

# Knowledge, attitudes, and referral behavior of pediatric dentists regarding the early diagnosis of orthodontic anomalies: a cross-sectional survey

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## Research Article

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# Abstract

## Background

Pediatric dentists are often the first clinicians to detect developing malocclusions and serve as gatekeepers for orthodontic referrals, yet their knowledge of early diagnosis, attitudes, and referral behavior have not been well characterized. This study aimed to assess pediatric dentists' knowledge, attitudes, and referral behavior regarding the early diagnosis of orthodontic anomalies and to examine associations with demographic and professional characteristics.

## Methods

This cross-sectional study used an anonymous 28-item online questionnaire covering knowledge, attitudes, and practice/referral domains, distributed to pediatric dentists via social media and professional groups from January to February 2026. The questionnaire was developed de novo, content-validated by an expert panel, and pilot-tested. Knowledge responses were scored (0–11) and categorized as poor, moderate, or good. Data were analyzed using descriptive statistics, the Mann-Whitney U and Kruskal-Wallis tests, and chi-square or Monte Carlo tests with Benjamini-Hochberg correction; significance was set at  $p < 0.05$ .

## Results

A total of 120 pediatric dentists participated (83.3% female). The mean knowledge score was  $8.28 \pm 1.41$  out of 11; 44.2% had good, 50.0% moderate, and 5.8% poor knowledge. Correct-response rates were lowest for the timing of unilateral posterior crossbite treatment (20.8%) and for the recommended age for the first orthodontic evaluation (61.7%). Attitudes were highly positive ( $\geq 94\%$  agreed that diagnostic knowledge, early referral, and communication with orthodontists are important), but only 37.5% considered undergraduate education adequate. The knowledge score was not associated with any demographic variable, whereas the number of referrals was significantly higher among respondents who routinely collaborated with an orthodontist ( $p = 0.006$ ).

## Conclusions

Pediatric dentists demonstrated moderate knowledge, with specific gaps in the timing of early intervention, alongside strongly positive attitudes. However, a gap between attitudes and preventive practice and a perception of inadequate undergraduate education were evident. Strengthening education and continuing professional development, and fostering pediatric dentist-orthodontist collaboration, are warranted.

# Background

Malocclusion is among the most prevalent oral conditions in children, and many dentofacial anomalies become detectable during the primary and early mixed dentition [1]. Early detection of developing malocclusions, such as posterior crossbites with functional shifts, anterior open bites related to oral habits, and skeletal discrepancies, allows timely interceptive measures that can guide growth, reduce the severity of the problem, and limit the need for complex comprehensive treatment later [1–2]. The American Academy of Pediatric Dentistry assigns clinicians the responsibility to recognize, diagnose, and manage or refer abnormalities in the developing dentition, based on the complexity of the problem and the individual clinician's scope of practice [1]. Because children attend dental clinics regularly from an early age, pediatric dentists are often the first professionals positioned to identify these anomalies [3].

As the first point of contact, pediatric dentists act as gatekeepers who decide whether, when, and where to refer a child for orthodontic care [4]. However, the orthodontic services they provide and their confidence in diagnosing cases requiring intervention vary widely across settings and countries [5–7]. Surveys of pediatric dentists and related practitioners have reported comparable variability in Jordan, Syria, and Peru, and among pediatricians [8–11], and have shown that practitioners often agree on diagnosis yet diverge on perceived treatment need and timing [12–13]. Inappropriate or mistimed referrals are a recognized problem [14–15], and the adequacy of undergraduate education for orthodontic diagnosis has been questioned [16–17].

Questionnaire-based studies are a recognized and widely used method for assessing the knowledge, attitudes, and practices (KAP) of dental professionals [18–19], provided that the instrument is appropriately developed and validated [20–21]. Such studies have repeatedly revealed a gap between theoretical knowledge and clinical practice in pediatric and interceptive dentistry [22–23]. However, most previous surveys have focused on the range of orthodontic treatments that pediatric dentists provide or on general referral patterns, rather than on their knowledge of the early diagnosis of specific developmental anomalies, along with their attitudes and referral behavior [3, 12]. To the best of our knowledge, no study has simultaneously evaluated the knowledge, attitudes, and referral behavior of pediatric dentists specifically regarding the early diagnosis of orthodontic anomalies.

