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Interest in Orthodontic Tooth Alignment in Adult Patients Affected by Periodontitis: A Questionnaire-Based Cross-Sectional Pilot Study

Running Title: Interest in Orthodontic Treatment in Periodontitis Patients

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Summary Sentence:

The findings of this study show that a considerable number of adult patients with moderate to severe periodontitis is interested in undergoing orthodontic treatment in order to improve oral and overall health, function and esthetics.

3 **Figures**; 2 **Tables**; 50 **References**; 3475 **Words**

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ABSTRACT

Background: Orthodontic treatment can successfully align pathologically migrated teeth and lead to improvement of periodontal stability in patients with periodontitis. Periodontic-orthodontic approaches have gained increasing attention in the past years. Here, we investigated the interest of adults affected by chronic periodontitis in undergoing orthodontic treatment as well as patient-related and tooth-related influence factors.

Methods: Periodontal and orthodontic measurements/indices were taken from 115 adult patients with moderate to severe periodontitis. The study participants answered a questionnaire investigating patient demographics, quality of life aspects and their interest in undergoing orthodontic treatment. Correlations between clinical data, questionnaire responses and this interest were analyzed by means of an age- and gender-adjusted multiple regression model.

Results: Two thirds of the participants were interested in orthodontic therapy and indicated long-term healthy and esthetically appealing teeth as their main motives. A significant correlation was found between subjectively felt impaired dental esthetics and an interest in orthodontic treatment. However, there were no correlations with the severity of periodontitis, tooth alignment or patient demographics, including gender. Older patients were significantly more often interested in orthodontic treatment. Most participants had never been provided with information about orthodontic treatment options for adults.

Conclusion: A considerable number of adult patients with periodontitis is interested in orthodontics to improve tooth alignment. However, severity of periodontitis and tooth misalignment or demographic factors may not be indicative thereof. Therefore, dental

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practitioners need to be aware of patients wishing to align their teeth and to provide them with the relevant information and, if appropriate, enable interdisciplinary treatment planning.

Keywords: periodontitis, orthodontics, adult, surveys and questionnaires, quality of life, esthetics

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INTRODUCTION

Periodontitis is a chronic inflammatory disease of the gingival tissues and alveolar bone triggered by oral biofilms [1]. If left untreated, in susceptible individuals, this inflammation results in periodontal attachment loss and eventually tooth loss [2]. Periodontitis can also lead to pathologic tooth migration (PTM), which often motivates patients to seek periodontal therapy [3]. PTM occurs in 30-56% of the patients, mainly caused by diminished periodontal tissue support, mechanical pressure of edematous gingiva, dysfunctions or malocclusion [4, 5]. As a consequence, teeth become extruded, protruded and gaps can develop between the anterior teeth. This appearance can worsen after molar loss, often leading to mesial tipping of posterior teeth and resulting in a deeper bite with increased anterior occlusal loading. Dysbalanced perioral muscular forces and bruxism can further diminish oral function and phonetic problems may occur [6, 7]. Periodontal therapy alone is unlikely to completely resolve the esthetic challenges of such patients. Due to soft tissue shrinkage after successful periodontal therapy, cervical areas often become exposed and black triangles develop. Thus, the oral/dental appearance of these patients is impaired which affects their dentofacial attractiveness [8]. These developments can drastically reduce the patient's self-confidence and quality of life (QOL) [9, 10]. Orthodontic treatment is aimed at correcting malpositioned teeth and in the past decades, the number of orthodontic therapies in adults has continuously increased in the United States and Europe [11, 12].

Realignment of malpositioned teeth can substantially help maintaining the natural dentition, control periodontal breakdown and restore oral function [13-16], however, it is crucial to achieve a stable and non-inflamed periodontal condition, as well as a high level of compliance regarding oral hygiene, prior to orthodontic intervention [17]. The correction of some orthodontic problems, such as excessively tipped molars, traumatic deep-bites and flared and

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spaced incisors, may be particularly beneficial in periodontally compromised individuals [18]. Despite possible, temporary, compromise in esthetics and comfort as well as financial effort during orthodontic therapy, a considerable number of adult patients pursue orthodontic therapy to rectify PTM and optimize their dental esthetics [19]. According to previous reports, the key motives for patients seeking orthodontic treatment are improvements in esthetic appearance, functional and phonetic rehabilitation, maintenance of teeth and an improvement in QOL [20-23]. Oral health related QOL is a subjective parameter and is evaluated by assessing functional restrictions of the orofacial system, orofacial pain, dentofacial esthetics as well as psychosocial influence of oral health.

Given that periodontitis and periodontal therapy significantly impact on dental esthetics and orthodontic therapy may reduce this impact, there is little information in the literature regarding the interest of adult patients with periodontitis in undergoing orthodontic therapy. Therefore, the first aim of this study was to characterize, in a cohort of adult patients in Germany affected by moderate to severe periodontitis, the patient- and tooth-related factors associated with seeking orthodontic treatment. The second aim of this study was to investigate predictors of an interest in orthodontic treatment (IOT) within this cohort.

METHODS

Patients

A total of 115 patients were recruited for this study. Patients were recruited between 02/2013 and 06/2013 from the Periodontology department at the Dental Hospital of the University of Würzburg, Germany. All participants were undergoing non-surgical periodontal therapy in regular recall visits and were chosen for the study based on their basic periodontal examination (BPE) scores. Inclusion criteria were

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- aged >18 years
- BPE of ≥ 3 in at least three sextants
- diagnosis of generalized chronic periodontitis, defined by: a predominantly horizontal pattern of radiographic bone loss, the teeth affected (non-molar-incisor bone loss pattern), patient age and the initial presence of plaque and/or calculus.

