implantitis therapies are usually paid out-of-pocket and are not reported by health authorities. Therefore, to estimate the peri-implantitis treatment statistics, we followed a three-step reasoning: 1) How many implants are already inserted? 2) How many inserted implants lead to peri-implantitis? 3) How many treatments does a dental implant need if peri-implantitis is diagnosed?

1. We assessed the number of inserted dental implants from reports from the dental companies Straumann and Nobel Biocare, the American College of Prosthodontists, and the Millennium Research Group. On the one hand, according to the new classification of periodontitis and peri-implantitis by the EFP and the American Academy of Periodontology (AAP), both diseases are considered treatable but not curable.<sup>5,6</sup> This means that patients with peri-implantitis should regularly come to their dentists for maintenance therapy. Hence, the number of implants to be treated in a given year is not the number of inserted implants in that year, but statistically, the cumulative number of inserted implants, which is much higher.
2. On the other hand, the insertion of a dental implant does not necessarily lead to the occurrence of peri-implantitis. Hence, we need to consider the prevalence and incidence of peri-implantitis as reported in the scientific literature. The number of peri-implantitis cases can then be calculated from the cumulative number of inserted implants over the years and the prevalence of peri-implantitis.
3. The current guideline for the treatment of peri-implant infections recommends regular check-up (ideally initially every three months and then according to individual risk) in order to identify the need for follow-up treatment at an early stage.<sup>7</sup> In case follow-up treatment is necessary, a professional cleaning and disinfection of the implant should take place at least twice a year.<sup>8-10</sup> Will the patients come to their dentist that often? This frequency seems realistic according to the survey of 435 699 people worldwide,<sup>11</sup> which showed that nearly 68% visit their dentist at least once a year and about 50% get a professional dental cleaning on a yearly basis. Therefore, treatment need can reasonably be estimated to be twice the number of peri-implantitis cases.

### Periodontitis

We first looked into the data provided by the statutory and private German health insurances<sup>12</sup> and considered the relevant positions related to periodontitis treatments. These positions are P200, P201, P202, and P203 of the BEMA (Einheitliche Bewertungsmaßstab für zahnärztliche Leistungen = uniform standard for the assessment of dental services, i.e., statutory health insurance), and 4070, 4075, 4090, and 4100 of the GOZ (Gebührenordnung für Zahnärzte = fee schedule for dentists, i.e., private health insurance).

Because few countries collect data on the treatments being performed,<sup>13</sup> we assume a five-fold ratio between the number of periodontal treatments carried out in Europe compared to Germany. This is based on the following considerations:

- The prevalence of periodontal disease in European countries<sup>14</sup> though diagnosis of periodontal disease varies from country to country and prevalence values are only an approximation.<sup>15</sup>
- The spending on oral healthcare services in European countries<sup>16</sup> though the relatively higher cost of healthcare in Germany alters the relation between cost and number of treatments.

The periodontitis market in the United States has been evaluated by Flemmig and Beikler over many years.<sup>17</sup> They observed a low percentage of treatments in relation to the prevalence of periodontitis, increasing from about 4% in 1990 to 5% in 2006. By extrapolating the percentage of the population undergoing periodontitis treatment (from the figures of 1990, 1999, and 2006) and taking into account the demographics of the United States, one can compute the number of periodontal treatments for the year 2019 and the following years.

### Endodontics

Similar to the periodontitis case, we used the data provided by the statutory and private German health insurances<sup>12</sup> to estimate the number of root canal treatments (RCTs) performed in Germany. For the European market, the number is estimated to be five times that of the German market. This ratio is here further underpinned by the 22.5% market value share of Germany (in \$) compared to that of the European market in the “endodontics and orthodontics” sector.<sup>18</sup> To cross-check those results, an alternative method was applied based on the number of sold files used for RCT from a report on the dental instrument purchases.<sup>18</sup> In order to forecast the future number of endodontic treatments, one should consider the trend from the Future Market Insights report,<sup>18</sup> though tared to the figure from the health insurance for the year 2019. Assuming that the number of files per treated tooth is the same in the USA as in Europe, the number of treated teeth in the United States ( $Z_{USA}$ ) is calculated using the ratio  $Z_{USA}/Z_{EU} = F_{USA}/F_{EU}$ , with  $F_{USA}$

representing the number of sold files in the United States.

