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The effect of the root dilaceration on the treatment duration and prognosis of unilateral impacted immature maxillary central incisors

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Introduction: This study aimed to investigate the effect of root dilaceration on the closed-eruption technique treatment and prognosis on impacted immature maxillary central incisors. **Methods:** In this retrospective study, we compared the age at the beginning of the treatment, the treatment duration, root development, and alveolar bone mass after the closed-eruption technique between the impacted immature maxillary central incisors with dilacerated roots (group 1) and those with straight roots (group 2). **Results:** The mean age at the time of the surgery of group 1 was 0.9 years younger than that of group 2 ($P = 0.008$). The mean traction time was greater in group 1 (8.0 ± 1.8 months), with a difference of 1.4 months than in group 2 (6.6 ± 2.1 months) ($P = 0.042$). The measurements of lingual bone thickness at the alveolar crest (C) showed significant differences between the 2 groups ($P = 0.025$). No significant differences were found in other treatment duration or measurements of root development and alveolar bone mass between the 2 groups. **Conclusions:** Patients with impacted immature incisors with dilacerated roots were younger at the beginning of the closed-eruption treatment and had a longer traction time than those with impacted immature incisors having straight roots. The root dilaceration had little or no effect on root development and alveolar bone mass after the closed-eruption treatment. The closed-eruption treatment of impacted immature incisors with root dilaceration is suggested to commence as early as possible. (Am J Orthod Dentofacial Orthop 2023;163:79-86)

Dilaceration is often observed in the root of an impacted tooth and is commonly found unilaterally in the maxillary central incisors.[1,2] The criteria for defining tooth dilaceration vary in the relevant literature. Some authors consider root dilaceration toward the mesial or distal direction if there is a 90° angle or greater along the axis of the tooth or root,[3] whereas others consider a tooth dilacerated when its apical deviation is ≥20° relative to the normal tooth axis.[4]

Dilacerations are reported to occur in 3.00%-3.78% of all permanent dentitions,[2,3] and approximately 50% of teeth with dilaceration are impacted.[5] The prevalence rate for dilacerations of maxillary central incisors is 0.4%-1.2% based on periapical and panoramic radiographs, with the criterion for root dilaceration set as a degree of deviation of 90°.[3,6] Lyu et al[7] found that 65.7% of impacted incisors had dilacerations >20° in their study. In a study of 30 impacted permanent maxillary central incisors, Shi et al[8] found 24 teeth with dilaceration. Dilaceration for maxillary central incisors is reported to be one of the most common etiologies for unerupted incisors.[9]

The closed-eruption technique has been suggested to be a successful treatment option for impacted immature maxillary incisors, with promising therapeutic outcomes as reported by previous studies on this subject.[8,10-12] Many researchers have reported that orthodontic treatment beginning in younger patients with incomplete root formation yields a longer root length

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and less root resorption.[13,14] However, some researchers have also found that incisors with root dilacerations tend to have greater root resorption during forced orthodontic extrusion,[15,16] and that root dilaceration is a predictor of root resorption for impacted maxillary central incisors. The samples in this study include both children and adults.[17] There is still a lack of systematic research about the effect of root dilaceration on the prognosis of impacted immature incisors after the closed-eruption technique.

Regarding the effect of root dilaceration on the treatment duration of impacted maxillary central incisors, some researchers have found a strong negative relationship; the greater the root dilaceration, the longer the forced eruption treatment time.[10,18,19] However, there is no clear definition of how many degrees of root curvature can be classified as tooth dilaceration in these studies. In addition, the impacted incisors consist of young and mature permanent teeth, as the patients selected in many studies include children, adolescents, and even adults.

Our study aimed to compare the age at the beginning of treatment, the treatment duration, root development, and alveolar bone mass after the closed-eruption technique between unilateral impacted immature maxillary central incisors with dilacerated roots and those with straight roots and to investigate the effect of root dilaceration on the treatment and prognosis of unilateral impacted immature maxillary central incisors.