Exclusion criteria were

- extensive prosthetic restorations such as partial dentures
- gaps of more than one missing tooth, in order to exclude the possibility that potential oral discomfort assessed in the questionnaire was caused by large spaces alone
- dysgnathia such as cleft lip/palate.

All patients participated in the study after signing informed consent and the study was approved by the ethics committee of the University Hospital Würzburg, Germany (approval number: AZ 41/12).

Measures of periodontal status

To assess the periodontal status of patients, periodontal probing was performed of all teeth at six sites for single-rooted teeth and eight or ten sites for upper or lower molars, respectively. Bleeding on probing (BOP) and gingival recessions were also recorded for each site. All measurements were taken by one examiner (A.H.). The updated case definition by the Centers for Disease Control/American Academy of Periodontology (CDC/AAP) working group (2012) [24] was used to classify periodontal health into none/mild/moderate/severe periodontitis.

Measures of orthodontic malocclusions

Bite registrations were taken in habitual occlusion and alginate impressions of both jaws were

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taken. Orthodontic study models were made and trimmed three-dimensionally in order to measure and evaluate malpositions using a sliding caliper (Munich Pattern). Little's irregularity index and contact point deviations of upper incisors were surveyed by measuring the distances from their anatomical interproximal contact area parallel to the occlusal plane. Five values (in mm) in each jaw were summed up, from the mesial contact area of one canine to the mesial contact area of the other canine in the same jaw. To estimate dental attractiveness, the esthetic component (AC) of the Index of Orthodontic Treatment Need (IOTN) was assessed (IOTN/AC) [25].

Questionnaire

All 115 study participants filled out a questionnaire in German. The questionnaire was divided into seven subsections and contained a total of 34 questions. Section 1 collected demographic data (age, gender, family status, rural or urban living environment, education, profession, income, smoking status). Sections 2-6 were derived from the German Oral Health Impact Profile (OHIP-G49), assessing oral health related QOL in adults [26] and referred to the time period of the preceding month. For this survey, selected OHIP-G49 questions were modified to focus on possible periodontitis-related and tooth alignment-related discomfort. Section 7 investigated attitudes towards orthodontic intervention and previous orthodontic experience. The questionnaire translated from German to English is shown in the **Supplementary Table 1**.

Statistical analysis

A priori sample size calculation was performed using the following parameters: one tailed, effect size = 0.23; alpha level = 0.05 and power = 0.8, indicating that a total sample size of

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n=115 was required ¶. We hypothesized a positive correlation between IOT and increased orthodontic and periodontal clinical parameters. The effect size was calculated according to the standard deviations published by Masood et al., who assessed the impact of malocclusion on oral health-related QOL by means of an OHIP questionnaire [27]. To address the aims of the study, patient- and tooth-related factors as well as QOL-related influence factors associated with seeking orthodontic treatment were assessed, considering clinical data and answers obtained from the questionnaire. Data were analyzed using a multiple regression model with the help of a statistical software [#].

RESULTS

Cohort description

Of the 115 patients enrolled in the study, 60% (n=69) were women. The participants had a mean age of 56.8 ± 9.3 years. This cohort lived mostly (61%) in an urban environment and with a partner (81%). 63% were employees or self-employed with a regular monthly income, which was predominantly in the range of 1,500-3,000€ (58%) and lower (31%). 73% of the participants had a non-university degree (vocational training degree). Most patients had a statutory health insurance (77%) and 13% were privately insured (**Table 1**). Amongst the patients were 17 smokers.

Periodontal assessment of the cohort

Given the inclusion criteria, all participants were classified as either "moderate" (n=36) or

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¶ G*Power Statistical Power Analyses software version 3.1.1, University of Düsseldorf, Germany (Faul et al., 2007)
[#] STATA 15 software, StataCorp. 2017, College Station, TX, USA

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"severe" (n=79) periodontitis according to the 2012 CDC/AAP classification [24]. The mean number of teeth, including wisdom teeth, was 25.7. Mean PPD, CAL and recessions were 2.3mm, 2.8mm and 0.5mm, respectively (**Table 2**).

Orthodontic assessment of the cohort

In our cohort, 23.5% showed an IOTN/AC score of >5, indicating a moderate to definite treatment need [28] (**Table 2**). The mean Little's index (lower anterior teeth) was 7.5mm, whereas the mean contact point deviation (upper anterior teeth) was 8.2mm.

Characteristics of patients seeking orthodontic treatment

In this cohort, 78 patients (68%) expressed an IOT. This group had a mean age of 54.4 (SD 7.9) years and 56% were female. Patients with severe periodontitis were more likely to express an interest in orthodontic treatment. 27% of patients who expressed an interest in orthodontics had an IOTN/AC >5, with a mean contact point deviation of 7.8mm (SD 2.9mm) and a mean Little's index of 7.7mm (SD 3.3mm) (**Table 2**). Of those patients with an IOT, half had been provided with information about treatment options. Although more than one third (36%) of all participants had undergone orthodontic treatment previously, no significant correlation between past treatment and current IOT was detectable.

Of the patients who reported an interest in orthodontic treatment, half preferred treatment durations of six months or one year (**Figure 1a**). The majority of patients (72%) indicated a preference for transparent aligners as an orthodontic appliance (**Figure 1b**) and expressed that visibility of the orthodontic appliance would be a matter of moderate to high concern for them. 22% of patients interested in orthodontic treatment indicated that they would be willing to undergo treatment which included dental extractions. Patients were also asked to indicate which treatment costs would be acceptable for them. 44% were not willing to pay for this

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service, whereas 36% would agree to invest 1,000€ or more (20%) (**Figure 1c**).