This study aimed to assess pediatric dentists' knowledge, attitudes, awareness, and referral behavior regarding the early diagnosis of orthodontic anomalies, and to examine whether these outcomes were associated with demographic and professional characteristics.

## Methods

### Study design and ethical considerations

This cross-sectional, questionnaire-based study was conducted and reported in accordance with the Checklist for Reporting Results of Internet E-Surveys (CHERRIES) [23]. The study was approved by the

Non-Interventional Researches Ethics Committee of Kocaeli Health and Technology University (decision no. 2025/89) and was conducted in accordance with the principles of the Declaration of Helsinki. The first page of the questionnaire presented an informed-consent statement describing the aim of the study, the voluntary and anonymous nature of participation, the approximate completion time, and the use of data for scientific purposes only; agreeing to proceed constituted informed consent.

## **Sample size**

An a priori sample-size calculation was performed using G\*Power (version 3.1.9.2). Based on a moderate expected effect size (correlation  $r = 0.30$ ) derived from previous surveys of pediatric dentists' orthodontic knowledge and referral practices [3, 8], a two-sided alpha of 0.05, and a statistical power of 0.90, the minimum required sample size was 112 participants. The final sample of 120 pediatric dentists, recruited via convenience sampling through open online distribution, exceeded this minimum.

## **Study population and recruitment**

The target population comprised pediatric dentists. An anonymous online questionnaire was created using Google Forms and distributed openly between 12 January and 12 February 2026 through social media (Instagram), professional messaging groups (WhatsApp), and the national pediatric dentistry association. Because the survey used open distribution, the number of individuals who viewed the invitation could not be determined, and a conventional response rate could not be calculated [24]; a total of 120 complete responses were obtained. The form was configured to accept a single response per respondent to prevent duplicate entries, and the estimated completion time was 8–10 minutes.

## **Questionnaire development and validation**

The questionnaire was developed de novo based on the American Academy of Pediatric Dentistry guideline on the management of the developing dentition and occlusion [1] and the relevant literature [3, 12], following recommendations for the development and validation of survey instruments [20–21]. Content validity was evaluated by an expert panel of seven pediatric dentists and two orthodontists, and the items were revised according to their feedback. The instrument was then pilot-tested in a single round with 10 pediatric dentists who were not included in the main sample to assess clarity, comprehensibility, and completion time; ambiguous items were reworded before the final version was deployed. The internal consistency of the final instrument was assessed in the main sample (see Statistical analysis), in line with recommendations for reporting survey-based research [18]. The full English-language version of the questionnaire is provided as Additional file 1.

## **Questionnaire structure**

The final questionnaire comprised 28 items organized in four sections: (i) demographic and professional characteristics (gender, age, frequency of collaboration with an orthodontist, workplace, and postgraduate experience); (ii) knowledge of the early diagnosis of orthodontic anomalies (11 items, including two clinical vignettes; each single-best-answer item included an “unsure” option, and three items allowed multiple responses); (iii) attitudes and awareness (seven items on a five-point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree); and (iv) clinical practice and referral behavior (number of patients referred in the previous 6 months, clinical situations prompting referral, post-referral follow-up, barriers to referral, and frequency of routine screening for orthodontic problems).

## Scoring

Each knowledge item was scored as correct (1) or incorrect (0); multiple-response items were scored as correct only when all correct options were selected and no incorrect options were selected. The total knowledge score ranged from 0 to 11 and was categorized as poor ( $\leq 5$ ), moderate (6–8), or good (9–11). Attitude items were analyzed both individually and as a composite of items A1-A6; the item assessing the perceived adequacy of undergraduate education was analyzed separately because it reflects a perception rather than a positive attitude.