## Results

### Peri-implantitis

The penetration rates of dental implants given by Straumann for 2011 and 2017 are shown in Table 1 for Germany and the United States.<sup>19,20</sup> The reports give figures for many more countries. These numbers correlate well with data from other sources:

- Nobel Biocare: 12 Mio. implants were inserted in 2012<sup>21</sup> (vs. 14.2 Mio. worldwide, calculated from data from the Straumann Group<sup>19</sup> in 2011)
- Millennium Research Group: “Last year [2012], an estimated 1.26 Mio. dental implant procedures were performed in the United States”<sup>22</sup> (vs. 1.59 Mio. from Straumann Group<sup>19</sup> in 2011)
- American College of Prosthodontists (2017): “Approx. 2.3 million implant-supported crowns are made annually”<sup>21</sup> (vs. 2.6 Mio. in the USA from the Straumann Group<sup>20</sup> in 2017)

Scientific reports show that peri-implantitis occurs statistically years after implant insertion and that its prevalence and incidence increase dramatically in the lifetime of the inserted implants. This means that the treatment need in a particular year is not related to the number of inserted implants in that year.

- “Prevalence (patient level) for peri-implant mucositis (inflammation of the mucous membrane)

and peri-implantitis vary from 19 to 65% and 1 to 47%, respectively. The weighted average prevalence for peri-implant mucositis is 43% (1196 patients, 4209 implants) and 22% for peri-implantitis (2131 patients, 8893 implants).<sup>27</sup>

- Another industry independent analysis of the effectiveness of peri-implantitis therapy in a Swedish population in 2016 showed that after 9 years, 60% of patients suffered from moderate or severe peri-implant changes.<sup>23</sup>
- The incidence and progression of peri-implantitis was reported to be non-linear and to accelerate over time.<sup>24</sup>
- Several studies also showed 100% implant-related mucositis in patients.<sup>25-27</sup>

Hence, we concluded that the number of implants presenting peri-implantitis in a given year is, statistically, the sum of all implants inserted up to 9 years ago (because it is not curable)  $\times$  60% (prevalence after 9 years). The needed peri-implantitis treatment in that given year is twice that value due to the realistic two treatments per year. That value is the number of implants that require a primary therapy and, subsequently, a maintenance therapy, as shown in Figure 1 and Figure 2.

### Periodontitis

Adding the figures shown in Table 2 and 3, we arrive at a total of 30.23 Mio. teeth of statutory and private patients treated for periodontitis in 2019 (note that a therapy usually consists of several treatments or sessions). A German oral health study<sup>28</sup> showed that on average 2.7 teeth (for the 35- to 44-year-olds) to 3.1 teeth (in younger seniors, i.e., 65- to 74-year-olds) present a severe periodontal disease. If a patient is treated for periodontitis (as accounted in Tables 2 and 3), the dentist will treat on average three teeth per treatment. This means that 10.1 million periodontal treatments (sessions) were performed

Table 1. Number of inserted implants

	2011		2017	
	Penetration rate (per 10k Inhab.)	Quantity (Mio.)	Penetration rate (per 10k Inhab.)	Quantity (Mio.)
Germany	120	0.97	160	1.32
Europe	80	4.07	110	5.63
USA	50	1.59	80	2.55