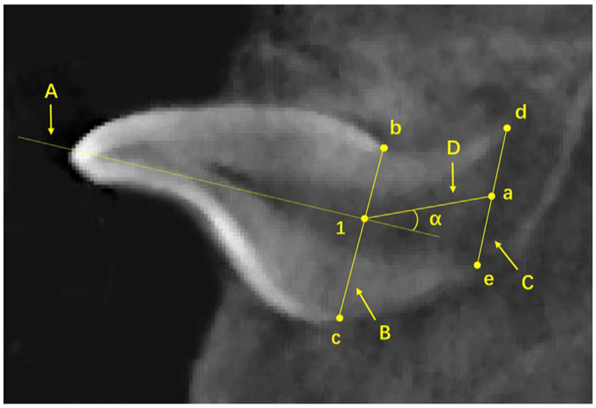

Fig 1. Illustration of the angle of the dilaceration defined in this study. *a,* root apex of the impacted maxillary central incisor, the middle point of the line C; *b,* dilaceration point at the labial side; *c,* dilaceration point at the lingual side; *d,* labial part of the developing root apex; *e,* lingual part of the developing root apex; *1,* the point of intersection of lines A and B; *A,* long axis of the central incisor; *B,* a line connecting b and c; *C,* a line connecting d and e; *D,* a line connecting a and 1; α, the angle between lines A and D. $\alpha \geq 20°$ = dilacerated root; $\alpha < 20°$ = straight root.

MATERIAL AND METHODS

This is a retrospective study. A total of 264 patients with impacted maxillary central incisors were consecutively treated by the same operator (S.Z.) in the Departments of Pediatric and Preventive Dentistry at the Peking University School and Hospital of Stomatology from 2004 to 2019. Of these, 39 patients (19 boys, 20 girls) were included in our study. They met the following criteria: (1) coexistence of a unilateral impacted maxillary central incisor, with incomplete root formation at the beginning of the closed-eruption treatment, with a contralateral erupted maxillary central incisor; (2) the closed-eruption technique had been completed ≥12 months prior, and the root apices of the incisors had completed development before the posttreatment cone-beam computed tomography (CBCT) examination; (3) complete patient records, including diagnostic and treatment notes, pretreatment and posttreatment CBCT records; and (4) the patient and parents cooperated with the treatment plan and provided informed consent. The exclusion criteria were as follows: (1) trauma to the maxillary frontal area from the date of the permanent central incisors erupted into the oral cavity to the date of posttreatment CBCT examination, (2) combined impaction of other teeth, (3) a mechanical obstacle to eruption (eg, supernumerary teeth, tumors, odontoma, or cysts), and (4) systemic diseases. Approval was obtained for this clinical study from the ethics committee of the School and Hospital of Stomatology of Peking University.

The diagnosis of impaction was made on the basis of diagnostic clinical and radiologic examinations. Dilaceration of the root was defined as a degree of root deviation equal to or exceeding 20° from the normal tooth axis. On the pretreatment CBCT images, the angle of the dilaceration was defined as the angle between the long axis of the crown and the axis of the dilacerated root when viewed on an axial slice (Fig 1, $\alpha \geq 20°$ dilacerated root; $\alpha < 20°$ straight root). The impacted incisors with dilaceration were collected in group 1, and those without dilaceration were collected in group 2.

All patients were treated with the standardized closed-eruption technique by the same operator (S.Z.). The treatment procedures followed the order we have described elsewhere.[8] There were 29 patients (21 dilacerated roots, 8 straight roots) whose space was insufficient to accommodate the impacted incisors before treatment. Three patients with dilacerated roots received space-gaining orthodontic procedures before the closed-eruption technique.

The day of the surgery was considered the beginning of the closed-eruption technique. A bracket was bonded to the crown of the impacted incisor during surgery, and this was tied to an orthodontic elastomeric chain (Clear Generation II power chain, closed space 639-0002; Ormco, Orange, Calif) for orthodontic traction. A 0.016 $\times$ 0.022-in stainless steel archwire enhanced anchorage with an omega-shaped bend to direct the elastomeric chain. The maxillary anterior teeth, which had erupted to the occlusal plane, were usually used as anchorage teeth. The elastomeric chain was progressively excised and reconnected to the archwire to obtain light orthodontic extrusive traction force. It is recognized that this method is inherently inconsistent in the level of force applied. Patients were recalled every 4-5 weeks to adjust their elastomeric chain and archwire. The position of the bracket on the crown of the previously impacted incisor was adjusted when the crown erupted into the oral cavity. Subsequently, the impacted incisor was orthodontically positioned in the dental arch. When the orthodontic movements of the impacted incisor were finished and the tooth was well aligned with the adjacent teeth, closed eruption was considered complete.