## Statistical analysis

Statistical analyses were performed using Python (version 3.9). Categorical variables were summarized as frequencies and percentages, and the knowledge score as mean  $\pm$  standard deviation and median (interquartile range). As the knowledge score was not normally distributed (Shapiro-Wilk test), between-group comparisons used the Mann-Whitney U test (two groups) and the Kruskal-Wallis test (more than two groups), and associations between categorical variables used the chi-square test (Fisher or Monte Carlo simulation when expected counts were small). Correlations between the knowledge score and the attitude score, screening frequency, and referral count were assessed using the Spearman rank correlation. p-values were adjusted for multiple comparisons using the Benjamini-Hochberg procedure. Internal consistency was assessed with the Kuder-Richardson 20 coefficient (knowledge; KR-20 = 0.281) and Cronbach's alpha (attitude;  $\alpha$  = 0.793). A p value  $< 0.05$  was considered statistically significant.

## Results

A total of 120 pediatric dentists completed the questionnaire. The sample was predominantly female (100 of 120, 83.3%), and most participants were 25–30 years old (57, 47.5%) and had 0–5 years of postgraduate experience (82, 68.3%). Most worked in a university setting (77, 64.2%), and the most common pattern of interaction with an orthodontist was as-needed contact (67, 55.8%), whereas 16 (13.3%) reported never collaborating with an orthodontist (Table 1).

## Knowledge of early diagnosis of orthodontic anomalies

The mean knowledge score was  $8.28 \pm 1.41$  out of 11 (median 8, interquartile range 8–9; range 4–11). According to the predefined classification, 53 participants (44.2%) had good knowledge, 60 (50.0%) had moderate knowledge, and 7 (5.8%) had poor knowledge. Correct-response rates were highest for the consequence of untreated posterior crossbite (99.2%), the diagnostic approach to maxillary constriction (95.0%), and the problem predisposed by mouth breathing (95.0%). In contrast, the lowest correct-response rates were observed for the optimal timing of unilateral posterior crossbite treatment (20.8%), the open-bite vignette (46.7%), the optimal age for the first orthodontic evaluation (61.7%), and the spontaneous closure age of physiologic diastema (69.2%) (Table 2).

## Attitudes and awareness

Attitudes toward early diagnosis and referral were generally positive (Table 3). Agreement (responses of 4 or 5) was high for the importance of adequate diagnostic knowledge (94.2%), the value of early referral in reducing the need for advanced treatment (95.0%), and the benefit of regular communication with orthodontists (94.2%). Agreement was lower for self-reported clinical behaviors, including performing a growth and development assessment (72.5%) and questioning about oral habits at every recall (70.8%). Only 37.5% agreed that undergraduate education devoted adequate time to orthodontic anomalies. The attitude scale (items A1-A6) showed acceptable internal consistency (Cronbach's alpha = 0.793).

## Clinical practice and referral behavior

The median number of patients referred to an orthodontist in the preceding 6 months was 20 (interquartile range, 10–40); 33.6% referred 1–10 patients, 37.0% referred 11–30 patients, and 17.6% referred more than 50 patients. After referral, 32 participants (26.7%) reported not following up with the patient, whereas 40.0% screened for orthodontic problems at every visit. The most frequently reported barriers to referral were treatment cost and the child's cooperation or behavior management (Table 4).

## Associations

The knowledge score did not differ significantly by gender, age, professional experience, workplace, or frequency of collaboration with an orthodontist (all  $p > 0.05$  after false discovery rate correction; Table 5). In contrast, the number of referrals in the previous 6 months differed significantly according to the frequency of collaboration with an orthodontist (Kruskal-Wallis  $H = 12.513$ ,  $p = 0.0058$ , adjusted  $p = 0.0407$ ,  $\epsilon^2 = 0.106$ ), with respondents who collaborated routinely reporting more referrals.