Motives for orthodontic treatment

Those who indicated IOT, most frequently reported maintaining their own teeth, improvement of esthetic appearance, enhancement of overall well-being and improving functional aspects as their main motives to undergo this treatment (**Figure 2**). There was a correlation between self-observed (questionnaire) esthetic impairment due to malpositioned teeth and IOT. This correlation was seen after dichotomization of the 5-step Likert scale answers (never vs. ever) ($p<0.001$, OR=2.169–12.171, CI=95%). Interestingly, there was no statistically significant correlation between the orthodontic clinical data collected and self-observed misaligned teeth. However, this result is inversely associated with IOT: 68% of those patients who felt esthetically impaired due to their tooth position were not interested in orthodontic treatment. Furthermore, there was no correlation between IOT and other QOL-related factors such as tooth-related self-consciousness, avoidance of smiling or worry and depression (data not shown). None of the OHIP-G49 derived questionnaire results related to QOL impairment due to tooth positions, the orofacial system and gingivae showed to have an influence on IOT in our regression model.

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IOT is independent of clinical parameters but associated with age

Two thirds (67.8%) of the participants (71% of the men, 63% of the women) indicated an IOT. Interestingly, a higher trend towards an interest in orthodontic treatment was observed with increasing age ($p=0.055$, OR=0.99-1.1, CI=95%). Multiple regression analysis showed that neither the periodontal parameters (mean clinical attachment loss, $p=0.264$, recession, $p=0.515$) nor orthodontic misalignment measured by IOTN/AC (dichotomized in scores 1-5 and 6-10), Little's irregularity index and contact point deviation of upper anterior teeth had

an influence on IOT (p=0.245, 0.268 and 0.075 respectively). Adjustment for age and gender in the regression model confirmed these results. Furthermore, patient demographics like monthly income, education, type of health insurance, profession, living environment (rural versus urban) and family status had no influence on IOT (**Table 1**).

Information sources of orthodontic treatment possibilities for adults

All participants were asked to report sources from which they had obtained information about orthodontic treatment for adults. 57% indicated that they had never been informed before, whereas dentists and orthodontist were a major information source for many others. Internet and media such as magazines or television only played a minor role (**Figure 3**). Of those patients with an IOT, half had been provided with information about treatment options. Although more than one third (36%) of all participants had undergone orthodontic treatment previously, no significant correlation between past treatment and current IOT was detectable (p=0.3).

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DISCUSSION

The patient population with a history of periodontitis and pathologic tooth migrations is likely to increase in orthodontic clinics over the coming years, as in ageing populations a prolonged maintenance of teeth is observed [29]. This study characterizes for the first time a cohort of periodontitis patients regarding their interest in orthodontic tooth alignment in relation to their periodontal and orthodontic indices as well as patient demographics. In our study cohort, the majority of participants were over 50 years old, reflecting the increasing incidence of chronic periodontitis in aged individuals [30]. As an important finding of this study, a large proportion (68%) of our cohort expressed an IOT. Those who indicated IOT most frequently reported maintaining own teeth, improvement of esthetic appearance,

enhancement of overall well-being and improving functional aspects as their main motives. This indicates that many patients are aware of the importance of oral and overall health and are seeking to improve both.

It was previously reported that orthodontic therapy may not only ameliorate periodontal parameters but could also help patients to gain better self-assurance and psychological well-being and to provide amended possibilities of oral hygiene [31-33]. Past surveys also revealed that esthetic appearance and dentofacial harmony are key drivers for a patient's decision to undergo orthodontic treatment and that patients are often aware of tooth deviation and malocclusion [20-22]. Dental esthetics and function often decrease with the progression of periodontitis, recession formation and general factors like tooth wear and discoloration, all of which are typically increased with age [34]. Interestingly, however, our study showed that self-reported impaired dental esthetics due to misaligned teeth were not positively correlated with IOT. Moreover, this reported esthetic impairment was not corresponding to the measured orthodontic indices. These results indicate that patients judge their own dental esthetics individually and independently of orthodontic treatment need, and that orthodontic indices and even self-reported dental esthetic impairment are not predictive factors of IOT. Similarly, our analysis revealed that there were no differences between men and women in expressing IOT, being in accordance with previous reports [35, 36].

In our cohort, one third showed a moderate to definite orthodontic treatment need, however, higher IOTN/AC scores or contact point deviations were not correlated with IOT. It is possible that the presence of periodontitis, regular periodontal treatment visits and therefore increased dental awareness may influence these patients' judgments and change their oral and dental health priorities. Nearly half of those study participants having a history of orthodontic

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intervention was interested in retreatment, although there was no significant correlation between previous treatment and current interest. The investigation of psychosocial aspects in orthodontically treated and untreated adults in a study by Demasure-Trockels et al. reported that there appears to be a higher degree of sensitivity and self-observation in already-treated patients, leading to a higher motivation for orthodontic re-intervention [37]. In our cohort, the frequent periodontal treatment visits may have a similar effect, supported by the fact that most patients reported that their oral health awareness had increased due to the frequent recall visits.

Our results further show that many patients (46% of those with IOT) would favor treatment periods of one year or less, although 36% indicated that treatment duration would not play an important role in the decision to undergo orthodontic treatment. More permanent treatment modes like fixed orthodontic braces (36%) and dental extractions (22%) were indicated as acceptable by a considerable proportion, which may reflect a more serious interest and higher motivation in these patients. At the same time, although the majority of participants would be prepared to fund their orthodontic treatment partially or in full, a significant proportion (44%) indicated that treatment costs would not be acceptable for them. Thus, potential treatment devices and costs need to be considered and discussed with periodontal patients wishing to undergo orthodontic therapy.

