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Space closure versus space opening for bilateral absent upper lateral incisors: what is the duration of orthodontic treatment?

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Summary

Background: Assessment of orthodontic treatment outcomes such as treatment duration in patients with hypodontia are lacking.
Objectives: To assess the overall treatment duration of cases of bilateral absent upper lateral incisors treated with either orthodontic space closure (SC) or space opening (SO). The secondary aim was to determine factors which influence overall treatment duration.
Subjects and methods: A retrospective cohort study was undertaken within the Orthodontic department at Kings College Hospital NHS Foundation Trust. Consecutively treated patients between 2008 and 2018 with bilateral absent upper lateral incisors were identified from clinic lists, clinical logbooks, and multidisciplinary clinics. All study data variables were collected by a single investigator using a pre-specified data collection sheet.
Results: In total, 52 cases were included, 29 in the SC group and 23 in the SO group. Overall non-extraction treatment was favoured ($P = 0.001$) with differences in restorations provided post-treatment evident ($P = 0.01$). Although not statistically significant, the mean overall orthodontic treatment duration was less in the SC group 25.7 months (SD 7.6) compared to the SO group 27.4 (SD 6.1). Overall treatment duration was reduced if treatment was carried out on an extraction basis (–7.02, 95% CI: –11.93, 2.11, $P = 0.01$) but increased as the amount of crowding in the lower arch increased (0.89, 95% CI: 0.08, 1.71, $P = 0.03$).
Conclusions: Within the study limitations, there is no difference in the overall treatment duration between both treatment approaches. Treatment duration is reduced in both SO or SC treatment plans if extractions are undertaken. The presence of lower arch crowding increases the duration of treatment.

Introduction

Hypodontia commonly affects the permanent dentition (1). Within European populations the reported prevalence of hypodontia in females and males is 6.3% and 4.6%, respectively (2). The incidence of developmentally absent upper maxillary lateral incisors is 2% (1) with bilateral agenesis occurring more often than unilateral agenesis (2).

Multiple factors including dental development (3), occlusal variables (4, 5), treatment modalities (6), and patient compliance (7)

have been reported to influence the duration of orthodontic treatment. In a meta-analysis of prospective studies, the average duration of a course of comprehensive orthodontic treatment from appliance placement to removal was reported at 20.02 months (95% CI 19.71, 20.32) (6). In contrast, retrospective studies report an average treatment time between 23.5 (5) and 28.6 months (8). Assessment of the duration of multidisciplinary treatment in hypodontia cases is lacking. Within the literature, the mean duration of combined orthognathic treatment and alignment of ectopically positioned maxillary canines have been reported at 32.8 months (SD 11.3) (9) and 28.8 months, respectively (10).

Among individuals with hypodontia, the primary motivation for treatment is to improve aesthetics. Dissatisfaction is associated with delays in treatment and lack of communication (11). Usually a multidisciplinary approach is adopted involving either orthodontic space closure (SC) by substituting the maxillary canine into the position of the lateral incisor with subsequent aesthetic modification or orthodontic redistribution of spaces for future prosthetic replacement units. In the comparison of SC or space opening (SO) treatment options for patients with absent upper lateral incisors, no difference in patient satisfaction (12) and periodontal parameters (13) have been reported. Despite SC treatment being advocated as the ideal treatment (14), there appears to be a lack of scientific evidence demonstrating the superiority of one treatment modality over the other (15). The majority of studies have tended to evaluate on the aesthetic result and periodontal outcomes. Within the literature there is a lack of assessment of patient-centered outcomes such as treatment duration of multidisciplinary cases. Systematic analysis of hypodontia studies has reported that only 39% studies assessed patient-related outcomes (16). In addition, clinician reported outcomes tended to focus primarily on the aesthetic result.

The purpose of this investigation was to assess the overall orthodontic treatment duration of orthodontic patients with bilateral absent upper lateral incisors treated with full arch conventional fixed appliances with the treatment objective of either SC and substituting the maxillary canine into the lateral incisor position or redistributing the space for prosthetic replacement of the lateral incisors. The secondary aim was to determine factors which influence treatment duration.