In pre-specified correlation analyses, the knowledge score was weakly but significantly correlated with the attitude score (Spearman  $\rho = 0.254$ , 95% CI 0.078 to 0.414,  $p = 0.005$ ). In contrast, the knowledge score was not significantly correlated with the frequency of routine orthodontic screening ( $\rho = 0.128$ ,  $p = 0.165$ ) or with the number of referrals ( $\rho = 0.079$ ,  $p = 0.396$ ) (Table 5).

## Discussion

This study assessed pediatric dentists' knowledge, attitudes, and referral behavior regarding the early diagnosis of orthodontic anomalies. Overall, participants demonstrated moderate knowledge, with most

classified as having moderate or good knowledge, and held markedly positive attitudes toward early diagnosis and referral. However, these positive attitudes were accompanied by lower rates of self-reported preventive practices and specific knowledge gaps. Knowledge level was not associated with any demographic or professional characteristic.

Although correct-response rates were high for several core concepts, the lowest performance was observed for the optimal timing of unilateral posterior crossbite treatment (20.8%), the open-bite management vignette (46.7%), the optimal age for the first orthodontic evaluation (61.7%), and the spontaneous closure of physiologic diastema (69.2%). These items concern the timing of early intervention, a domain the American Academy of Pediatric Dentistry emphasizes as the clinician's responsibility in managing the developing dentition [1]. The relatively low awareness of the recommended age for a first orthodontic evaluation and of the appropriate timing of interceptive treatment is consistent with previous reports that pediatric dentists vary in their confidence and the services they provide [3, 5–6]. As Aldrees et al. observed, pediatric dentists tend to agree on diagnosis but diverge on the appropriate treatment approach and its timing [12], a pattern that mirrors the timing-related gaps identified here.

The absence of a significant association between the knowledge score and gender, age, experience, workplace, or frequency of collaboration with an orthodontist suggests that these gaps are systemic rather than confined to a particular subgroup. A similar lack of association between knowledge and demographic or professional variables was reported by Babakurd et al. and in a national survey of pediatricians' oral health knowledge [22–23], both of which framed the deficit as a systemic, education-related issue. This contrasts with Wang et al., who found that educational level and workplace significantly influenced knowledge and practice in a different clinical domain [25], and with a recent survey of pediatric dentistry postgraduates in which knowledge varied significantly by training year and workplace [26]. The discrepancy may reflect differences in topic, setting, and the comparatively homogeneous, predominantly early-career sample in the present study.

Attitudes toward early diagnosis and referral were strongly positive, with most participants endorsing the importance of adequate diagnostic knowledge, the value of early referral, and the importance of regular communication with orthodontists. Nonetheless, agreement was lower for self-reported clinical behaviors such as routine growth assessment and questioning of oral habits, indicating a gap between favorable attitudes and reported practice. Such attitude-practice discrepancies are well recognized in questionnaire-based research, where self-reported beliefs may not fully mirror clinical behavior [19, 21]. A recent KAP survey of pediatric dentistry postgraduates showed the same pattern: strongly positive attitudes toward functional appliance therapy did not translate into clinical practice [26]. Notably, only 37.5% of participants agreed that their undergraduate education had devoted adequate time to orthodontic anomalies, echoing earlier reports that undergraduate preparation for orthodontic diagnosis is often perceived as insufficient and earlier calls for strengthened education and continuing professional development in interceptive orthodontics [3, 10, 16–17]. This dissociation was also evident at the individual level: the knowledge score correlated with the attitude score but not with routine

screening frequency or referral volume, indicating that greater knowledge was associated with more favorable attitudes yet did not translate into more frequent preventive or referral practices.

With respect to referral behavior, the median number of referrals in the previous 6 months was 20, and 26.7% of participants reported not following up patients after referral, while treatment cost and the child's cooperation were the most frequently reported barriers. The number of referrals was significantly higher among respondents who routinely collaborated with an orthodontist, supporting the view that pediatric dentists act as gatekeepers whose referral decisions are shaped by their interactions with specialists [4]. Because both unnecessary and delayed referrals burden orthodontic services [8, 11, 14], the combination of positive referral attitudes with incomplete post-referral follow-up suggests that structured referral and feedback pathways could improve continuity of care.