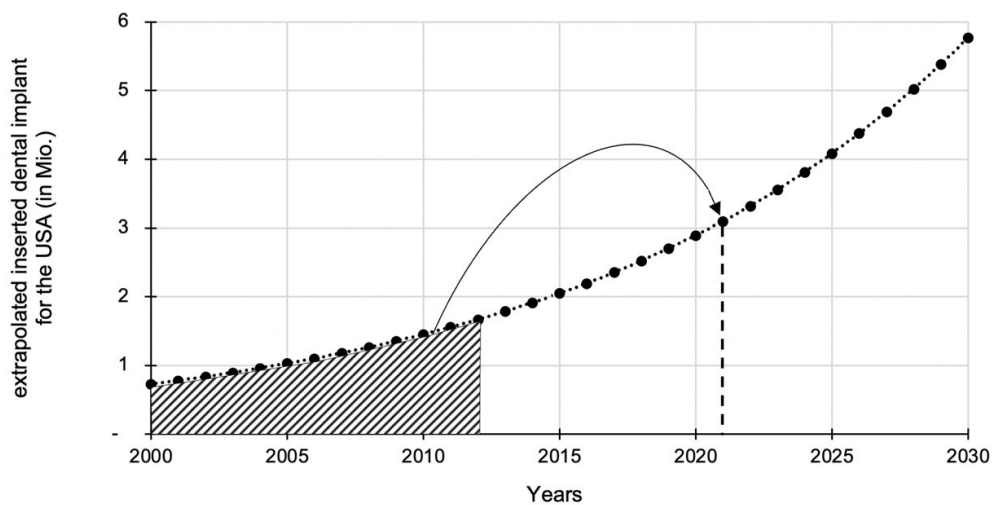
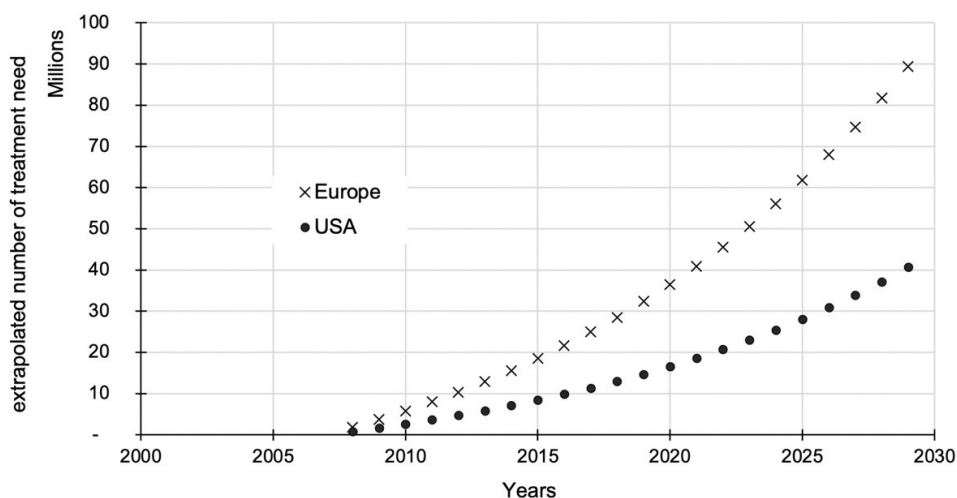


Figure 1. Computed number of inserted dental implants in the United States. The sum of implants inserted up the 9 years before (here 2012, hatched area) is the relevant reference to estimate the number of needed treatments in the target year (here 2021)



**Figure 2.** Computed peri-implantitis treatment need. The need follows an exponential growth because peri-implantitis cannot be cured as it is considered a chronic oral disease

**Table 2.** Statutory health patients in 2019 in Germany

BEMA position	BEMA description	Quantity
P200	Systematic treatment of periodontal diseases (supra- and sub-gingival debridement), closed procedure per treated single-rooted tooth	14 774 700
P201	Systematic treatment of periodontal diseases (supra- and sub-gingival debridement), closed procedure per treated multi-rooted tooth	7 999 300
P202	Surgical therapy per single-root tooth	87 700
P203	Surgical therapy per multi-root tooth	106 800
<b>TOTAL</b>		<b>22 968 500</b>

Note. BEMA=Einheitliche Bewertungsmaßstab für zahnärztliche Leistungen=uniform standard for the assessment of dental services.

**Table 3.** Private patients in 2019 in Germany

GOZ position	GOZ description	Quantity
4070	Surgical therapy per tooth with single root canals	4 070 000
4075	Surgical therapy per tooth with several root canals	3 060 000
4090	Flap OP, open curettage anterior tooth per periodontium	50 000
4100	Flap OP, open curettage posterior tooth per periodontium	80 000
<b>Total</b>		<b>7 260 000</b>

Note. GOZ=Gebührenordnung für Zahnärzte=fee schedule for dentists.

in Germany and 50.38 million periodontitis treatments were carried out in the EU (Incl. Germany) in 2019. In the USA, nearly 19.7 Mio. periodontal treatments were performed in 2019 (Table 4).

To forecast the number of periodontitis treatments for the coming years, we take the value from the annual report of the National Association of Statutory Dental Health Insurance<sup>29</sup>: “Expenditure on periodontological services increased by 3.1 percent. The long-term upward trend in the area of periodontal treatment is reflected in the

**Table 4.** Number of periodontitis treatments in the United States

Year	Population	Number of treatments in thousands	Percentage of treatments in relation to the population (%)
1990	252 120 309	10 000	3.97
1999	281 710 909	13 000	4.61
2006	294 993 511	15 000	5.08
2019	329 978 171	19 766	5.92 (determined from a linear regression line)

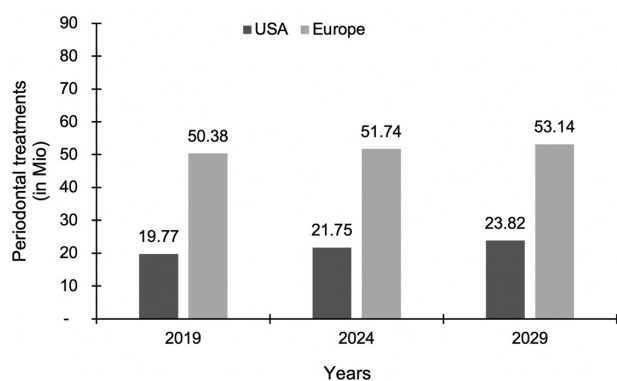
increase in the number of cases. In the field of periodontal treatment, the number of cases has risen by a total of around 49% over the past 15 years, or by an average of 2.7% per year.” For the European market, we apply a five-fold ratio to the German market. The forecasted values for the U.S. market can be computed for the coming years based on the data gathered by Fleming et al. (see Table 4). This leads to the forecast shown in Figure 3.

