Orthodontic knowledge and referral patterns: a survey of paediatric specialists and general dental practitioners

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Introduction: Early diagnosis and referral is essential in order to provide the best orthodontic care. Paediatric specialists (PSs) and general dental practitioners (GDPs) are usually the first dental professionals to diagnose a malocclusion.  
Aim: To evaluate the knowledge and approach of PSs and GDPs in the management of children in reference to the timing of referral and early orthodontic intervention.  
Methods: A survey assessed referral patterns and the respondents’ orthodontic knowledge regarding treatment timing and indications for early treatment in the early and late mixed dentition.  
Results: One hundred and seventeen dentists participated in the study, of whom 79 were GDPs and 38 were PSs. The average total accuracy score in a 27-knowledge questionnaire was 68.6%, resulting in a statistically significant difference between the PSs and the GDPs. This difference arose from confusion regarding the prevention of maxillary permanent canine impaction and the need for a leeway space maintainer.  
Conclusions: The GDPs and the PSs had a sound knowledge of orthodontics and a reasonable referral pattern, although the knowledge of PSs was significantly higher than that of the GDPs. There is a need for further education regarding orthodontic treatment needs and timing both in undergraduate/postgraduate training as well as in professional continuing education programs.  
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Introduction
Commonly accepted orthodontic treatment goals are to improve skeletal relations and dental occlusion, achieve better function and profile harmony, while enhancing dental aesthetics. Malocclusion and tooth malposition may lead to dental caries, gingival and periodontal disease, increased susceptibility to trauma, and low self-esteem.

Orthodontic treatment may start in the late mixed dentition, which typically coincides with a rapid growth period, allowing for efficient correction of jaw discrepancies, the beneficial use of leeway space and the definitive correction of malocclusions. In certain conditions, early orthodontic intervention could be beneficial in preventing further complications associated with a malocclusion. Early diagnosis and referral for orthodontic consultation is beneficial in order to enable optimal patient care. Paediatric specialists (PSs) and general dental practitioners (GDPs) who are treating children examine patients at an early age. They are usually the first clinicians to diagnose a malocclusion and refer patients for orthodontic opinion. Both PSs and GDPs play an essential role in the education and motivation of children and their parents regarding the need for orthodontic treatment.
The goal of the present study was to evaluate the knowledge level and approach of PSs and GDPs in the orthodontic management of children related to the timing and need for early intervention. It was therefore beneficial to ascertain the practitioner’s level of knowledge and attitude regarding orthodontic treatment.

Materials and methods
Distributed to PSs and GDPs, the present study utilised a questionnaire that surveyed biographic data (age, specialty existence, and experience (years in practice)) and assessed the respondent’s orthodontic knowledge and referral pattern. The survey contained 26 questions, 24 of which involved ‘Yes/No’ answers. Each correct answer was scored ‘one’ and each incorrect answer was scored ‘zero’. The questions assessed orthodontic knowledge regarding treatment timing and indications for treatment in the early and late mixed dentition, and also considered reasons for referral. The correct answers were determined by three orthodontic specialists from the orthodontic department of Tel Aviv University and derived from current evidence-based literature. An overall score was calculated as a percentage of the correct answers.

An additional two questions required a multiple choice response (Table IV). The first raised the subject of permanent canines that were not buccally palpable at a dental age of 10 years. The four answer options were: (a) Follow up, (b) Send for a panoramic X-ray and extract teeth 53+63 if needed, (c) Send for a panoramic X-ray and refer for an orthodontic consultation or (d) Refer for an orthodontic consultation. The second question tried to assess the treatment approach in case of severe lower anterior crowding (7 mm or more) in the mixed dentition. The four possible answers were: (a) Follow up, (b) Bond a lingual arch, (c) Send for a panoramic X-ray and bond a lingual arch if needed, (d) Refer for orthodontic consultation.

Ethical aspects
The study was approved by the ethics (Helsinki) committee of Tel Aviv University, Israel and was conducted in full accordance with the World Medical Association Declaration of Helsinki. Written informed consent was obtained from all participants.

