Interceptive orthodontic treatment in Singapore: A descriptive study

Yi Lin Song1-3, Elaine Li Yen Tan1-3, Benn Chi Jin Chua4, Rachel Jing Yi Ng4 and Natalie Kar Poh Lam4

Abstract

Background: The benefits of interceptive orthodontic treatment have always been a subject of much debate, and it is understandable that clinicians are confused about how to advise parents of potential interceptive orthodontic patients.

Objective: The aim is to study the treatment outcomes of interceptive orthodontics associated with different appliances. Demographic information on patients presenting for interceptive treatment, prevalence and types of dental conditions treated, types and frequency of appliances used, treatment duration and the number of visits taken were also investigated.

Methods: This study involved analyzing records of interceptive orthodontic patients seen at the National Dental Centre Singapore from January 2011 to December 2017. Treatment outcomes were divided into success, improvement and failure according to pre-determined treatment objective parameters.

Results: A total of 1324 patient records (654 females, 670 males) were studied, with an average age of 10.6±1.9 years. The most common dental condition seen was the anterior crossbite while the most common interceptive orthodontic appliance used was the bite plate. Average treatment duration was 10.8±6.8 months (9.8±9.2 visits) for fixed appliances, 7.5±6.5 months (6.9±3.4 visits) for removable appliances and 10.8±3.2 months (12.6±3.3 visits) for a combination. Interceptive orthodontic treatment had an overall success rate of 75.5%, improvement rate of 9.5% and failure rate of 15.0%. The most common reason for failure was attributed to non-compliance.

Conclusion: The data above shed light on interceptive orthodontic treatment in an Asian population and gives useful information for primary care clinicians to provide for concerned parents.

Keywords

Interceptive orthodontic treatment, early braces, growth modification

Introduction

Interceptive orthodontic treatment is a treatment concept attempting to “prevent or minimize dental development abnormalities while enabling craniofacial growth modification” and “entails monitoring for a variety of conditions, including excessive space, severe crowding, open or deep bites, anterior and/or posterior crossbites, severe overjet, and abnormal eruption patterns”.1 Its primary intention is to either correct or intercept a malocclusion to simplify future treatment or even the necessity for treatment. There has always been a debate on early orthodontic treatment, with the crux centering on the benefit to cost ratio.2,3 A systematic review to investigate the usefulness of interceptive orthodontic treatment has suggested insufficient evidence to show that early treatment brings about increased benefit; however, this does not mean that it is ineffective.4 Additional cost and burden to the patient, parent and clinician will also need to be considered. This debate is therefore likely to continue, as it is difficult to reach a consensus in quantifying the benefits of early treatment.

Specifically, several landmark randomized controlled trials have been funded to investigate the efficacy of various interceptive orthodontic treatments in Class II treatment but clinically significant supplementary mandibular growth was not found after functional appliance treatment.5–7 Pitfalls of these

1 National Dental Research Institute Singapore, National Dental Centre Singapore
2 Department of Orthodontics, National Dental Centre Singapore, Singapore
3 Oral Health Academic Clinical Programme, Duke-NUS Medical School
4 Faculty of Dentistry, National University of Singapore, Singapore

Corresponding author:
Yi Lin Song, BDS, MDS, M Orth RCS (Edinburgh), Consultant, Department of Orthodontics, National Dental Centre Singapore, 5 Second Hospital Avenue, 168938, Singapore.
Email: song.yi.lin@singhealth.com.sg

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trials were, however, acknowledged and could be attributed to individual growth pattern variability, difficulty in measuring mandibular growth and limitations of statistics. On the other hand, for Class III cases, systematic reviews of interceptive treatment have largely shown significant benefit, although the risk of relapse due to continuing mandibular growth during puberty is acknowledged. In the transverse dimension, a risk of relapse due to continuing mandibular growth during treatment have largely shown significant benefit, although the hand, for Class III cases, systematic reviews of interceptive mandibular growth and limitations of statistics. On the other to individual growth pattern variability, difficulty in measuring excluded. Three investigators (BCCJ, RNJY, NLKP) analyzed attend follow-up appointments after appliance issue were included. Patients who did not (i.e. absence of cleft lip/palate or any other congenital craniofacial deformities) were included. Patients who did not ⩽ 17 years 0 days for females and ⩽ 19 years 0 days for males. Only standard non-syndromic patients with no relevant medical history (i.e. absence of cleft lip/palate or any other congenital craniofacial deformities) were included. Patients who did not attend follow-up appointments after appliance issue were excluded. Three investigators (BCCJ, RNJY, NLKP) analyzed each patient record independently. If there were any discrepancies during data collection, a discussion was convened with the orthodontists (SYL, ETLY) before coming to a final conclusion. Patient records comprised:

- Treatment notes from the Electronic Dental Record System
- X-rays and clinical photos from MiPACS (Medicor Imaging Picture Archiving and Communication System) Dental Enterprise Viewer
- Study models from OrthoAnalyser.