More than half of the study participants had never been introduced to orthodontic treatment possibilities for adults. The other half had received information from dental professionals and through their own childrens' treatment, but rarely through mass media and internet. A previous study showed that individuals who receive mass media messages containing health-related information, can recall these messages at a high rate [38]. Therefore, to better inform

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adult periodontitis patients about orthodontic treatment options, audiovisual media, social media and the internet could become an important information source in the future [39]. Communication between patients and dentists should also be improved in this area, as it is an indispensable way to advise patients individually and in detail as well as to ensure that patients obtain reliable and high quality information from the media and internet [40].

The wish to undergo orthodontic treatment is likely to be influenced by socio-cultural background and the society's esthetic expectations and ideals. In Germany, as in other industrialized nations, esthetic appearance and dentofacial harmony play an important role in society. It was shown that established norms for dental and facial appearance do not vary widely among industrialized nations [41]. These norms and ideals are broadcasted through the media, having a strong impact on the behavior and decision-making of beauty-conscious societies, and leading to an increased demand for esthetic improvement from the public [42]. Moreover, harmonious dental appearances and oral health were shown to have an impact on employment and professional success [43, 44].

The option to undergo orthodontic treatment is also often influenced by financial aspects. Orthodontic treatment of adult patients to correct malpositioned teeth is currently not funded by the statutory health insurance in Germany [45], whereas some private health insurances may contribute to or fully cover the costs arising from such treatment. Therefore, for most patients this treatment would be self-funded and may not always be affordable. The per capita net (after taxes) income in Germany in the year 2011 was 2,174 € (2,756 US$) and, for comparison, in the USA 2,984 US$ (using purchasing power parity exchange rates) [46]. This average income is comparable between Germany and the USA when considering living expenses: the consumer price index (CPI) for Germany in 2011 was 102.1 and for the USA

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103.2 (2010 = 100) [47]. According to the Gebührenordnung für Zahnärzte (GOZ, dental fee schedule), the costs of orthodontic treatment, on average and for treatment of all teeth, ranges between 4,000 and 6,000 € (≈ 4,500 – 6,800 US$) [48]. However, treatment cost can substantially deviate from this average, depending on the specific case complexity, treatment duration, techniques and materials used.

A limitation of this study is that it does not allow for comparison with IOT in periodontally healthy individuals, which may reveal a potential influence of existing periodontitis or periodontal therapy on IOT. Moreover, the questionnaire used in this pilot study requires to be fully validated in the next step, which is also aimed at expanding the study cohort and to include patients with a wider range of PTM severity. Nevertheless, as most questions in our questionnaire were derived from the OHIP-G49, we argue that potential biases derived from the questionnaire design, if any, may be minor and inconsequential for the outcomes of this pilot survey. Additionally, the inclusion of further orthodontic indices such as the IOTN/DC in a future study may reveal statistically significant correlations with self-observed PTM and IOT. Expanding the study cohort should also be aimed at increasing the sample size for the purpose of fully validating the questionnaire, and to increase the generalizability of our findings to the wider population of patients affected by periodontitis.

CONCLUSION

As there do not appear to be factors that can reliably predict a patient's wish to undergo orthodontic tooth alignment other than the explicit statement thereof, improved communication between patients and dental practitioners as well as between periodontists and orthodontists can help to identify patients interested in correcting the position of their pathologically migrated teeth [49, 50]. However, this communication between the dental

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practitioner and the patient should also be aimed at carefully managing expectations regarding treatment cost, duration, risks and possible outcomes, as these are key to attaining high satisfaction with treatment outcomes in both parties [17]. Importantly, this group of patients needs to be made aware of the necessity to stabilize their periodontal condition and maintain high standards of oral hygiene prior to any orthodontic intervention.

The results of this study can facilitate addressing the treatment wishes of adult periodontitis patients, as they demonstrate that adult patients with periodontitis are often interested in orthodontic tooth alignment, however, this interest was not related to demographic factors, subjective tooth-related physical or psychological discomfort and clinical indices in our cohort.

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CONFLICT OF INTEREST STATEMENT

The authors declare that they have no conflict of interest. This study was financially supported by the German Society of Periodontology (DGParo; Regensburg, Germany) and German Society of Dental Oral and Maxillofacial Medicine (DGZMK; Düsseldorf, Germany).

REFERENCES

1. Meyle J, Chapple I. Molecular aspects of the pathogenesis of periodontitis. *Periodontol 2000* 2015;69:7-17.
2. Needleman I, Garcia R, Gkranias N, et al. Mean annual attachment, bone level, and tooth loss: A systematic review. *J Clin Periodontol* 2018;45 Suppl 20:S112-s129.
3. Brunsvold MA. Pathologic tooth migration. *J Clin Periodontol* 2005;76:859-866.
4. Martinez-Canut P, Carrasquer A, Magan R, Lorca A. A study on factors associated with pathologic tooth migration. *J Clin Periodontol* 1997;24:492-497.
5. Dadlani H, Ramachandra SS, Mehta DS. Spontaneous correction of pathologically migrated teeth with periodontal therapy alone. *J Indian Soc Periodontol* 2013;17:531–534.
6. Towfighi PP, Brunsvold MA, Storey AT, Arnold RM, Willman DE, McMahan CA. Pathologic migration of anterior teeth in patients with moderate to severe periodontitis. *J Periodontol* 1997;68:967-972.
7. Rathod SR, Kolte AP, Chintawar S. The dynamic relationship between pathological migrating teeth and periodontal disease. *J Indian Soc Periodontol* 2013;17:762-764.
8. Tugnait A, Clerehugh V. Gingival recession-its significance and management. *J Dent* 2001;29:381-394.
9. Zhang M, McGrath C, Hagg U. The impact of malocclusion and its treatment on quality of life: a literature review. *Int J Paediatr Dent* 2006;16:381-387.
10. Klages U, Bruckner A, Zentner A. Dental aesthetics, self-awareness, and oral health-related quality of life in young adults. *Eur J Orthod* 2004;26:507-514.
11. Khan RS, Horrocks EN. A study of adult orthodontic patients and their treatment. *Br J Orthod* 1991;18:183-194.