### Endodontics

Adding up the relevant positions of the statutory and private health insurances (see Table 5), a total of about 9.3 Mio. root canals were prepared in Germany in 2019.

Assuming an average of 1.73 root canals per tooth,<sup>30</sup> the number of treated teeth (RCT) was approximately 5.38 Mio. in Germany. For the European market, five times the value for the German market leads to approximately 26.90 Mio. RCTs.

Future Market Insights<sup>18</sup> reported that 32.47 million files were sold in Europe. This is higher than the determined number of treatments using the data from health insurance. An explanation for this difference may be the price difference of the sold files inside the European market, which would lead to a deviance from the five-fold ratio assumed above. The difference may further be explained by possible evaluation deviations in the survey of the practices provided by the Federal Chamber of



**Figure 3.** Number of treatments for periodontal inflammation in the United States and Europe. The very high prevalence for periodontitis counterbalances the fact that few people take care of their periodontal condition

**Table 5.** Number of root canal treatments for statutory and private patients in 2019 in Germany

Position	Description	Number
P32 (BEMA)	Root canal preparation (statutory patients)	8 206 900
2410 (GOZ)	Root canal preparation (private patients)	1 100 000
<b>Total</b>		<b>9 309 900</b>

Note. BEMA=Einheitliche Bewertungsmaßstab für zahnärztliche Leistungen=uniform standard for the assessment of dental services. GOZ=Gebührenordnung für Zahnärzte=fee schedule for dentists.

Dentists (BZÄK). It can also be that files are sold but not used or not used for endodontic treatments.

According to Future Market Insights,<sup>18</sup> 32.66 million endodontic files were sold in North America in 2019. From a market share value of about 89.4% (in \$) for the United States (rest = Canada, where the file cost is similar), it is possible to calculate that 29.2 Mio. endodontic files were sold in the United States in 2019. Keeping the same ratio of endodontic files to RCT, an estimated 25.58 Mio. root canals were treated in 2019 in the United States. This is displayed in Figure 4.

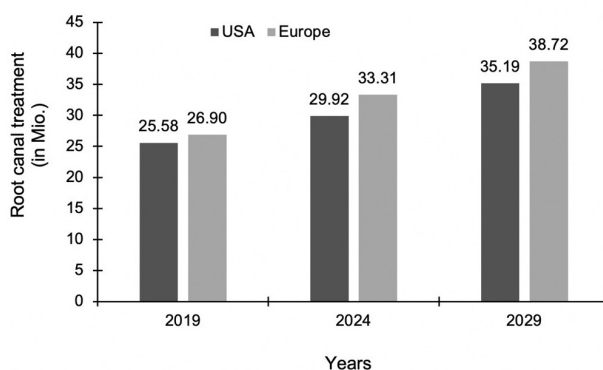
## Discussion

### Peri-implantitis

Table 1 shows a 33% growth rate between 2011 and 2017. Various factors explain the growth of the market for dental implants:

- Demography: As populations are ageing,<sup>31</sup> the need for dental prostheses increases;
- Affordability: The cost of dental implant systems is decreasing with new generations. Moreover, medical tourism is an expanding market lowering the cost hurdle of dental implants<sup>32</sup>;
- Training: The number of dentists trained in implant placement is increasing, albeit disparately.<sup>33,34</sup> New education tools and techniques facilitate continuous education<sup>35</sup>;
- Aesthetics: People are increasingly opting for cosmetic surgery and dental implants.<sup>36</sup>

The number of dental implant insertions is increasing



**Figure 4.** Number of root canal treatments in the United States and Europe

rapidly as shown above. The demand for peri-implantitis treatments is growing even faster: the latter is indeed calculated based on the cumulative sum of inserted implants. Our calculation shows that the need for treatment will almost double in about 6 years. This steep development was also recognized by the Millennium Research Group<sup>22</sup>: “The number of dental implant procedures is expected to double in 7 years to 2 540 000.” This figure predicted in 2013 for the year 2020 is lower than our actual estimation of 2.89 Mio. computed for 2020 in the United States, confirming that the dental implant market is developing even faster than predicted in 2013.