Statistical analysis
Continuous variables were presented as a mean ± standard error of the mean or as median (inter quartile range) as appropriate. Categorical variables were presented as a number (percent). The distribution of continuous variables was assessed using Q-Q plots. Categorical variables were compared using either the Chi-square test or Fisher’s exact test, as appropriate. Continuous variables were compared using the Mann-Whitney’s U test or the Kruskal-Wallis test as appropriate. A two-tailed \( p < 0.05 \) was considered statistically significant. Statistical analyses were performed using SPSS (IBM SPSS Statistics for Windows, Version 22.0, NY, USA).

Results
At a paediatric dentistry conference, 170 dentists were approached and asked to fill out the survey. Table I summarises the biographies of the dentists who completed the survey. A total of 117 dentists answered the questionnaire and were included in the study. Of these, 79 were GDPs and 38 were PSs. In comparison to the GDPs, the PSs were significantly older, more experienced (in number of years practicing dentistry), and predominantly treated children.

The participants were asked 27 knowledge questions. Table II summarises the average scores in the questionnaire according to the participant’s biographic details. The average total score of correct answers was 68.6 ± 1. A statistically significant difference was found in the average total score between the PSs and the GDPs (71.8 ± 1.8 versus 67.1 ± 1.2, respectively). There was no association between the average total score and all other parameters examined related to gender, years of experience as GDPs and PSs, and percentage of children treated in daily practice.

The first section of the questionnaire consisted of 24 ‘Yes/No’ questions regarding the need for early orthodontic referral. Each question described a different dental condition. Table III presents the referral pattern of the respondents. A statistically significant difference \( p < 0.001 \) in the referral pattern related to the different malocclusions (Class III, Class II Div 1, Class II Div 2) was found. Angle Class III cases were predominantly referred for orthodontic consultation by 100% of the PSs and 94.9% of the GDPs. However, the referral rates were lower in Class II cases. An additional finding was that only 57.9% of
the PSs and 49.4% of the GDPs referred patients for early orthodontic consultation in cases of lisping. It should be noted that the option of direct referral to a speech therapist was not assessed.

In two questions, a statistically significant difference in the response pattern between GDPs and PSs was found. In the case of a deep bite (>50% over bite) only 23.7% of the PSs chose to refer for an orthodontic consultation compared with 45.6% in the GDP group \( (p = 0.02) \). In the case of lower anterior crowding of up to 3 mm, 89.5% of the PSs chose to refer for an orthodontic consultation compared with 64.6% in the GDP group \( (p = 0.005) \). It should be noted that after applying the Hochberg correction to assess for a false discovery rate, both of these differences could be attributed to multiple comparisons.

In the case of a mixed dentition (dental age of 10 years) with maxillary permanent canines that could not be buccally palpated (Table IV), the distribution of answers was found to be significantly different

| Table I. | Biographic details of the participants. |
|---------------------------------|--------------------------------------------------|
| Gender                         | General dental practitioners | Paediatric specialists | \( \rho \) |
| Female                         | \( N=79 \)                     | \( N=38 \)             |
| Male                           | 38 (21.5%)                    | 72 (26.7%)            | 0.56 |
| Age (years)                    | 38.9 ± 1.0                     | 45.7 ± 1.4            | <0.001 |
| Years of experience            | \(<5\) 18 (22.8%)              | 0                     | <0.001 |
|                                 | 5–10 26 (32.9%)                | 4 (10.5%)             |
|                                 | >10 35 (44.3%)                 | 34 (89.5%)            |
| Years as paediatric specialists| \(<5\) N/A                    | 13 (34.2%)            | N/A |
|                                 | 5–10 10 (26.3%)                | 14 (36.8%)            |
| Proportion of children in practice | 0–25% 9 (11.4%)              | 1 (2.6%)              | 0.007 |
|                                 | 25–50% 9 (11.4%)               | 0                     |
|                                 | 50–75% 26 (32.9%)             | 7 (18.4%)             |
|                                 | 75–100% 33 (41.8%)            | 30 (78.9%)            |