After forced eruption, a 0.016 $\times$ 0.022-in stainless steel archwire was passively placed in the labial brackets of the central and lateral incisors as a fixed retainer. Posttreatment CBCT images were obtained at least 12 months after the completion of closed eruption.

The duration of orthodontic treatment was calculated from the surgical exposure to the date of the determined proper alignment of the impacted incisor in the dental arch. This period was divided into 2 constituent treatment periods (the duration of traction and the duration of alignment) according to the date that the impacted incisor was brought to the same level as the contralateral incisor in the arch.

The retention duration was calculated from determining the proper alignment of the impacted incisor in the arch to the debonding date of the maxillary incisors.

The follow-up duration was calculated from determining the proper alignment of the impacted incisor in the arch to the date of the posttreatment CBCT examination. The follow-up time, including the retention time, should be longer than 12 months.

Posttreatment CBCT examinations of the patients were exported in digital imaging and communications in medicine format and subsequently imported in the digital imaging and communications in medicine viewer PACS Carestream (version 3.1.S20.1; Carestream Health, New York, NY) for 3-dimensional reconstructions.

The measurement variables used in this study followed the same measurement methods as our research group,[8] as described in Figure 2 and Table I, including the root length (R), root canal width (W), alveolar bone loss (L), alveolar bone thickness of the alveolar crest (C) and alveolar bone thickness at the root apex (A).

For each group in this study, we defined $\Delta X = Xi - Xc$ (X referred to any of the above measurement indicators, ie, R, W, L, C, or A) as the representation of the differences in the measurement values between the impacted incisors (Xi) and their contralateral incisors (Xc). For example, $\Delta R_1 = Ri_1 - Rc_1$ was used to represent the difference in root length between the measurement values of the impacted incisors (Ri_1) and those of their contralateral incisors (Rc_1) in group 1. These ΔXs (ie, ΔR, ΔW, ΔL, ΔC, and ΔA) were used for the subsequent comparisons between the 2 groups (ΔX_1 for group 1 and ΔX_2 for group 2) to evaluate the effect of root dilaceration on the prognosis of root and alveolar bone after the treatment.

Because all the differences (ΔX) in the measurement values (X) were not 0, it was easier to compare the degree of variance between the differences (ΔX) by using logarithm transformation. Therefore, logarithm transformation (Log_2 X) was performed on the measurement data (X) in the following analysis.

Statistical analysis

All measurements were repeated by the same investigator (X.S.) at 2-week intervals, and the values were averaged. We applied logarithm transformation (log_2 X) before analysis, and $\Delta Log_2 X = log_2 Xi - log_2 Xc$ was used as the final value for the statistical analysis.

The intraexaminer error was determined by the interclass correlation coefficient.

Statistical analyses were conducted using SPSS software (version 23.0; IBM, Armonk, NY). Data distribution normality was determined with Shapiro-Wilk tests. Independent t or Mann-Whitney U tests were used to compare the groups, depending on data normality. Group comparability regarding sex, etiology, and impaction location were evaluated with Fisher exact probability tests. All P values were 2-tailed, and statistical significance was set at $P < 0.05$ for all tests.

RESULTS

The interclass correlation coefficient was 0.977.

There were 25 patients with dilacerated roots (group 1) and 14 with straight roots (group 2). The patients' characteristics are presented in Table II, and no differences were found in sex, etiology, or impaction location between the 2 groups.