Clinically, these findings suggest that efforts to improve early management of developing malocclusions should target the specific knowledge gaps identified, particularly the timing of interceptive treatment and the recommended age for a first orthodontic evaluation, rather than knowledge in general. They should also reinforce the translation of positive attitudes into routine preventive practice. Strengthening collaboration and feedback between pediatric dentists and orthodontists may further support timely and appropriate referral.

This study has several limitations. First, participants were recruited through open online distribution, so the sample was a convenience sample; the number of individuals reached could not be determined, a conventional response rate could not be calculated, and the findings may not be representative of all pediatric dentists. Second, the data were self-reported, which may introduce social desirability bias and may explain the observed attitude-practice gap. Third, the cross-sectional design precludes causal inference. Fourth, the sample was predominantly female and early-career, which may limit generalizability. Fifth, the internal consistency of the knowledge scale was low ( $KR-20 = 0.281$ ), reflecting the heterogeneous, single-best-answer nature of the items and a ceiling effect on several questions; the knowledge items are therefore best interpreted individually rather than as a unidimensional scale. Finally, the study was conducted in a single country, and the reference answers for a few items reflect current guideline-based consensus on which expert opinion may vary.

Future studies should employ representative, multi-region sampling and validated instruments, and evaluate whether targeted continuing education interventions improve knowledge of the timing of early orthodontic intervention and the translation of positive attitudes into clinical practice.

## Conclusions

Within the limitations of this study, pediatric dentists demonstrated moderate knowledge of the early diagnosis of orthodontic anomalies, with specific gaps concerning the timing of interceptive treatment and the recommended age for a first orthodontic evaluation, alongside strongly positive attitudes toward early diagnosis and referral. The gap between favorable attitudes and self-reported preventive practice, together with the perception that undergraduate education devoted insufficient time to orthodontic

anomalies, points to the need to strengthen education and continuing professional development and to foster structured collaboration between pediatric dentists and orthodontists.

## Abbreviations

KAP

knowledge, attitudes, and practice

AAPD

American Academy of Pediatric Dentistry

CHERRIES

Checklist for Reporting Results of Internet E-Surveys

IQR

interquartile range

CI

confidence interval

KR-20

Kuder-Richardson 20

FDR

false discovery rate.

## Declarations

**LLM statement.** Large Language Models (LLMs), such as ChatGPT, do not currently satisfy our authorship criteria. Use of an LLM is documented in the AI Declaration of the manuscript.

### Human Ethics and Consent to Participate

This study was approved by the Non-Interventional Researches Ethics Committee of Kocaeli Health and Technology University (decision no. 2025/89) and was conducted in accordance with the principles of the Declaration of Helsinki. Electronic informed consent was obtained from all participants before participation.

### Consent for publication.

Not applicable.

## Clinical trial number.

Not applicable.

## Competing interests.

The authors declare no competing interests.

## AI Declaration

The authors used Claude (Anthropic, claude.ai) as a generative AI tool during manuscript preparation to assist with language editing, grammar correction, and structural revision. The tool was not used for scientific content generation, data interpretation, hypothesis formulation, or drafting of conclusions. All AI-generated suggestions were critically reviewed and verified by the authors. The authors take full responsibility for the integrity, scientific accuracy, and originality of the manuscript.

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## Author Contribution

H.Ö. contributed to conceptualization, methodology, investigation, data curation, and writing of the original draft. H.Ö. and Z.A.Y. contributed to methodology, investigation, and review of the manuscript. T.Ö. contributed to conceptualization, formal analysis, supervision, writing, review, and editing. All authors read and approved the final manuscript.

## Acknowledgement

The authors declare no competing interests.