| Table II. | Average scores according to participants’ biographic details. |
|----------------|---------------------------------------------------------------|
| Average score (\( \pm \) SEM) | \( \rho \) |
| Dental qualification | GDPs | 67.1 ± 1.2 | 0.03 |
|                             | PSs  | 71.8 ± 1.8 |
| Gender | Male | 70.1 ± 1.8 | 0.48 |
|                             | Female | 68.2 ± 1.2 |
| Years as dentist | \(<5\) | 66.1 ± 2.1 | 0.2 |
|                             | 5–10 | 67.6 ± 1.9 |
|                             | >10  | 69.8 ± 1.4 |
| Years as paediatric specialist | \(<5\) | 69.5 ± 2.6 | 0.06 |
|                             | 5–10 | 67.4 ± 3.8 |
|                             | >10  | 74.8 ± 2.6 |
| Percent of children treated in daily practice | 0–25 | 66.9 ± 2 | 0.36 |
|                             | 25–50 | 62.8 ± 4.1 |
|                             | 50–75 | 70.2 ± 1.5 |
|                             | 75–100 | 69.1 ± 1.6 |

Data are presented as mean ± standard error of the mean. Statistical analyses were performed using the Mann–Whitney’s U test or Kruskal–Wallis test as appropriate.
between the PSs and GDPs ($p = 0.006$). While a similar percentage of the PSs and GDPs would refer for a panoramic X-ray followed by orthodontic consultation if needed (44.7% vs. 43.6%, respectively), more GDPs chose to review only (32.1% vs. 7.9%, respectively).

In the case of the mixed dentition (dental age of 10 years) with significant lower anterior crowding (of 7 mm or more), a low DMF and no early loss of teeth (Table IV), the distribution of answers was found to be significantly different between the PSs and GDPs ($p = 0.025$). Most PSs and GDPs (92.1% and 67.1%, respectively) would refer for orthodontic consultation in cases in which a space maintainer required consideration.

**Discussion**

Early orthodontic treatment can reduce the severity of a developing malocclusion, the complexity of future orthodontic treatment and overall treatment time, improve self-esteem and perhaps reduce future orthodontic cost. It has been suggested that developing problems in the mixed dentition could be fully corrected with interceptive orthodontic treatment in 15% and improved in 49% of cases. Shalish et al. found that almost one-third of school children examined in the mixed dentition required early orthodontic treatment. Both GDPs treating children and PSs are the gatekeepers for specialist dental care and need to decide, as part of their daily clinical work, whether, when, and where to

| Will you refer to an orthodontic specialist consultation at a dental age of 8–9 years in the following cases? | Recommended management | Pediatric specialists | General dental practitioners | $P$ |
|---|---|---|---|---|
| Trapped lower lip | Orthodontic referral | 33 (86.8%) | 66 (83.5%) | 0.64 |
| Thumb sucking | Orthodontic referral | 26 (68.4%) | 49 (62%) | 0.5 |
| Tongue thrust | Orthodontic referral | 30 (78.9%) | 56 (70.9%) | 0.36 |
| Lisping | Orthodontic referral | 22 (57.9%) | 39 (49.4%) | 0.39 |
| Angle Class III | Orthodontic referral | 38 (100%) | 75 (94.9%) | 0.3 |
| Angle Class II/1 | Orthodontic referral | 25 (65.8%) | 48 (60.8%) | 0.6 |
| Angle Class II/2 | Orthodontic referral | 21 (55.3%) | 47 (59.5%) | 0.66 |
| Anterior open bite | Orthodontic referral | 27 (71.1%) | 61 (77.2%) | 0.47 |
| Posterior open bite | Orthodontic referral | 32 (84.2%) | 61 (77.2%) | 0.38 |
| Deep bite of 50% | Orthodontic referral | 9 (23.7%) | 36 (45.6%) | 0.02 |
| Deep bite greater than 75% | Orthodontic referral | 29 (76.3%) | 65 (82.3%) | 0.45 |
| Anterior cross-bite without functional shift | Orthodontic referral | 35 (94.6%) | 66 (83.5%) | 0.14 |
| Anterior cross-bite with functional shift | Orthodontic referral | 37 (97.4%) | 74 (93.7%) | 0.66 |
| Posterior cross-bite without functional shift | Orthodontic referral | 29 (76.3%) | 55 (69.6%) | 0.45 |
| Posterior cross-bite with functional shift | Orthodontic referral | 35 (92.1%) | 66 (84.6%) | 0.38 |
| Spaced dentition | Follow up | 32 (84%) | 60 (76.9%) | 0.36 |
| Upper anterior crowding of up to 3mm | Follow up | 29 (78.4%) | 48 (63.2%) | 0.1 |
| Upper anterior crowding greater than 4mm | Orthodontic referral | 35 (92.1%) | 65 (85.5%) | 0.38 |
| Lower anterior crowding of up to 3mm | Follow up | 34 (89.5%) | 51 (64.6%) | 0.005 |
| Lower anterior crowding greater than 4mm | Orthodontic referral | 34 (89.5%) | 64 (81%) | 0.245 |
| Upper diastema of up to 3mm | Follow up | 32 (84.2%) | 54 (68.4%) | 0.07 |
| Upper diastema greater than 4mm | Follow up | 17 (44.7%) | 23 (29.1%) | 0.1 |
| Overjet of 3–6mm | Follow up | 20 (52.6%) | 38 (48.1%) | 0.65 |
| Overjet bigger than 7mm | Orthodontic referral | 36 (94.7%) | 76 (96.2%) | 0.66 |