Subjects and methods

Ethical approval for this retrospective cohort study was granted by the Health Research Authority (18/HRA/0390, December 2017). Consecutively treated patients with a confirmed diagnosis of bilateral absent upper maxillary lateral incisors who have completed full arch conventional fixed appliance (pre-adjusted edgewise MBT prescription 0.022″ × 0.028″ slot size) (3M Unitek, Monrovia, California, USA) therapy at Kings College Hospital NHS Foundation Trust between 2008 and 2018 were included in this study. Patients with incomplete clinical records, cleft lip and/or palate, craniofacial anomalies or have undergone orthognathic treatment were excluded.

Patients were identified from clinic day lists, clinical logbooks, and orthodontic-restorative joint clinics held within the orthodontic department at Kings College Hospital NHS Foundation Trust. All patients were treated in the orthodontic department of this institution. The study variables were collected from patients' notes; study models and clinical photos and recorded in a pre-specified password encrypted Microsoft Excel data collection sheet. The following data variables were collected from the clinical records:

1. Age of patient at start of treatment (date fixed appliances placed)
2. Gender
3. Grade of clinician treating the patient
4. Pre-treatment occlusal variables (incisor relationship, overjet, molar relationship, overbite, level of crowding or spacing (mm) within the upper and lower dental arches, and skeletal pattern)
5. Treatment plan (non-extraction or extraction)
6. Space opening or closure
7. Planned restorative prosthesis
8. Number of orthodontic breakages during treatment
9. Number of orthodontic appointments
10. Overall treatment duration (defined as the time between the date of placement of fixed appliances and the date when the fixed appliances were removed)

Sample size calculation

A sample size calculation was undertaken based on the primary outcome of treatment duration. On the basis of the results of a previous meta-analysis (6) which reported a mean treatment time/duration of 20 months (standard deviation, 6.4 months), a total of 50 (25 per group) patients were required to demonstrate a clinically meaningful difference of 6 months in treatment duration with a power of 90% and P value less than 0.05.

Statistical analysis

Descriptive statistics were calculated. Pearson chi-squared test, Fisher's exact test, or a t-test were used to compare the variables between SO and SC groups. Linear regression modelling was implemented with univariable analysis to identify characteristics associated with overall treatment duration (SC or SO mechanics, treatment plan, molar relationship, and crowding of the arches); multivariable modelling was used to determine the adjusted effect on overall treatment duration. Significant predictors identified during the univariable analysis were entered individually in the multivariable model. The final model was derived by comparing candidate models using the likelihood ratio test. A two-tailed P-value of 0.05 was considered statistically significant. All analyses were performed using Stata statistical software version 15 (StataCorp, College Station, Texas, USA).

Results

In total, 66 cases were initially identified. After application of the inclusion and exclusion criteria, 52 cases were included in the final analysis: SC group (n = 29) and SO group (n = 23). Table 1 reports the study demographics and pre-treatment malocclusion variables for both groups. Overall, the sample included 14 males and 38 females. The mean age in the SC group was 14.8 (SD 3.6) and 16.1 (SD 4.4) years in the SO group. In the SC group the most common skeletal pattern was Class II. Whereas, in the SO group Class I and Class II Skeletal patterns were equal. The most frequent incisor relationship was Class I in both groups. The mean overjet recorded in the SC group was 2.6 mm (SD 2.2) and 2 mm (SD 1.3) in the SO group. An asymmetric molar relationship was present in 58.6% cases in the SC group and 43.5% in the SO cases. In the SC and SO groups, the mean spacing in the upper arch was 7.4 mm (SD 5.9) and 9.3 mm (SD 5.8), respectively. The SC group had the highest amount of lower arch crowding (mean 2.24 mm).

Table 2 summarizes the mean (SD) values of treatment-related variables for both groups. The mean number of clinicians involved

Table 1. Study demographics and pre-treatment malocclusion variables for both space closure (n = 29) and spacing opening groups (n = 23)