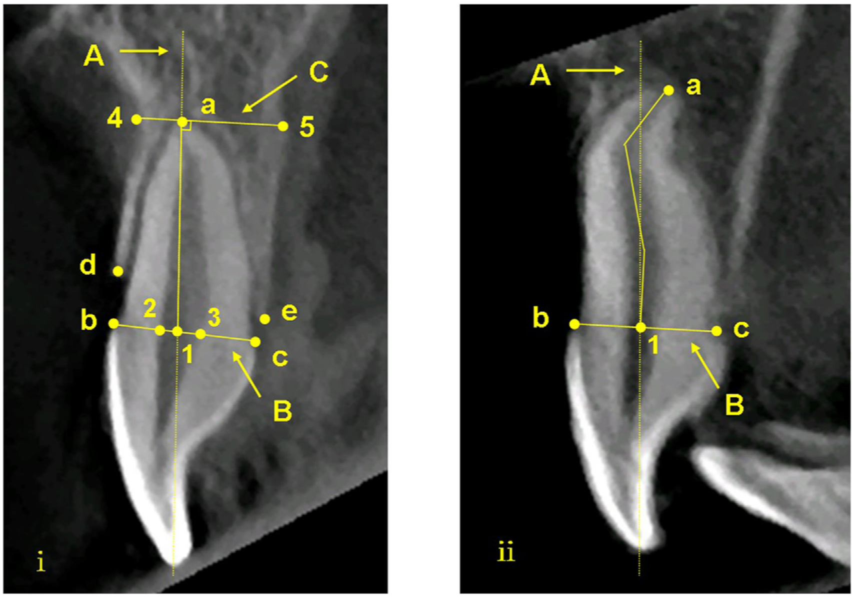

Fig 2. Illustration of reference points and lines used in this study: **i,** *a,* root apex; *b,* CEJ at the labial side; *c,* CEJ at the lingual side; *d,* alveolar crest at the labial side; *e,* alveolar crest at the lingual side; *A,* long axis of the central incisor; *B,* a line connecting b and c; *C,* a line connecting 4 and 5; *1,* the point of intersection of lines A and B; *2,* the point of intersection of line B and the labial wall of the root canal; *3,* the point of intersection of line B and the lingual wall of the root canal; *4,* the point of intersection of a line perpendicular to the long axis of the incisor, with the labial contour of the maxilla; *5,* the point of intersection of a line perpendicular to the long axis of the incisor, with the lingual contour of the maxilla; **ii,** When the root was dilacerated, root length was measured from point 1 to a in a line following the curvature, and the image would be rotated when needed.

Table I. Definitions of measurements used in this study (see Fig 2)

Measurement variable	*Definition*
R	Root length: distance from a to 1
W	Root canal width: distance from 2 to 3
L	Alveolar bone loss: distance from b to d (c to e) measured parallel to line A
C	The alveolar bone thickness of the alveolar crest: the thickness of the alveolar bone 1 mm under point d (point e) measured perpendicular to line A
A	Alveolar bone thickness at the root apex: distance from a to 4 (a to 5) measured perpendicular to line A

Table III gives the mean ages at the time of the surgery. The mean age of group 1 was 0.9 years younger than that of group 2 ($P = 0.008$).

Table IV lists the durations of treatment. The traction time was greater in group 1 (mean, 8.0 $\pm$ 1.8 months), with a difference of 1.4 months than in group 2 (mean, 6.6 $\pm$ 2.1 months) ($P = 0.042$). No significant between-group differences were identified in the alignment, retention, follow-up, or total orthodontic treatment duration.

In our study, the development of root apices of the impacted incisors was completed at the end of the follow-up period. No obvious radiographic sign of root resorption or periapical radiolucency was observed on posttreatment CBCT images. Regarding the differences ($\Delta X = Xi - Xc$) in the measurement values of impacted incisors (Xi) and contralateral incisors (Xc), as shown in Table V and Table VI, only the measurements of lingual bone thickness at the alveolar crest (C) showed significant differences between the 2 groups. The ΔC_2 (mean, 0.41 $\pm$ 0.46 mm) in group 2 was greater than the ΔC_1 (mean, 0.08 $\pm$ 0.30 mm) in group 1 ($P = 0.025$) on the lingual side. Other values showed no significant differences between the 2 groups.

DISCUSSION

In this study, we compared the age at the start of the treatment, the treatment duration, root development, and alveolar bone mass between impacted immature incisors with dilacerated roots and those with straight roots to investigate the effect of root dilaceration on

Table II. Patient characteristics

Characteristic	*n*	*Group 1*[†]	*Group 2*[‡]
Sex		25	14
Male	19	10	9
Female	20	15	5
Location of impaction			
Right	23	15	8
Left	16	10	6
Etiology			
Trauma	7	5	2
Caries	23	16	7
Unknown	9	4	5

[†]Group of the impacted incisors with dilacerated roots; [‡]Group of the impacted incisors with straight roots.