For Peer Review

12. Proffit WR, Fields HWJ, Moray LJ. Prevalence of malocclusion and orthodontic treatment need in the United States: estimates from the NHANES III survey. *Int J Adult Orthodon Orthognath Surg* 1998;13:97-106.

13. Ong MMA, Wang HL. Periodontic and orthodontic treatment in adults. *Am J Orthod Dentofacial Orthop* 2002;122:420–428.

14. Re S, Corrente G, Abundo R, Cardaropoli D. Orthodontic treatment in periodontally compromised patients: 12-year report. *Int J Periodontics Restorative Dent* 2000;20:31-39.

15. Corrente G, Abundo R, Re S, Cardaropoli D, Cardaropoli G. Orthodontic movement into infrabony defects in patients with advanced periodontal disease: a clinical and radiological study. *J Periodontol* 2003;74:1104-1109.

16. Panwar M, Jayan B, Arora V, Singh S. Orthodontic management of dentition in patients with periodontally compromised dentition. *J Indian Soc Periodontol* 2014;18:200-204.

17. Gkantidis N, Christou P, Topouzelis N. The orthodontic-periodontic interrelationship in integrated treatment challenges: a systematic review. *J Oral Rehabil* 2010;37:377-390.

18. Antoun JS, Mei L, Gibbs K, Farella M. Effect of orthodontic treatment on the periodontal tissues. *Periodontol 2000* 2017;74:140-157.

19. Gazit-Rappaport T, Haisraeli-Shalish M, Gazit E. Psychosocial reward of orthodontic treatment in adult patients. *Eur J Orthod* 2010;32:441-446.

20. Espeland LV, Stenvik A. Perception of personal dental appearance in young adults: Relationship between occlusion, awareness, and satisfaction. *Am J Orthod Dentofacial Orthop* 1991;100:234–241.

For Peer Review

21. McKiernan EX, McKiernan F, Jones ML. Psychological profiles and motives of adults seeking orthodontic treatment. *Int J Adult Orthodon Orthognath Surg* 1992;7:187-198.

22. Meyer-Marcotty P, Alpers GW, Gerdes AB, Stellzig-Eisenhauer A. Impact of facial asymmetry in visual perception: a 3-dimensional data analysis. *Am J Orthod Dentofacial Orthop* 2010;137:168.e161-168; discussion 168-169.

23. Pabari S, Moles DR, Cunningham SJ. Assessment of motivation and psychological characteristics of adult orthodontic patients. *Am J Orthod Dentofacial Orthop* 2011;140:e263-272.

24. Eke PI, Page RC, Wei L, Thornton-Evans G, Genco RJ. Update of the case definitions for population-based surveillance of periodontitis. *J Periodontol* 2012;83:1449-1454.

25. Brook PH, Shaw WC. The development of an index of orthodontic treatment priority. *Eur J Orthod* 1989;11:309-320.

26. John MT, Patrick DL, Slade GD. The German version of the Oral Health Impact Profile--translation and psychometric properties. *Eur J Oral Sci* 2002;110:425-433.

27. Masood Y, Masood M, Zainul NNB, Araby NBAA, Hussain SF, Newton T. Impact of malocclusion on oral health related quality of life in young people. *Health Qual Life Outcomes* 2013;11:25-25.

28. Kapoor P, Singh H. Evaluation of esthetic component of the index of orthodontic treatment need: The orthodontists' perspective. *Indian J Dent* 2015;6:181-184.

29. Tonetti MS, Bottenberg P, Conrads G, et al. Dental caries and periodontal diseases in the ageing population: call to action to protect and enhance oral health and well-being as an essential component of healthy ageing - Consensus report of group 4 of the joint EFP/ORCA workshop on the boundaries between caries and periodontal diseases. *J Clin Periodontol* 2017;44 Suppl 18:S135-s144.

For Peer Review

30. Eke PI, Wei L, Borgnakke WS, et al. Periodontitis prevalence in adults >/= 65 years of age, in the USA. *Periodontol 2000* 2016;72:76-95.

31. de Couto Nascimento V, de Castro Ferreira Conti AC, de Almeida Cardoso M, Valarelli DP, de Almeida-Pedrin RR. Impact of orthodontic treatment on self-esteem and quality of life of adult patients requiring oral rehabilitation. *Angle Orthod* 2016;86:839-845.

32. Johal A, Alyaqoobi I, Patel R, Cox S. The impact of orthodontic treatment on quality of life and self-esteem in adult patients. *Eur J Orthod* 2015;37:233-237.

33. Hunt O, Hepper P, Johnston C, Stevenson M, Burden D. Professional perceptions of the benefits of orthodontic treatment. *Eur J Orthod* 2001;23:315-323.

34. Carvalho TS, Lussi A. Age-related morphological, histological and functional changes in teeth. *J Oral Rehabil* 2017;44:291-298.