Responses to the yes/no questions regarding early orthodontic referral. Data are presented as number (percent) for categorical variables. Statistical analyses were performed using Chi square test or Fisher’s exact test as appropriate.
appropriately refer patients. If orthodontic referrals are made before the patient is ready for orthodontic intervention, unnecessary appointments are made. O’Brien et al. suggests that one reason for the excessive waiting list of new orthodontic patient consultation is the unnecessary referral of patients by GDPs. However, if referrals for orthodontic consultation are made after the ‘ideal’ time, the orthodontic treatment that follows may be more complex and lengthy as a result. These findings emphasise the importance of educating undergraduate and postgraduate dental students regarding the appropriate referral timing for early orthodontic consultation.

The results show acceptable knowledge regarding the need and timing of referral of GDPs treating children and PSs. A statistically significant difference was found in orthodontic knowledge related to referral timing between the PSs and the GDPs (71.8 and 67.1, respectively). The results differed from Berk et al., whose findings compared treatment need assessment scores of orthodontists, general dental practitioners, and paediatric specialists and determined high levels of agreement regarding orthodontic treatment needs. It was found that Angle Class III cases were referred for orthodontic consultation by 100% of the PSs and 94.9% of the GDPs. This finding reflects the knowledge that early referral may be advised as maxillary protraction, if needed, is thought to be most successful when performed during the early mixed dentition. The finding of reduced referral rates of Class II cases in comparison with Class III cases may reflect a lack of consensus regarding the effectiveness of early intervention in Class II patients.10,11 The primary indications for early intervention in Class II malocclusions relate to psychosocial problems and the need for early reduction of an overjet to prevent dental trauma.13 This may explain the higher referral rates in Angle Class II Div 1 cases, in which there was an increased overjet in comparison with the Angle Class II Div 2 cases.

The identification of an abnormal oral habit and the assessment of its potential immediate and long-term effects on the dentition should be made at an early stage. Habits such as non-nutritive sucking, finger-sucking, a tongue thrust swallow, and abnormal tongue position are the most common factors influencing dentoalveolar development and potentially facial growth during childhood. Oral habits, present in sufficient frequency, duration and intensity, may be associated with increased overjet, reduced overbite, posterior crossbite or an increased facial height.14,15 Interestingly, only 57.9% of the PSs and 49.4% of the GDPs referred cases of lisping for early orthodontic consultation. A systematic review by Pisani et al. on orthodontic and orthopaedic treatment for anterior open bite in the mixed dentition confirmed the effectiveness of early treatment. It should be noted that the option of direct referral to a speech therapist was not assessed.

### Table IV. Responses for the multiple choice questions regarding orthodontic cases management.

| What will you do regarding a patient in the mixed dentition stage (dental age: 10y) when the permanent canines are not palpated buccally? | PSs | GDPs | ρ |
|---|---|---|---|
| Follow up | 3 (8%) | 25 (32.1%) | 0.006 |
| Send for a panoramic X-ray and extract teeth 53+63 if needed | 5 (13.2%) | 2 (2.6%) | 0.006 |
| Send for a panoramic X-ray and refer to an orthodontist if needed | 17 (44.7%) | 34 (43.6%) | 0.006 |
| Refer for orthodontic consultation | 13 (34.2%) | 17 (21.8%) | 0.006 |

| What will you do regarding a patient in the mixed dentition stage (dental age: 10y) with severe lower anterior crowding (7mm or higher), low DMF and no early loss of teeth? | PSs | GDPs | ρ |
|---|---|---|---|
| Follow up | 1 (2.6%) | 18 (22.8%) | 0.025 |
| Bond a lingual arch | 1 (2.6%) | 3 (3.8%) | 0.025 |
| Send for a panoramic X-ray and bond a lingual arch if needed | 1 (2.6%) | 5 (6.3%) | 0.025 |
| Refer for orthodontic consultation | 35 (92.1%) | 53 (67.1%) | 0.025 |