Table III. Age at the beginning of the closed-eruption technique

Variable	*Mean ± SD*	*Range*	*P value*
Age (y)	8.1 ± 1.1	6.5-11.2	
Group 1[†]	7.8 ± 0.9	6.5-9.4	0.008*
Group 2[‡]	8.7 ± 1.2	7.3-11.2	

SD, standard deviation.
*Statistically significant differences; [†]Group of the impacted incisors with dilacerated roots; [‡]Group of the impacted incisors with straight roots.

Table IV. Treatment duration

Variable	*Mean ± SD*	*Range*	*P value*
Taction time (mo)	7.5 ± 2.0	2.6-12.0	
Group 1[†]	8.0 ± 1.8	5.0-12.0	0.042*
Group 2[‡]	6.6 ± 2.1	2.6-10.3	
Alignment time (mo)	4.9 ± 4.6	0.0-23.1	
Group 1[†]	4.8 ± 3.6	0.0-14.2	0.460
Group 2[‡]	5.1 ± 6.1	0.6-23.1	
Total orthodontic treatment time (mo)	12.4 ± 5.2	4.7-31.7	
Group 1[†]	12.8 ± 4.4	5.9-23.6	0.236
Group 2[‡]	11.7 ± 6.6	4.7-31.7	
Retention time (mo)	12.9 ± 8.2	3.2-47.3	
Group 1[†]	13.9 ± 8.5	3.2-47.3	0.089
Group 2[‡]	11.1 ± 7.4	5.6-29.3	
Follow-up time (mo)	33.6 ± 26.2	12.1-145.8	
Group 1[†]	38.0 ± 30.7	12.1-145.8	0.236
Group 2[‡]	25.7 ± 12.8	12.4-56.3	

SD, standard deviation.
*Statistically significant differences; [†]Group of the impacted incisors with dilacerated roots; [‡]Group of the impacted incisors with straight roots.

the treatment and prognosis of unilateral impacted immature maxillary central incisors. The results confirmed the importance of the early treatment of the immature impacted incisors with dilaceration from a new perspective.

The mean age of all patients at the beginning of the closed-eruption treatment was 8.1 ± 1.1 years, and the age of the group with dilacerated roots (group 1) was 0.9 years younger than that of the group with straight roots (group 2). This significant difference might be because clinicians tend to wait for the spontaneous eruption of impacted incisors if the roots of impacted incisors are straight. In contrast, clinicians usually start treatment early when the impacted incisor has a dilaceration. It is well accepted that the treatment of dilacerated incisors should start as early as possible and aim at tooth alignment in the dental arch.[1,2] However, for patients with impacted incisors and straight roots, clinicians need to be aware that subsequent root curvature may develop as patients age.[7]

In our study, the impacted incisors with dilacerated roots had a longer traction time than those with straight roots, which was similar to findings in previous studies.[10,18,19] These researchers deemed that the traction duration was significantly longer in the dilaceration group because the dilacerated incisors had more highly impacted crowns, a longer path of movement, and a higher degree of rotation in the buccolingual plane to move them to the occlusal level than those with straight roots. In addition, a dilacerated incisor might need more bone remodeling procedures than the straight one because of the increased root surface area in the eruption pathway. However, the difference of 1.4 months in traction time between the 2 groups in our study was shorter than that of previous studies (3-4 months).[18,19] In addition, no significant differences were observed for alignment or orthodontic treatment time. It seems that the effect of root dilaceration on orthodontic treatment time in our study is not as great as that of previous studies. There could be 2 reasons for this. First, the criterion of dilaceration in our study was defined as a deviation of ≥20° along the tooth axis, indicating that patients with a probably lower level of root deviation were likely to fall into the group of dilacerated roots. Hu et al[10] found that the traction duration increased with the degree of dilaceration, measured by the angle between the crown and root with a range of 57.80°-177.80° for the study samples (a larger angle indicated a lower degree of dilaceration, and vice versa). The treatment time was shorter for dilacerated incisors with a lower degree of dilaceration. This might reduce the differences in comparing treatment durations between the 2 groups in our study. Second, the mean age of the group with dilaceration at the beginning of treatment