## Data Availability

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

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## Tables

**Table 1 Demographic and professional characteristics of the participants (n = 120)**

| Characteristic                                  | n (%)      |
|-------------------------------------------------|------------|
| Gender                                          |            |
| Female                                          | 100 (83.3) |
| Male                                            | 20 (16.7)  |
| Age group (years)                               |            |
| 25-30                                           | 57 (47.5)  |
| 31-35                                           | 34 (28.3)  |
| 36-40                                           | 17 (14.2)  |
| 41-45                                           | 5 (4.2)    |
| 46-50                                           | 5 (4.2)    |
| 51+                                             | 2 (1.7)    |
| Postgraduate professional experience            |            |
| 0-5 years                                       | 82 (68.3)  |
| 6-10 years                                      | 23 (19.2)  |
| 11-15 years                                     | 7 (5.8)    |
| 16+ years                                       | 8 (6.7)    |
| Workplace                                       |            |
| University                                      | 77 (64.2)  |
| Private clinic                                  | 31 (25.8)  |
| Public/community dental center                  | 12 (10.0)  |
| Frequency of collaboration with an orthodontist |            |
| Routine collaboration                           | 20 (16.7)  |
| As-needed contact                               | 67 (55.8)  |
| Rarely                                          | 17 (14.2)  |
| Never                                           | 16 (13.3)  |

*Values are frequencies and percentages. Percentages are column percentages of the total sample.*

**Table 2 Correct responses to the knowledge items (n = 120)**

| Knowledge item                                                                                    | Correct, n (%) | 95% CI    |
|---------------------------------------------------------------------------------------------------|----------------|-----------|
| K1. Optimal age for first orthodontic evaluation                                                  | 74 (61.7)      | 52.7-69.9 |
| K2. Consequence of untreated early posterior crossbite                                            | 119 (99.2)     | 95.4-99.9 |
| K3. Optimal timing for unilateral posterior crossbite treatment                                   | 25 (20.8)      | 14.5-28.9 |
| K4. Most useful approach for early diagnosis of maxillary constriction                            | 114 (95.0)     | 89.5-97.7 |
| K5. Habits associated with anterior open bite (multiple response)                                 | 101 (84.2)     | 76.6-89.6 |
| K6. Orthodontic problem most predisposed by mouth breathing                                       | 114 (95.0)     | 89.5-97.7 |
| K7. Most common etiologic origin of Class III malocclusion                                        | 100 (83.3)     | 75.7-88.9 |
| K8. Age at which physiologic diastema closes spontaneously                                        | 83 (69.2)      | 60.4-76.7 |
| K9. Parameters to consider in orthopedic treatment timing (multiple response)                     | 101 (84.2)     | 76.6-89.6 |
| K10. Vignette 1: 8-yr unilateral posterior crossbite, narrow maxilla, functional shift            | 106 (88.3)     | 81.4-92.9 |
| K11. Vignette 2: 9-yr anterior open bite with thumb-sucking and tongue thrust (multiple response) | 56 (46.7)      | 38.0-55.6 |

*CI, confidence interval (Wilson). Total knowledge score (range 0-11): mean  $\pm$  SD = 8.28  $\pm$  1.41; median (Q1-Q3) = 8 (8-9); range 4-11. Knowledge level: poor ( $\leq 5$ ) 7 (5.8%); moderate (6-8) 60 (50.0%); good (9-11) 53 (44.2%). Multiple-response items were scored as correct only when all correct options and no incorrect option were selected.*

**Table 3 Attitude and awareness items (n = 120)**

| Attitude / awareness item (5-point Likert)                                              | Median (Q1-Q3) | Agree (4-5), n (%) |
|-----------------------------------------------------------------------------------------|----------------|--------------------|
| A1. Pediatric dentists should have adequate knowledge to diagnose orthodontic anomalies | 5 (5-5)        | 113 (94.2)         |
| A2. Early referral can reduce the need for advanced treatment                           | 5 (5-5)        | 114 (95.0)         |
| A3. I perform a growth and development assessment before orthodontic treatment          | 5 (3-5)        | 87 (72.5)          |
| A4. I question oral habits (thumb-sucking, tongue thrust) at every recall               | 4 (3-5)        | 85 (70.8)          |
| A5. 3D imaging and digital tools are useful in early diagnosis                          | 5 (4-5)        | 92 (76.7)          |
| A6. Regular communication with orthodontists improves clinical success                  | 5 (5-5)        | 113 (94.2)         |
| A7. Adequate time was devoted to orthodontic anomalies in undergraduate education       | 3 (2-4)        | 45 (37.5)          |