Data are presented as number (percent) for categorical variables. Statistical analyses were performed using Chi square test.
The maxillary permanent canine is the second most frequently impacted tooth and treatment usually involves surgical exposure, followed by orthodontic traction. Bone loss, root resorption, and gingival recession around the treated teeth are unwelcome and common complications. Early recognition and interceptive treatment may result in less complex treatment that saves time and expense, and reduces the discomfort experienced by the patient. In mixed dentition cases (dental age of 10 years) involving maxillary permanent canines that cannot be palpated buccally, there is a need for a panoramic radiograph followed by an orthodontic consultation. The distribution of questionnaire answers regarding the canine was found to be significantly different between the PSs and GDPs (\( p = 0.006 \), Table IV). While a similar percentage of the PSs and GDPs replied correctly (44.7% and 43.6%, respectively), more GDPs preferred follow-up management compared with PSs (32.1% and 7.9%, respectively). That might suggest that almost one-third of the GDPs were not familiar with the developing signs of maxillary permanent canine impaction, which therefore might be overlooked.

In the late mixed dentition, leeway space may be utilised to relieve moderate crowding. This protocol takes advantage of the difference in width of the primary canine and molars compared with the permanent canines and premolars. In the permanent dentition space may be generated either by a decrease in the amount of tooth structure (extractions or interproximal reduction) or by increasing the arch length either by transverse expansion or anterior tooth proclination, which may lead to bone dehiscence and/or an unstable treatment result. In describing a case of mixed dentition (dental age of 10 years) with significant lower anterior crowding (of 7 mm or more), low DMF and no early loss of teeth, it was found that the distribution of answers was significantly different between the PSs and GDPs (\( p = 0.025 \), Table IV). While most PSs (92.1%) and GDPs (67.1%) would send for an orthodontic consultation, a surprising number of GDPs, 22.8%, would only follow up in such a case. This approach may lead to a lost opportunity for a space maintainer. Another noteworthy finding was that most PSs and GDPs indicated that they would choose to refer for orthodontic consultation in cases in which a space maintainer should be considered, rather than treating the case themselves. This may be due to the complex and specific indications for using a space maintainer, which has the potential to create iatrogenic damage.

The present study was limited by the difficulties encountered as a result of incomplete surveys. Although a high (79%) response rate was achieved, 10% of the surveys were partially filled and were therefore excluded from the statistics. This might have been due to the length of the survey as it was distributed during a conference and people may have preferred to attend lectures or mingle during the break time. The study questionnaire was perhaps not robust enough to thoroughly assess individual orthodontic knowledge. However, the aim of the questionnaire was to gauge the knowledge level that would enable dentists to decide whether and when to refer patients for further orthodontic consultation.

A possible source of selection bias in the present study was that the study’s population was comprised of PSs and GDPs who attended a conference. Practitioners who attend professional conferences may be more knowledgeable and updated than non-attending colleagues and therefore this population may not necessarily reflect PSs and GDPs in general.

It is difficult to compare the present results with previous reports due to the wide differences between earlier studies with respect to study design, study population and local practices. The current study should be the basis for further investigations regarding the interdisciplinary knowledge related to orthodontic diagnosis and treatment timing recommendations. The results of additional studies may impact the undergraduate/postgraduate curriculum and influence professional continuing education programs.

Conclusions

Based on the present study, the following may be concluded:

1. The knowledge of orthodontics and referral pattern of GDPs treating children and PSs is appropriate.
2. The orthodontic knowledge and referral pattern of PSs is significantly higher than that of GDPs.
3. There is a need for further education regarding orthodontic treatment needs and referral timing in undergraduate/postgraduate training as well as in professional continuing education programs.
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The authors declare no conflict of interest.

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