Table V. Root development

	Group 1[†]			Group 2[‡]			
ΔX	ΔX_1		$\Delta log_2\ X_1$	ΔX_2		$\Delta log_2\ X_2$	
Variable	*Mean ± SD (mm)*	*Range*	*Mean ± SD*	*Mean ± SD (mm)*	*Range*	*Mean*	P *value*
ΔR	0.71 ± 1.81	−2.29 to 4.46	0.077 ± 0.241	−0.42 ± 1.45	−3.48 to 1.53	−0.059 ± 0.184	0.075
ΔW	0.13 ± 0.31	−0.37 to 0.85	0.103 ± 0.243	0.08 ± 0.30	−0.29 to 0.80	0.054 ± 0.228	0.544

X, representation of the measurements, *R, W, L, C, A*; ΔX, $\Delta X = Xi - Xc$, the difference between the measurement values of the impacted incisors and their contralateral incisors; *Xi*, the measurements of the impacted incisors; *Xc*, the measurements of the contralateral incisors; $Log_2\ X$, logarithm transformation performed on the measurement data *X*; $\Delta Log_2\ X$, $\Delta Log_2\ X = \Delta Log_2\ Xi - \Delta Log_2\ Xc$, the difference between the $Log_2\ X$ of the impacted incisors and their contralateral incisors; *SD*, standard deviation; *R*, root length, distance from a to 1 (Fig 2); *W*, root canal width, distance from 2 to 3 (Fig 2).
[†]Group of the impacted incisors with dilacerated roots; [‡]Group of the impacted incisors with straight roots.

Table VI. Alveolar bone mass

	Group 1[†]			Group 2[‡]			
	ΔX_1		$\Delta Log_2\ X_1$	ΔX_2		$\Delta Log_2\ X_2$	
ΔX	*Mean ± SD (mm)*	*Range*	*Mean ± SD*	*Mean ± SD (mm)*	*Range*	*Mean ± SD*	P *value*
ΔL							
La	3.37 ± 3.24	−0.68 to 9.89	1.454 ± 1.612	1.67 ± 2.03	−0.23 to 6.73	0.917 ± 0.884	0.258
Li	0.22 ± 0.59	−0.77 to 1.71	0.489 ± 0.514	−0.27 ± 0.98	−2.96 to 0.74	−0.230 ± 0.482	0.114
ΔC							
La	−0.09 ± 0.22	−0.61 to 0.41	−0.201 ± 1.607	−0.15 ± 0.25	−0.83 to 0.20	−0.336 ± 0.454	0.427
Li	0.08 ± 0.30	−0.45 to 0.90	0.096 ± 1.192	0.41 ± 0.46	−0.22 to 1.73	0.413 ± 1.547	0.025*
ΔA							
La	−0.50 ± 2.79	−7.38 to 5.23	−0.474 ± 0.43	0.22 ± 1.16	−1.13 to 2.27	0.061 ± 0.355	0.447
Li	0.15 ± 2.84	−8.03 to 6.61	−0.060 ± 0.821	−0.69 ± 1.93	−5.19 to 2.20	−0.183 ± 0.443	0.160

X, representation of the measurements, *R, W, L, C, A*; ΔX, $\Delta X = Xi - Xc$, the difference between the measurement values of the impacted incisors and their contralateral incisors; *Xi*, the measurements of the impacted incisors; *Xc*, the measurements of the contralateral incisors; $Log_2\ X$, logarithm transformation performed on the measurement data *X*; $\Delta Log_2\ X$, $\Delta Log_2\ X = \Delta Log_2\ Xi - \Delta Log_2\ Xc$, the difference between the $Log_2\ X$ of the impacted incisors and their contralateral incisors; *SD*, standard deviation; *L*, alveolar bone loss, distance from b to d on the labial side (from c to e on the lingual side), measured parallel to line A (Fig 2); *C*, the alveolar bone thickness of alveolar crest, the thickness of the alveolar bone 1 mm under point d on the labial side (point e on the lingual side), measured perpendicular to line A (Fig 2); *A*, alveolar bone thickness at the root apex, distance from a to 4 on the labial side (from a to 5 on the lingual side), measured perpendicular to line A (Fig 2).
*Statistically significant differences; [†]Group of the impacted incisors with dilacerated roots; [‡]Group of the impacted incisors with straight roots.