The following data were obtained from these records:

- Basic demographic information (age, gender)
- Diagnosis of dental and skeletal relationships
- Type of interceptive orthodontic appliance used
- Duration of treatment
- Number of appointments attended

This single-center retrospective descriptive research was determined to be exempt from ethical approval due to its non-invasive quality improvement project nature by the SingHealth Centralized Institutional Review Board (CIRB Ref: 2018/2637).

**Determination of treatment outcomes**

Treatment outcomes were divided into three categories: (1) Success, (2) Improvement and (3) Failure. Treatment was considered a success when the clinician has achieved the planned treatment objectives during interceptive orthodontics or if the parameters shown in Table 1 are documented in the treatment notes/ X-rays/ clinical photos/ study models. In the cases where ideal treatment outcomes were not achieved during interceptive orthodontic treatment but the teeth were in a better position compared with before, the case was considered an improvement. Cases that did not benefit from interceptive orthodontic treatment were considered failures.

**Statistical analysis**

Descriptive statistics were used to summarize the data collected using Microsoft Excel’s descriptive statistics tool.

**Results**

Out of the 1384 patients obtained from the collated charge code list, 58 patients did not return to NDCS for continuation of treatment and two patients were above the cut-off age. These 60 cases were excluded from data analysis, resulting in a total of 1324 patients. A profile of interceptive orthodontic treatment for these patients is summarized in Table 2.

**Patient demographics**

A total of 1324 patient records (654 females, 670 males) were included in the analysis. The average age of patients at start of
### Table 1. Examples of successful treatment outcomes.

| Dental conditions seen during interceptive orthodontic treatment | Parameters for success |
|---------------------------------------------------------------|------------------------|
| Anterior crossbite                                             | Teeth no longer in crossbite |
| Posterior crossbite                                            | Teeth no longer in crossbite |
| Impacted teeth                                                 | Teeth erupted fully intra-orally |
| Excessive dental spacing                                      | Spaces closed |
| Anterior deep bite                                             | Overbite reduced to cover \(\leq\) 1/3 of opposing incisors |
| Anterior open bite                                             | Positive overbite achieved |
| Skeletal Class II malocclusion                                 | Reduction in \(|O|\) to \(\leq\) 2mm achieved |
| Skeletal Class III malocclusion                                | Positive overjet of \(\geq\) 2mm achieved |

### Table 2. A profile of interceptive orthodontic treatment in NDCS.

| Fixed Appliances                                      | Average age of patients (in years) | Treatment duration (in months) | No. of visits | Total no. of patients | Treatment outcomes of various appliances |
|-------------------------------------------------------|-----------------------------------|-------------------------------|--------------|-----------------------|------------------------------------------|
| Gold chain and brackets                               | 10.1 ± 1.3                        | 13.9 ± 6.5                    | 11.7 ± 5.1   | 147                   | 146 (99.3%) Success                      |
| Brackets only                                         | 9.8 ± 1.6                         | 9.3 ± 6.8                     | 8.7 ± 4.9    | 197                   | 180 (91.4%) Success                     |
| Hyrax expander                                        | 10.1 ± 0.91                       | 9.7 ± 4.0                     | 8.7 ± 4.0    | 3                     | 2 (66.7%) Success                       |
| Quad helix expander                                   | 10.2 ± 0.38                       | 8.3 ± 0.6                     | 6.7 ± 2.3    | 3                     | 0                                        |
| Transpalatal arch                                     | 10.4 ± 2.5                        | 12.7 ± 5.7                    | 10.2 ± 3.9   | 15                    | 13 (86.7%) Success                      |
| Lower lingual arch                                    | 12.9 ± 3.0                        | 20 ± 8.1                      | 8 ± 2.3      | 4                     | 4 (100%) Success                       |
| Halterman appliance                                   | 9.2 ± 0.96                        | 9.1 ± 5.1                     | 9.8 ± 5.7    | 8                     | 7 (87.5%) Success                      |
| Removable Appliances                                  |                                   |                               |              |                       |                                          |
| Twin block                                            | 12.2 ± 1.7                        | 11.8 ± 7.5                    | 7.9 ± 2.4    | 219                   | 106 (48.4%) Success                     |
| Headgear                                              | 11.9 ± 0.8                        | 13.7 ± 11.8                   | 10 ± 3.5     | 6                     | 68 (3.1%) Failure                      |
| Bionator                                              | 12.6 ± 1.4                        | 8.8 ± 4.2                     | 7.3 ± 2.5    | 13                    | 4 (30.8%) Failure                      |
| Reverse Bionator                                      | 9.5 ± 0.7                         | 3.0 ± 0.5                     | 3.0 ± 0.5    | 3                     | 3 (100%) Failure                       |
| Facemask                                              | 9.7 ± 1.5                         | 8.1 ± 5.5                     | 7.1 ± 2.9    | 129                   | 94 (72.9%) Success                     |
| Bite plates and all other removable appliances         | 9.6 ± 1.4                         | 5.5 ± 5.4                     | 5.6 ± 3.3    | 572                   | 437 (76.4%) Success                     |
| Combination                                           | 10.7 ± 2.8                        | 10.8 ± 3.2                    | 12.6 ± 3.3   | 5                     | 109 (19.1%) Failure                    |
| Use of brackets and bite plate                        |                                   |                               |              |                       |                                          |
treatment was 10.6±1.9, with female patients starting at 10.0±1.9 years and male patients starting at 10.4±2.0 years.