	Space closure (n = 29)	Space opening (n = 23)	
			t-test or Pearson chi-squared test or Fisher's exact test (P < 0.05)
Demographics			
Mean age (years) (SD)	14.8 (3.6) (95% CI: 13.4, 16.1)	16.1 (4.4) (95% CI: 14.2, 18.1)	NS
	n (%)	n (%)	
Gender			
Male	8 (28.0)	6 (26.0)	NS
Females	21 (72.0)	17 (74.0)	
Malocclusion			
Skeletal pattern			
Class I	10 (34.4)	10 (43.5)	NS
Class II	11 (37.9)	10 (43.5)	
Class III	8 (27.7)	3 (13.0)	
Incisor classification			
Class I	11 (37.9)	8 (34.8)	NS
Class II div 1	6 (20.7)	3 (13.0)	
Class II div 2	2 (6.8)	5 (21.7)	
Class III	10 (34.6)	7 (30.5)	
Mean overjet (mm) (SD)	2.6 mm (2.2) (95% CI: 1.8, 3.4)	2 mm (1.3) (95% CI: 1.4, 2.6)	NS
Molar relationship			
Class I	9 (31.1)	10 (43.5)	NS
Class II	0 (0.0)	3 (13.0)	
½ Unit Class II	3 (10.3)	0 (0.0)	
Class III	0 (0.0)	0 (0.0)	
Asymmetric	17 (58.6)	10 (43.5)	
Mean disproportion of arches (SD)			
Upper (crowding/mm)	0.14 (0.74) (95% CI: −0.14, 0.42)	0.28 (1.0) (95% CI: −0.23, 0.67)	NS
Upper (spacing/mm)	7.4 (5.9) (95% CI: 5.16, 9.66)	9.3 (5.8) (95% CI: 6.7, 11.8)	NS
Lower (crowding/mm)	2.24 (3.0) (95% CI: 1.09, 3.39)	0.48 (1.1) (95% CI: 0.01, 0.95)	NS
Lower (spacing/mm)	1.21 (3.6) (95% CI: −0.16, 2.58)	3.69 (6.7) (95 CI: 0.78, 6.59)	NS
Overbite			
Average	12 (41.4)	9 (39.1)	NS
Increased	4 (13.8)	8 (34.8)	
Reduced	13 (44.8)	6 (26.1)	

NS, not significant.

in both groups; 1.45 (SD 0.67) (SC) and 1.35 (SD 0.47) (SO) was similar. The majority of the cases in both groups were treated by orthodontic postgraduates or registrars. Cases treated on non-extraction basis were significantly higher than cases treated with extractions in both groups (P = 0.001). Most of the cases in the SC group received canine composite additions (62.1%). There was a difference in the restorative restorations planned in both cohorts (P = 0.01), with resin-bonded bridges commonly provided (78.3%) (P = 0.01). The mean number of orthodontic breakages during treatment was equivalent in both groups. The mean total number of orthodontic appointments was 20.6 months (SD 4.6) in SC group and 22.3 months (SD 5.1) in SO group. The mean overall orthodontic treatment duration was less in the SC group 25.7 months (SD 7.6) compared to the SO group 27.4 (SD 6.1) but this was not statistically significant.

Comparisons were made between baseline (a reference category) and the following potential predictors on overall treatment duration: SC or SO mechanics, treatment plan, molar relationship, and crowding of the arches (Table 3). In the univariable analysis, the overall treatment duration was shorter if an extraction approach was employed (−5.26, 95% CI: −9.65, 0.87, P = 0.02). No significant differences were observed for the other variables. In the multivariable analysis, overall treatment duration was reduced if treatment was carried out on an extraction basis (−7.02, 95% CI: −11.93, 2.11, P = 0.01) but increased as the amount of crowding in the lower arch increased (per unit) (0.89, 95% CI: 0.08, 1.71, P = 0.03). In addition, the predicted treatment duration was reduced in extraction cases compared to non-extraction cases for both SC and SO groups (Figure 1)

Discussion

Knowledge of the duration of the orthodontic treatment they are about to embark upon is important to patients (6). In the clinical

Table 2. Mean (SD) values of treatment-related variables for both space closure (n = 29) and spacing opening (n = 23) groups