was younger in our group than that of previous studies. Ho and Liao[18] reported a strong positive correlation between treatment duration and patient age. Treatment time decreased in younger patients, which has also been reported by other authors.[10,19,20] They attributed this correlation to the residual eruptive potential and the comparatively lower level of bone density in younger patients, which might have facilitated expedient forced eruption of early-treated impacted incisors.[10,18,19] In our study, all of the patients in group 1 were aged <10 years, with the mean age of group 1 being younger than that of group 2. This indicates that timely treatment at a younger age (aged <10 years) may help to shorten the treatment time of impacted immature incisors with dilaceration.

In terms of root development, there was no obvious root resorption in dilacerated impacted immature incisors in our study. Similar results were reported by Pavlidis et al[2] in a systematic review, tooth morphology is unlikely to be a causative factor for root resorption associated with orthodontic tooth movement.[21] In contrast, Sameshima et al[16] found that the worst root resorption was seen in teeth with dilacerated roots in their orthodontic treatment. Graber et al[15] suggested that dilacerated teeth were more resistant to extrusion than teeth with normal roots, making the apical area more prone to resorption. The lack of resorption in our study may be due to the young age with incomplete root formation when the treatment commenced. The short dilacerated part of the root with residual eruptive potential and the less bone density in younger patients possibly made the orthodontic traction of the dilacerated impacted incisors more efficient than that started at an older age.[18] The orthodontic traction force was light, the duration was short, and residual eruptive potential was present, which likely assisted continued root development of the dilacerated incisors.

Moreover, many previous studies have reported that incomplete root formation helped prevent root resorption. Lin et al[22] suggested that dilacerated teeth with incomplete root formation should have a better prognosis for orthodontic traction than those with complete root formation. Mavragani et al[13] speculated that root-forming tissue surrounding immature incisors could protect mineralized root tissue from apical resorption during orthodontic treatment. Hence, root dilaceration will not affect eventual root length if the treatment is carried out early and the forces are light and continuous. Taken together, early treatment of dilacerated impacted immature incisors is necessary and important to the eventual health of the root.

Compared with those with no dilaceration, impacted incisors with dilaceration had longer travel distances and longer traction times to be brought to their normal positions, which theoretically increased the possibility of alveolar bone loss.[10] However, our study identified no significant differences between the 2 groups in alveolar bone loss (L) and alveolar bone thickness at the root apex (A). The differences reached statistical significance only for the lingual bone thickness at the alveolar crest (C), which revealed that the axis of the roots at the alveolar crest of the impacted incisors inclined toward the labial aspect,[23] in which the extent of the inclination of the impacted incisors was more obvious than that of their contralateral incisors in the straight root group. In addition, the difference of ΔC (ie, the bone thickness at the alveolar crest of the impacted incisor minus that of control) between the 2 groups was 0.32 mm, which was statistically, but not clinically, significant. The results in our study indicate that the root dilaceration of impacted immature incisors had little effect on the alveolar bone mass after the closed-eruption treatment. Therefore, the impacted immature incisors with dilacerated roots should be treated early.

CONCLUSIONS

In this study, patients with impacted immature incisors of dilacerated roots were younger at the beginning of the closed-eruption treatment and had a longer traction time than those with impacted immature incisors of straight roots, but there was no significant difference in the total orthodontic treatment time. The root dilaceration of impacted immature incisors did not affect root development after the closed-eruption treatment, whereas a very slight influence was observed on the corresponding alveolar bone mass.

The closed-eruption treatment of impacted immature incisors with root dilaceration is suggested to commence as early as possible.

AUTHOR CREDIT STATEMENT

Xiangru Shi contributed to investigation, writing-original draft preparation, reviewing and editing; Xiangyu Sun contributed to investigation, writing-reviewing and editing; Xiaozhe Wang contributed to methodology; Chenying Zhang contributed to formal analysis; Yang Liu contributed to software; Junkang Quan contributed to methodology; Shuguo Zheng contributed to conceptualization, supervision.

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