Prevalence and types of dental conditions

Among the 1324 records analyzed, the top three most prevalent diagnosis (Table 3) that presented for interceptive orthodontic treatment were anterior crossbite (40.0%) followed by Class II skeletal malocclusion (25.2%) and impacted teeth (16.7%).

Types and frequency of interceptive orthodontic appliances used

Out of 1324 patients, 942 patients (71.1%) had removable appliances, 377 patients (28.5%) had fixed appliances and five patients (0.3%) had a combination of both fixed and removable appliances. The fixed appliances used included a combination of gold chain and brackets, brackets only, hyrax expander, quad helix expander, transpalatal arch, lower lingual arch and the Halterman appliance. Removable appliances used included the twin block, head gear, bionator, reverse bionator, facemask and bite plate. The most common appliance used was the bite plate (572 cases), followed by the twin block (219 cases). Further details on the frequency of use for each type of appliance are provided in Table 2.

Treatment duration and number of visits

The average treatment duration for fixed appliances was 10.8±6.8 months with an average of 9.8±9.2 visits, while the average treatment duration for removable appliances was 7.5±6.5 months with an average of 6.9±3.4 visits. The average treatment duration for a combination of both fixed and removable appliances was 10.8±3.2 months, with an average of 12.6±3.3 visits.

Treatment outcomes

Out of the 1324 records examined, interceptive orthodontic treatment had an overall success rate of 75.5% (1000 cases), improvement rate of 9.5% (126 cases) and failure rate of 15.0% (198 cases). For fixed appliances, the overall success rate was 93.4% (352 out of 377 cases), while for removable appliances the overall success rate was 68.7% (647 out of 942 cases). Analyzing the 198 failure cases, the most common reason (36.4%) for failure was attributed to non-compliance. Failure was also attributed to: appliance breakages (11.6%) and poor retention/fit of appliances (12.6%). However, not all failure cases had clear reasons documented in the treatment notes.

Table 3. Prevalence and types of dental conditions seen in interceptive orthodontic patients.

| Diagnosis                        | No. of Cases | % of Cases |
|----------------------------------|--------------|------------|
| Anterior crossbite               | 529          | 40.0%      |
| Posterior crossbite              | 48           | 3.6%       |
| Impacted teeth                   | 221          | 16.7%      |
| Mal-aligned teeth                | 49           | 3.7%       |
| Excessive dental spacing         | 18           | 1.4%       |
| Anterior deep bite               | 126          | 9.5%       |
| Anterior open bite               | 4            | 0.3%       |
| Skeletal Class II malocclusion   | 334          | 25.2%      |
| Skeletal Class III malocclusion  | 172          | 13.0%      |

Discussion

The various dental conditions that presented for interceptive treatment in NDCS largely corresponded to the reasons for early treatment mentioned in the literature: “Class II and III malocclusions, open bite, deep overbite, transverse problems, ectopic eruption, moderate to severe crowding, large overjet, and large diastemas.”17,18 The most prevalent diagnosis was anterior crossbite (40.0%) followed by Class II skeletal malocclusion (25.2%), which were similar to findings from another study19 where the most common reasons for starting early orthodontic treatment in the public health care system were crossbite and increased overjet.

Although success rate of interceptive orthodontic treatment was found to be 75.5% in our study, it was difficult to make meaningful comparisons with other investigations in the literature as this depended on the parameters used to evaluate success and also the types of interceptive treatment rendered. Definitions for successful treatment vary widely; some believe success means eliminating the need for future Phase II treatment,20 while others aim to obtain a significant improvement in scores of validated occlusal indices.18,21 There were also variations in occlusal indices used for assessment of treatment results, which may impact on comparisons of success rates. Examining pre- and post-treatment casts using the peer assessment rating (PAR) index22 and the index of complexity (ICON),23 it was found that Phase I orthodontic treatment (involving facemask, headgear, fixed appliances, lingual holding arch, functional appliances, crib, serial extractions and expander) resulted in a significant 44.1% improvement in weighted PAR scores and 37.4% reduction in ICON score.21 Using the dental health component in the index for orthodontic treatment need (IOTN)24 and a specially devised local index to assess treatment outcome in a group of 102 children who underwent interceptive treatment (involving extractions of deciduous/permanent teeth or appliance therapy with or without extractions), average improvement rate was 71%, with 22% of cases being completely successful by scoring 100% in the devised local index.18 Meanwhile, in a retrospective cohort investigation on effectiveness of early orthodontics, scoring models using the ICON found a significant improvement in malocclusion though the types of interceptive treatment rendered were not specified.23 In another study19 on the effects of early orthodontic treatment (involving functional appliances, head gear, cross elastics and the quad helix), a significant reduction in treatment need scores were found using a modified IOTN and a scale adapted from the Treatment Priority Index.26 These studies therefore indicate that interceptive orthodontic treatment had generally been effective.