	Space closure (n = 29)	Space opening (n = 23)	
	n (%)	n (%)	t-test or Pearson chi-squared test or Fisher's exact test (P < 0.05)
Clinicians			
Mean number of clinicians involved in orthodontic treatment (SD)	1.45 (0.67) (95% CI: 1.19, 1.71)	1.35 (0.47) (95% CI: 1.14, 1.56)	NS
Grade of clinician involved in orthodontic treatment			
Consultant	2 (6.9)	4 (17.4)	NS
Post-CCST	2 (6.9)	2 (8.7)	
Postgraduate/registrar	13 (44.8)	9 (39.1)	
Therapist	2 (6.9)	0 (0.0)	
More than one clinician involved	10 (34.5)	8 (34.8)	
Treatment			
Treatment plan			
Non-extraction	18 (62.1)	22 (95.6)	<0.001
Extraction	11 (37.8)	1 (4.4)	
Planned prosthesis			
Partial denture	0 (0.0)	0 (0.0)	<0.01
Resin-bonded bridge	1 (3.4)	18 (78.3)	
Dental implant	0 (0.0)	1 (4.3)	
Composite additions	17 (62.1)	0 (0.0)	
Resin-bonded bridges and composite additions	3 (10.3)	4 (17.4)	
Dental implants and composite additions	0 (0.0)	0 (0.0)	
Resin-bonded bridges and dental implants	0 (0.0)	0 (0.0)	
No planned restoration	8 (24.2)	0 (0.0)	
Mean number of orthodontic breakages during treatment	1.34 (1.5) (95% CI: 0.78, 1.91)	1.8 (2.0) (95% CI: 0.99, 2.74)	NS
Mean total number of orthodontic appointments	20.6 (4.6) (95% CI: 18.8, 22.3)	22.3 (5.1) (95% CI: 20.0, 24.5)	NS
Mean overall orthodontic treatment duration (months)	25.7 (7.6) (95% CI: 22.8, 28.6)	27.4 (6.1) (95% CI: 24.7, 30.0)	NS

NS, not significant.

Table 3. Univariable and multivariable linear regression derived coefficients (β) and 95% confidence intervals (CI) for the effect on overall treatment duration for space closure or opening mechanics, crowding of the arches, treatment plan and molar relationship

		Univariable analysis		Multivariable analysis	
Predictor variables	Category	β	P-value	β	P-value
Space opening or closure	Open	Reference		Reference	
	Close	−1.667 (−5.57, 2.237)	0.40	−0.89 (−4.94, 3.17)	0.66
Disproportion of arches		0.339 (−0.44, 1.120)	0.39	0.89 (0.08, 1.71)	0.03
Lower arch crowding (per unit)					
Treatment plan	Non-extraction	Baseline (reference)		Baseline (reference)	
	Extraction	−5.26 (−9.65, 0.87)	0.02*	−7.02 (−11.93, 2.11)	0.01
Molar relationship	Class I	Baseline (reference)			
	½ Unit II	−5.54 (−14.10, 3.01)	0.20		
	Class II	6.12 (−2.44, 14.68)	0.16		
	Asymmetric	0.420 (−3.71, 4.54)	0.84		

management of patients with hypodontia, an orthodontic phase of treatment is commonly required to deliver the desired treatment outcome (17). In multidisciplinary cases, clinician-based outcomes are commonly reported in the literature with patient-based outcomes such as treatment duration often neglected (16). After consideration of various clinical variables, the treatment options for patients with bilateral absent maxillary lateral incisors usually involves either orthodontically redistributing the space within the arch for prosthetic replacement teeth or closing the space and substituting the maxillary canines into the position of the absent lateral incisors. The findings of this study have reported there is no significant difference in the overall orthodontic treatment duration between both approaches. The mean overall orthodontic treatment duration (months) for SC was 25.7 (SD 7.6) and 27.4 (SD 6.1) for SO. Compared to previous findings, the orthodontic treatment of patients with bilateral absent maxillary lateral incisors is greater than conventional orthodontic cases (6) but shorter than both combined orthodontic orthognathic (9) and oral surgery cases (10).

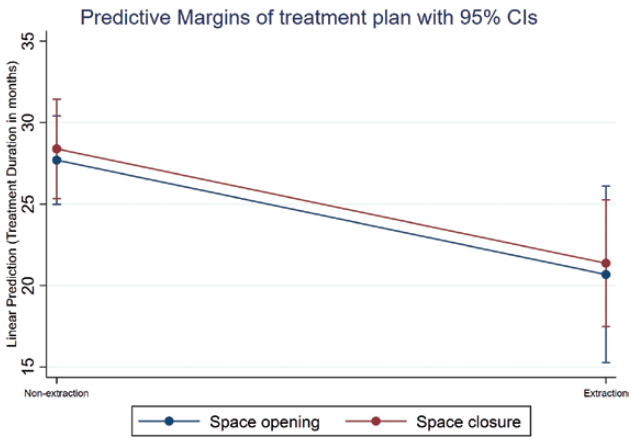

Figure 1. Predictive margins with 95% confidence intervals for treatment duration for space opening or closing and treatment plan (extraction or non-extraction)