35. Soderfeldt B, Palmqvist S, Arnbjerg D. Factors affecting attitudes toward dental appearance and dental function in a Swedish population aged 45-69 years. *Community Dent Health* 1993;10:123-130.

36. Al-Zarea BK. Satisfaction with appearance and the desired treatment to improve aesthetics. *Int J Dent* 2013;2013:912368.

37. Demasure-Trockels P, Katsaros C, Besold G, Berg R. [The psychosocial aspects in orthodontically treated and untreated adults with similar, clearly visible tooth malalignments]. *J Orofac Orthop* 1995;56:77-83.

38. Marcus BH, Owen N, Forsyth LH, Cavill NA, Fridinger F. Physical activity interventions using mass media, print media, and information technology. *Am J Prev Med* 1998;15:362-378.

39. Jorgensen G. Social media basics for orthodontists. *Am J Orthod Dentofacial Orthop* 2012;141:510-515.

For Peer Review

40. Cline RJ, Haynes KM. Consumer health information seeking on the Internet: the state of the art. *Health Educ Res* 2001;16:671-692.

41. Cons NC, Jenny J, Kohout FJ, Freer TJ, Eismann D. Perceptions of occlusal conditions in Australia, the German Democratic Republic and the United States of America. *Int Dent J* 1983;33:200-206.

42. Aschheim KW. *Esthetic dentistry: A clinical approach to techniques and materials, third edition*; 2014: 1-588.

43. Pithon MM, Nascimento CC, Barbosa GC, Coqueiro Rda S. Do dental esthetics have any influence on finding a job? *Am J Orthod Dentofacial Orthop* 2014;146:423-429.

44. Hyde S, Satariano WA, Weintraub JA. Welfare dental intervention improves employment and quality of life. *J Dent Res* 2006;85:79-84.

45. Bundesausschuss der Zahnärzte und Krankenkassen. Richtlinien des Bundesausschusses der Zahnärzte und Krankenkassen für die kieferorthopädische Behandlung. In: Bundesanzeiger, ed. *226*:24-966. Cologne: Bundesanzeiger Verlag, 2004.

46. OECD. Taxing Wages - Comparative tables: Net income after taxes - US dollars PPP exchange rates. Available at: https://stats.oecd.org/index.aspx?queryid=55145. 2019.

47. World Bank. Consumer price index (2010 = 100) - International Monetary Fund, International Financial Statistics and data files. Available at: https://data.worldbank.org/indicator/FP.CPI.TOTL?end=2011&start=2010. 2019.

48. Bundeszahnärztekammer. Gebührenordnung für Zahnärzte / Dental Fee Schedule (GOZ). Ed. Berlin: Federal Government of Germany, 2012.

49. Bills D. Collaboration between the general dentist and orthodontist: an essential partnership to ensure orthodontic success. *Compend Contin Educ Dent* 2013;34:262-267.

For Peer Review

50. Mavreas D, Athanasiou AE. Orthodontics and its interactions with other dental disciplines. *Prog Orthod* 2009;10:72-81.

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FIGURE LEGENDS

Figure 1. Patients' (n=78) acceptance of orthodontic therapy duration and appliances. **A)** Willingness to tolerate orthodontic therapy length, **B)** acceptable orthodontic appliances (multiple answers were possible), **C)** acceptable treatment costs payable. 1000 € ≈ 1100 US$, 5000 € ≈ 5700 US$, US$ rounded to the nearest 100. Currency conversion as of January 2019 (source: https://www.xe.com/currencyconverter/).

Figure 2. Motives for orthodontic treatment in male and female participants (n=78) interested in undergoing orthodontic tooth alignment (multiple answers were possible).

Figure 3. Previous sources of information regarding orthodontic treatment option for adult patients employed by all study participants (multiple answers were possible).

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TABLES

Table 1. Description of the cohort demographics and association with IOT.

Demographic parameters	Whole cohort (n=115)	IOT (n=78)	No IOT (n=37)	p-value*
Age (years)	56.8 (9.3)	54.4 (7.9)	57.9 (9.7)	0.055
Female (%)	60	56.4	67.6	0.310
Private Insurance (%)	13.0	16.7	5.4	0.138
Urban residence (%)	60.9	61.5	59.5	0.841
Monthly income** (after tax, in €) %				0.461
<1500 (<1700 US$)	30.6	31.9	27.8	
1500-3000	58.3	59.7	55.6	
>3000 (>3400 US$)	11.1	8.3	16.7	
Previous orthodontic treatment (% yes)	35.7	32.1	43.2	0.298

* comparing those interested in orthodontics VS not. Values are mean and (SD), unless otherwise stated. ** Currency conversion as of January 2019, US$ rounded to the nearest 100 (source: https://www.xe.com/currencyconverter/).

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Table 2. Description of the cohort's clinical parameters and association with IOT.

Clinical parameters	Whole cohort (n=115)	IOT (n=78)	No IOT (n=37)	p-value*
Periodontal diagnoses (%)				0.291
Moderate periodontitis	31.3	24.3	34.6	
Severe periodontitis	68.7	75.7	65.4	
Number of teeth	25.7 (2.8)	25.8 (2.8)	25.5 (2.7)	0.564
Mean PPD (mm)	2.3 (0.4)	2.2 (0.4)	2.3 (0.4)	0.374
Mean CAL (mm)	2.8 (0.7)	2.7 (0.6)	2.9 (0.8)	0.264
Mean recession (mm)	0.5 (0.6)	0.5 (0.6)	0.6 (0.8)	0.515
IOTN/AC >5 (%)	23.5	26.9	16.2	0.245
Mean contact point deviation (mm)	8.2 (3.1)	7.8 (2.9)	8.9 (3.4)	0.075
Mean Little's index	7.5 (3.4)	7.7 (3.3)	7.0 (3.5)	0.268
Self-perceived impaired dental esthetics (%)	40	27	68	<0.001

* comparing those interested in orthodontics VS not. Values are mean and (SD), unless otherwise stated. Abbreviations: IOTN = Index of Orthodontic Treatment Need, IOTN/AC esthetic component of the IOTN, IOT = interest in orthodontic treatment.