*Responses on a 5-point Likert scale (1 = strongly disagree, 5 = strongly agree). Q1-Q3, 25th-75th percentiles. Cronbach's alpha for the attitude scale (items A1-A6) = 0.793 (95% CI 0.73-0.846); item A7 (perception of undergraduate education) was reported separately and not included in the composite.*

**Table 4 Clinical practice and referral behavior (n = 120)**

| Practice / referral behavior                       | n (%)     |
|----------------------------------------------------|-----------|
| Referrals to an orthodontist in the past 6 months  |           |
| None                                               | 3 (2.5)   |
| 1-10                                               | 40 (33.6) |
| 11-30                                              | 44 (37.0) |
| 31-50                                              | 11 (9.2)  |
| >50                                                | 21 (17.6) |
| Post-referral follow-up method (multiple response) |           |
| Scheduled recall appointments                      | 53 (44.2) |
| Orthodontist report                                | 51 (42.5) |
| Family feedback                                    | 39 (32.5) |
| No follow-up                                       | 32 (26.7) |
| Routine screening for orthodontic problems         |           |
| At every visit                                     | 48 (40.0) |
| Every 6 months                                     | 28 (23.3) |
| Only when signs present / as needed                | 24 (20.0) |
| Monthly                                            | 10 (8.3)  |
| Every 3 months                                     | 9 (7.5)   |
| Yearly                                             | 1 (0.8)   |

*Referral count: median (Q1-Q3) = 20 (10-40); n = 119 with an interpretable numeric answer (1 respondent answered 'do not remember'). Multiple-response items sum to >100%.*

**Table 5 Associations and pre-specified correlations of the knowledge score, attitude, screening, and referral**

| Comparison                                          | Test           | p     | p (FDR) | Effect size                             |
|-----------------------------------------------------|----------------|-------|---------|-----------------------------------------|
| Knowledge score by gender                           | Mann-Whitney U | 0.082 | 0.192   | rank-biserial r = 0.24                  |
| Knowledge score by age                              | Kruskal-Wallis | 0.473 | 0.662   | $\epsilon^2 = 0.013$                    |
| Knowledge score by experience                       | Kruskal-Wallis | 0.790 | 0.790   | $\epsilon^2 = 0.004$                    |
| Knowledge score by institution                      | Kruskal-Wallis | 0.428 | 0.662   | $\epsilon^2 = 0.014$                    |
| Knowledge score by freq orthodontist                | Kruskal-Wallis | 0.655 | 0.764   | $\epsilon^2 = 0.014$                    |
| Referral count by freq orthodontist                 | Kruskal-Wallis | 0.006 | 0.041   | $\epsilon^2 = 0.106$                    |
| Referral count by experience                        | Kruskal-Wallis | 0.054 | 0.188   | $\epsilon^2 = 0.05$                     |
| Knowledge score vs attitude score (A1-A6 sum)       | Spearman       | 0.005 | 0.015   | $\rho = 0.254$ (95% CI 0.078 to 0.414)  |
| Knowledge score vs routine screening frequency (P5) | Spearman       | 0.165 | 0.248   | $\rho = 0.128$ (95% CI -0.053 to 0.3)   |
| Knowledge score vs referral count (P1)              | Spearman       | 0.396 | 0.396   | $\rho = 0.079$ (95% CI -0.103 to 0.255) |

*FDR, Benjamini-Hochberg false discovery rate.  $\epsilon^2$ , epsilon-squared;  $\rho$ , Spearman rank correlation coefficient. Demographic comparisons and the targeted correlations were corrected within their respective families. The knowledge score did not differ across demographic variables; referral count was higher with routine orthodontist collaboration; and the knowledge score correlated with the attitude score but not with screening frequency or referral count.*

## Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [additionalfile1.docx](#)