There was no significant association found between occlusal variables, age, gender, orthodontic breakages, and treatment duration which supports the findings of previous studies (4, 8, 18). Only the treatment plan (non-extraction or extraction) (−7.02, 95% CI: −11.93, 2.11, P = 0.01) and the amount of lower arch crowding (0.89, 95% CI: 0.08, 1.71, P = 0.03) significantly influenced the overall treatment duration. Extraction-based treatments resulted in shorter treatment duration. This trend was also evident if either SO or SC was undertaken (Figure 1). This finding should be viewed with caution as there was a difference in the treatment approaches (non-extraction or extraction) undertaken in both study cohorts. The duration of orthodontic treatment can be influenced by many factors (4, 6, 8, 18–20). Within the literature extraction-based treatments appear to increase treatment duration (20). In the assessment of five different practices, extractions were found to significantly increase treatment duration; however, shorter mean treatment duration were found in one office that had a high percentage of extraction cases (4). The extraction of teeth as part of orthodontic treatment is the most significant factor that influences the treatment duration (18). Conversely, treatment performed on a non-extraction basis was found to be 4.6 months faster than extraction cases (21). The presence of mandibular arch crowding significantly increased the treatment duration. This finding is consistent with the literature where the presence of more than 3 mm crowding in the lower arch has been reported to increase treatment duration (5).

The use of additional anchorage management appliances, number of extractions undertaken and overall treatment objectives in particular the desired final molar relationship following completion of treatment were not assessed in this study. In both groups, SC and SO, an asymmetric molar relationship was most commonly present. In these cases, if the aim was to obtain a Class I molar relationship, it can be assumed that treatment duration would be increased in non-extraction cases. A Class II molar relationship has been reported to increase treatment duration (5). However, in the comparison of Class II malocclusions treated either on a non-extraction basis or with the extraction of two maxillary premolars, the latter option was reported to result in a statistically shorter total treatment time. Compliance with anchorage reinforcement appliances in non-extraction treatment plans increased the total treatment time (22). Parallels can be drawn between these findings and the study results presented, as extractions would appear to reduce the anchorage demand resulting in shorter treatment duration. In addition, there was also increased amount of crowding in the lower arch in the SC group. Unsurprisingly, if extractions were prescribed to alleviate the crowding this could have reduced the treatment duration in the SC group.

The sample cohort included in this study was selected from a UK single centre secondary care teaching hospital hence potentially reducing the generalizability of the results. Although one of the most common developmental dental abnormalities, this sample consisted of patients with bilateral developmentally absent upper lateral incisors only and hence assumptions regarding the overall treatment duration of patients with more severe form of hypodontia or absent teeth in different sites within the dental arch cannot be drawn. The majority of these cases were treated by postgraduate students under consultant supervision. Within this environment, the overall treatment duration may have been underestimated in both groups due to the close monitoring of treatment progression. However, the reported mean treatment duration of a heterogeneous orthodontic case mix with either a great (IOTN DHC 4) or very great need for treatment (IOTN DHC 5) within a secondary care hospital service has been reported at 27 months which is similar to this study's findings (20). Although not a consideration of this study, future investigations could assess the influence of variables such as archwire selection, anchorage auxiliaries, and operator preferences on treatment duration. The relationship between the use of Temporary Anchorage Devices and treatment duration could also be explored. To reduce the introduction of confounders inclusion/exclusion criteria were adhered too. In addition, both groups were matched with no significant differences detected between the majority of baseline demographics or pre-treatment variables. Consecutively treated patients were included in this study to reduce selection bias. Only 52 cases were included in this study which appears to be a low for the study timeframe. Identification of previously treated cases proved to be challenging due to incomplete records.

The sample size calculation used in this investigation was based on the findings of a previous meta-analysis (6). The latter included the results of prospective studies of patients undergoing conventional orthodontic treatment on both non-extraction and extraction basis and not multidisciplinary care. It was felt by the authors that the use of the findings from surgical-orthodontic multidisciplinary studies would be not applicable to the current study population and may result in an over-estimation of the overall treatment duration. Conversely, future studies may wish to consider a smaller assumed clinical difference which would subsequently increase the study sample size required to detect differences between treatment interventions.

Conclusions

This study reports the overall treatment duration of cases of bilateral absent upper lateral incisors treated either by orthodontic SC and maxillary canine substitution or orthodontic redistribution of spaces for future prosthetic replacements. The findings of this study have shown there is no difference in the overall treatment duration between both treatment approaches. Overall treatment duration is reduced in both SO or SC treatment plans if extractions are undertaken. The presence of lower arch crowding increases the duration of treatment.

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None

Conflict of interest

None declared.

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