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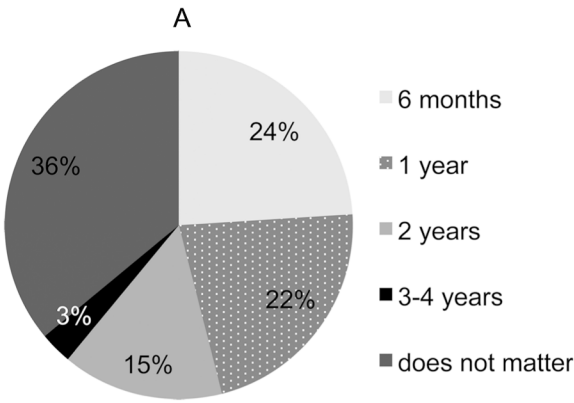
Figure 1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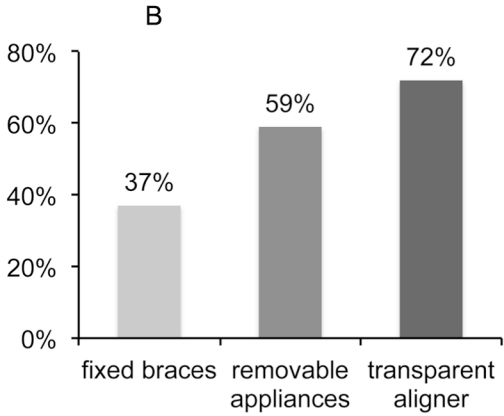
3%
36%
6 months
1 year
2 years
3-4 years
does not matter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20%
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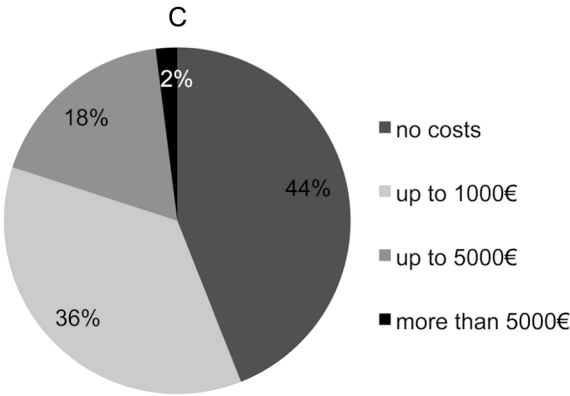
37%
59%
72%
fixed braces
removable appliances
transparent aligner