### Periodontitis

In Germany, there is a considerable discrepancy between periodontitis diagnosis (Approx. 25% of the people with statutory health insurance) and periodontitis therapy (only Approx. 2%).<sup>4</sup> Therefore, compared to the very high prevalence, there is undoubtedly a therapy deficiency. One reason might be that periodontal inflammation does not cause pain,<sup>3</sup> at least in its mild form. There might also be a lack of confidence in the treatment outcome. In fact, the IQWiG (German Institute for Quality and Efficiency in Health Care) evaluated the efficacy of current treatment methods. It reported that the closed mechanical therapy brings only a slight benefit compared to no treatment; All other therapy concepts (laser, photodynamic therapy, Widman flap technique, and surgical pocket elimination with osteoplasty), individualized oral hygiene education program, enamel matrix derivatives, antiseptic pocket irrigation, subgingival air-polishing, and chlorhexidine rinse showed no benefit over the closed mechanical therapy.<sup>37</sup> This result was confirmed by a longitudinal analysis of the accounting data of German statutory health insurance BARMER GEK, allowing an empirical consideration of the periodontal treatment results. Based on the “extraction-free survival” outcome over a four-year period, it showed that periodontally treated patients have an approximately 64% chance of keeping their treated tooth compared to a 73% risk of further

tooth extraction for the precisely matched untreated reference population.<sup>13</sup> In other words, the prevalence of periodontitis is not a good indication of the number of treatments being actually performed. Indeed, the prevalence of periodontal disease is decreasing.<sup>38</sup> However, the ageing of the population and the increase in the prevalence of diabetes<sup>16</sup> counterbalance those trends and the absolute number of treatments remains high and slightly increasing over time. Information campaigns about the importance oral hygiene and regular visits to the dentists are on-going and may increase the percentage of treatment actually sought by patients needing it in the coming years.<sup>39</sup>

### Endodontics

In 2017, the main German statutory health insurance (BARMER) reported a slight decrease in the age- and gender-standardized rate of claimed RCTs over the years 2010 to 2015 from 6.4% to 5.8%.<sup>40</sup> However, this decrease is not reflected in the number of sold files reported in the Future Market Insights report.<sup>18</sup> The first reason may be that the increase of the German population partly compensates for the rate of claimed treatments. Secondly, the ageing of the population may cause an increase in the number of sold files. As shown in the BARMER report,<sup>40</sup> the claim rate is not constant across the age group but is significantly higher among the 35- to 80-year-olds. This, in turn, means that an ageing society, as can be observed in all industrialized countries, implicates an increasing need for RCTs.

### Conclusion

The ageing of the population increases the prevalence of oral diseases and periodontitis will remain the second most common oral disease for the coming years. However, in the particular case of periodontitis, treatment need does not necessarily lead to therapy; although the absolute number of periodontal treatments will remain high because of the high prevalence among the population worldwide, it is only increasing slowly. The request for endodontic treatment may remain much lower than for periodontitis. However, driven by the acute pain, the need for treatment generally leads to actual treatment; Therefore, the absolute number of RCTs is relatively close to the treatment need, and both increase mainly due to demographic reasons.

Peri-implantitis is a totally different situation: It is the result of the insertion of a foreign body. Affordability and aesthetics, driving the increase of dental implant insertions, is indirectly increasing the need for peri-implantitis treatment. Because it is a chronic disease, the treatment need is growing exponentially. It remains to be seen whether the treatment need for peri-implantitis will lead to actual treatment being sought by patients. Whether there is a discrepancy between treatment need

and performed treatment (as for periodontitis) or not (as for endodontics), the forecasts show that the number of actual treatments for peri-implantitis may surpass that of periodontitis therapy by 2023 in Europe and in the United States.

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### Authors' Contribution

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**Formal analysis:** Loic Ledernez.

**Investigation:** Loic Ledernez.

**Methodology:** Loic Ledernez, Markus Altenburger.

**Project administration:** Michael Bergmann.

**Supervision:** Michael Bergmann, Markus Altenburger.

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**Resources:** Michael Bergmann, Markus Altenburger.

**Validation:** Loic Ledernez, Markus Altenburger.

**Visualization:** Loic Ledernez.

**Writing—original draft:** Loic Ledernez.

**Writing—review & editing:** Loic Ledernez, Michael Bergmann, Markus Altenburger.

### Competing Interests

The authors declared no conflict of interest.

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