Treatment failure reasons were attributed to non-compliance (36.4%), breakages (11.6%) and poor retention/fit of appliances (11.6%), with others having no explicit reasons...
stated. Another possible reason for failure that was not mentioned in the study could be continued unfavorable growth, as “normal stimulations of growth” may not have been re-established sufficiently.22 The limitations of a retrospective study based on clinical notes are acknowledged here, as not every clinician documents the reason for failure of interceptive treatment, resulting in a substantial number of failure cases that are unaccounted for.

This study yielded a high success rate of 93.4% (352 out of 377 cases) for fixed appliances as patient compliance issues were possibly eliminated. This corroborated with a similar research study on 196 subjects in Seattle where brackets were the most commonly used interceptive orthodontic treatment appliance and resulted in the best treatment effect.23 However, as inferential statistical analysis was not done due to the disproportionate sample size between different appliance types, (for example, there were only three reverse bionator cases but 572 bite plate cases) superiority of one type of interceptive orthodontic appliance from another cannot be inferred. A more uniform distribution of treatment modalities would definitely be more ideal, but these variables were unfortunately beyond our control. This study therefore only aims to provide clinicians with general descriptive statistical information of appliances and any generalized extrapolation of findings should be done with caution.

Also, despite the large sample size of 1324 patients in this study, it should not be seen as a random sample of the population as the list of patients were obtained from a single center and collated from a charge code list. Treatment procedures like selective grinding, which does not have a charge code to it, or serial extractions, which involved a general tooth extraction charge code not unique to interceptive orthodontics, were not captured in our data set.

Our research is of a descriptive nature and limitations of this study design are recognized. Descriptive studies are often a springboard to prepare for more rigorous studies with comparison groups.28 It does not intend to compare if interceptive orthodontic treatment is better than no treatment. Further trials of a randomized controlled nature are required to assess the effectiveness of interceptive treatment for a range of occlusal problems with a control group. Further long-term follow-up studies are also required to ascertain whether the successful short-term effects are maintained once growth has ceased.

Conclusion

This descriptive study has demonstrated an overall short-term success rate of 75.5% for interceptive orthodontic treatment, with the most common diagnoses being the anterior crossbite and skeletal Class II malocclusion. Treatment typically commenced at 10 years of age, with seven out of 10 patients using removable appliances. The most common removable appliance used was the bite plate. Fixed appliances were used in three out of 10 patients, with bracket bonding with or without gold chain traction being the most common treatment modality. The average treatment duration was 7.5 months for removable appliances and 11 months for fixed appliances. Average number of patient visits required for treatment completion was seven for removable appliances and 10 for fixed appliances. Failure of interceptive orthodontic treatment was most often attributed to non-compliance, though there remains a substantial portion of failure cases being unaccounted for.

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None.

Author contributions

Y.L.S. and E.T.L.Y. conceptualized the study. Y.L.S. and E.T.L.Y. verified the integrity of the work and gained ethical approval/waiver from the SingHealth Centralized Institutional Review Board. B.C.C.J., R.N.Y., and N.L.K.P. were involved in the data collection. All are involved in data analysis. Y.L.S. wrote the first draft of the manuscript while the rest of the authors reviewed and edited the manuscript. All approved the final version of the manuscript.

Availability of data

Data sharing is not applicable to this study and datasets are stored confidentially with the National Dental Centre Singapore research office.

Declaration of conflicting interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Ethical approval

This single-center retrospective descriptive research was determined to be exempt from ethical approval due to its non-invasive quality improvement project nature by the SingHealth Centralized Institutional Review Board (CIRB Ref: 2018/2637).

Informed consent

Informed consent was not sought for the present study because of the large number of cases involved and the basically non-invasive and quality improvement nature of the project, approved by the SingHealth Centralized Institutional Review Board (CIRB Ref: 2018/2637).

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ORCID iDs

Yi Lin Song https://orcid.org/0000-0003-2699-9337
Elaine Li Yen Tan https://orcid.org/0000-0002-2528-667X

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