C
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up to 1000€
up to 5000€
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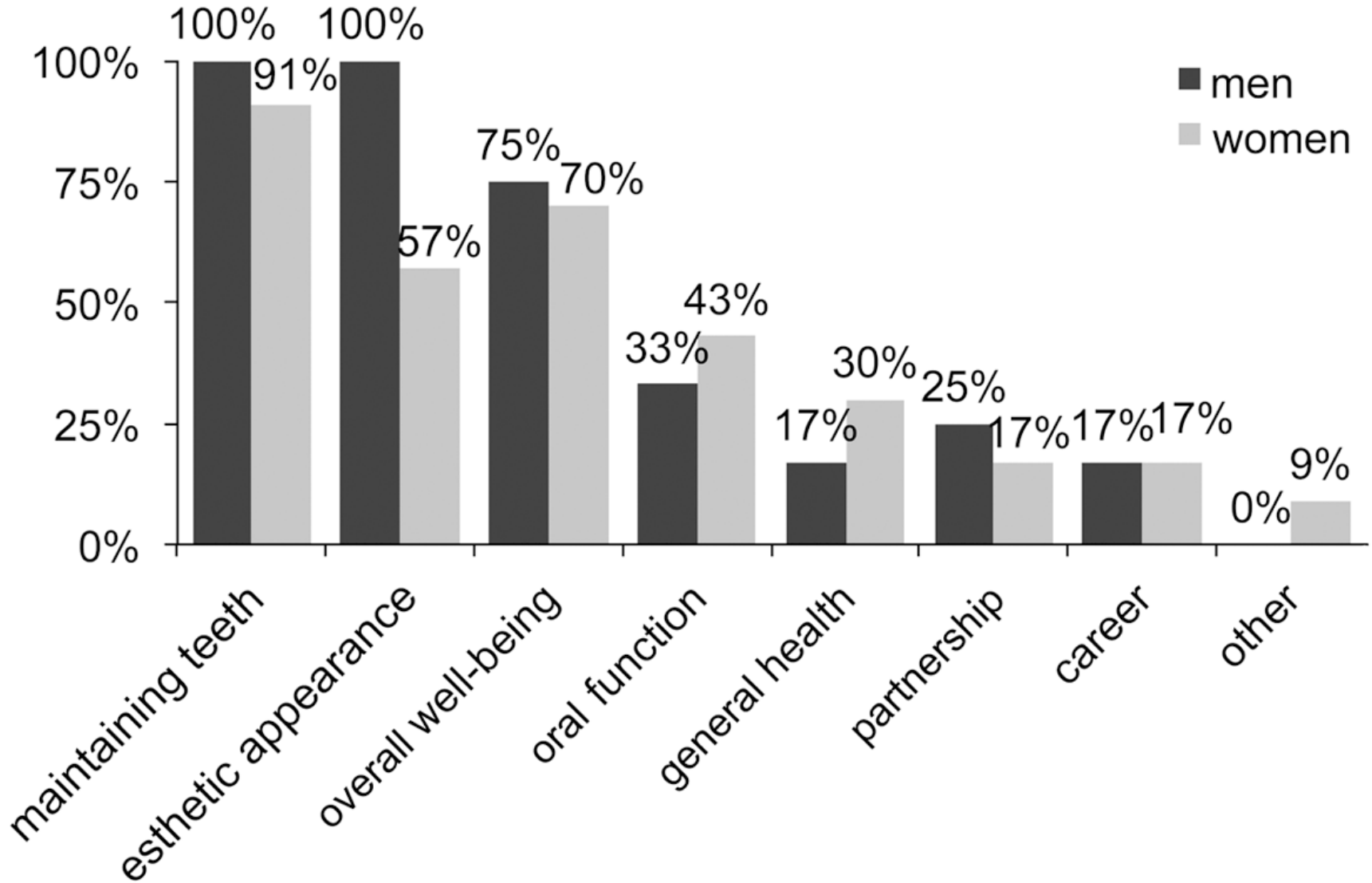
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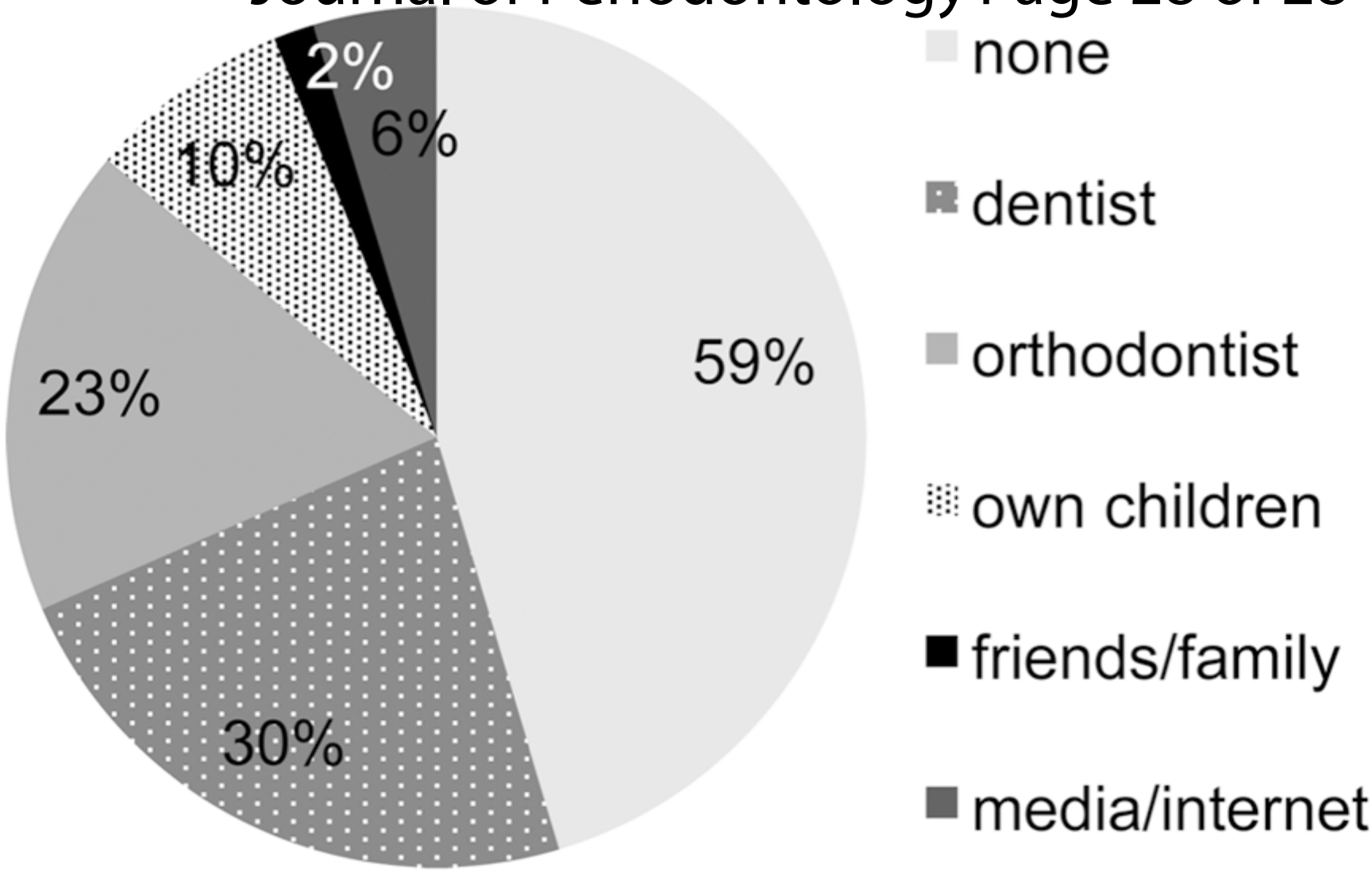
men
women
maintaining teeth
esthetic appearance
overall well-being
oral function
general health
partnership
career
other

Figure 3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10%
23%
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30%
none
dentist
orthodontist
own children
friends/family
media/internet