The treatment timing of labial inversely impacted maxillary central incisors: A prospective study

Hao Sun; Rongdang Hu; Manman Ren; Yan Lin; Xiuying Wang; Chaofan Sun; Yi Wang

ABSTRACT

Objective: To determine the timing of treatment for the labial inversely impacted maxillary central incisors.

Methods: Twenty-eight patients (mean age, 8.2 years) with labial inversely impacted maxillary central incisors were divided into early-treated and later-treated groups according to their dental age. All of the patients were treated with a combination of surgery and orthodontic traction using the Guide rod appliance. Cone-beam computed tomography images were taken immediately after treatment for assessing the root morphology, root length, and alveolar bone loss. Sagittal slices were evaluated at the widest labial-lingual width of the tooth in the axial view. All variables were evaluated by Simplant 13.0 software (Materialise Dental NV, Leuven, Belgium).

Results: The rank sum test indicated that the root length of two groups showed a statistically significant difference between the impacted and homonym tooth, with a shorter length in the impacted tooth ($P < .05$). The $D$-value (difference of root length between the impacted and homonym tooth) and alveolar bone loss on the labial side of the impacted incisor are significantly less in the early-treated groups when compared with the later-treated groups ($P < .05$). Spearman rank correlation analysis showed a statistically positive association between the treatment timing and $D$-value ($r = .623, P < .05$). The chi-square test for morphology of root apex indicated that the incidence of the root-apex-directed labial side is significantly higher in the later-treated groups when compared with the early-treated groups.

Conclusion: The labial inversely impacted maxillary central incisors should be treated early to promote root development by achieving a better morphology of root apex, thus reducing the risk of alveolar bone loss on the labial side. (Angle Orthod. 2016;86:768–774.)

KEY WORDS: Labially inversely impacted tooth; Central incisor; CBCT; Treatment timing

INTRODUCTION

The prevalence of impacted maxillary central incisors varies 0.06%–0.20%, which not only results in a disturbing esthetic dilemma of the teeth and maxillofacial region but also is a concern for social well-being. The labial inversely impacted maxillary central incisor is regarded as a special type of impacted tooth, showing its crown directing upward and its lingual side facing labial (Figure 1). As shown in Figure 2, most cases with root dilacerations (deformity of tooth as a result of a disturbance between the unmineralized and mineralized portions of the developing tooth germ). In our previous study, we found more similar features of the labial inversely impacted maxillary central incisors, such as dilacerations occurring more often in a later-age dental group and the dilacerated root clinging more to the palatal cortical bone.

Among many alternative treatments, two treatment approaches need to be considered: surgical exposure with orthodontic or extraction and prosthetic replacement with implant placement or fixed bridge. Surgical exposure with orthodontic was the most common choice, and previous researchers reported that many...
cases were presented with root dilaceration before treatment.\textsuperscript{5,6,7} Some stated that the root growth and development potential of the labial inversely impacted maxillary central incisor can be exploited by early treatment.\textsuperscript{8}

In the past, radiographic measurements have been based on two-dimensional (2D) images.\textsuperscript{9} The labial inversely impacted maxillary central incisor presents dilacerations as a result of the deformity of root labial-lingually, its curvature lies in a labial-lingual direction, and the central X-ray beam of periapical view and occlusal view radiographs pass almost parallel to the deviating part of the root. Thus a 2D radiographic image has limits when measuring more anatomic structures. Cone-beam computed tomography (CBCT) has been widely introduced in dentistry because it offers three-dimensional (3D) reconstruction and the capacity to evaluate any anatomic structure from any interesting plane\textsuperscript{10} and no difference when comparing measurements made directly on human skulls.\textsuperscript{11} Therefore, CBCT provides a new method for assessing root length, alveolar bone loss, alveolar bone thickness, and root morphology.\textsuperscript{12} However, previous studies about treatment timing have been mainly based on 2D images, and most were case reports. To the best of our knowledge, no well-controlled clinical trial has been reported. The purpose of this prospective study was to perform a multisample controlled clinical investigation by using CBCT analysis to determine the treatment timing of a labial inversely impacted maxillary central incisor.

**MATERIALS AND METHODS**

A total of 28 patients (13 boys, 15 girls; mean age, 8.2 years) with labial inversely impacted maxillary central incisors who were presented for treatment at the orthodontic department, Hospital of Stomatology, Wenzhou Medical University, from June 2008 to June 2012 were recruited for this study.

The inclusion criteria for enrollment were (1) clinical documentation of the patient's information and medical history, (2) clear CBCT images, (3) a preliminary diagnosis of unilateral maxillary inversely impacted incisor in the mixed dentition as shown in Figure 1 and the homonym teeth with normal root formation and orientation, and (4) a completed informed consent form. The exclusion criteria were (1) other serious oral and maxillofacial diseases and (2) systemic disease. Approval was obtained from the Ethical Committee for the Clinical Trial, Hospital of Stomatology, Wenzhou Medical University.

All of the patients were divided into the early-treated group (stages 7 and 8) or the later-treated group (stages 9 and 10) according to Nolla's method.\textsuperscript{13} Briefly, the tooth with one-third root formation (stage 7) or two-thirds root formation (stage 8) was assigned to the early-treated group, whereas those with almost root completion but open apex (stage 9) or completion of the root apical end (stage 10) were assigned to the later-treated group.

All of the patients were treated with the method of surgical exposure and orthodontic traction using the
Guide rod appliance invented by Professor Hu Rongdang (Figure 3), which is similar to the Modified Nance arch. The position and direction of the hook can be adjusted in 3D according to the movement of impacted teeth, providing reasonable traction force to the impacted crown (Figure 4). There were no dropouts. CBCT scans (NewTom, QR s.r.l, Verona, Italy) were performed on all patients after treatment with the following parameters: 110 KV, 1-20 mA (pulse mode), 26-second scanning time with an axial thickness of 0.25 mm, 15 × 15 cm field of view, and 0.30 mm × 0.25 mm voxel size.

The data generated from the NNT Workstation software in DICOM format (QR srl, Verona, Italy) were imported into the SimPlant Pro 13.0 program (Materialise Dental NV, Leuven, Belgium). Reference points, lines, and measurement variables are described in Figure 5 and Tables 1 and 2. The measurement methods were revised from Kim et al. and followed the same methods as reported in our previous study when measuring a nonuniform root shape. Sagittal slices were evaluated where the maxillary central incisor showed the widest labiolingually in the axial view. The root length was defined as the distance between points 4 and 8. Alveolar bone loss in labial side (LBC) and alveolar bone loss in lingual side (PBC) were defined as the alveolar bone loss on both sides and measured parallel to long axis. Alveolar bone thickness in labial side (LA) and alveolar bone thickness in lingual side (PA) is defined as the root apex to the alveolar cortex and measured perpendicular to the long axis of tooth. A multiplaner reconstruction method was used to locate the landmark from sagittal, coronal, and axial slices simultaneously, consistent with Gribel and de Oliveira (Figure 6).

Statistical Analysis

All measurements were repeated after 2 weeks by the same investigator, and the mean of the two measurements was used in the statistical analysis. The intraexaminer error between the two measurements was determined by intraclass correlation coefficient (ICC) and based on a two-way mixed analysis of variance. Descriptive statistics were used as means (standard deviations). All statistical analyses included the rank sum test, Spearman rank correlation analysis, or chi-square test and were used with SPSS 17.0 statistical software (IBM, Armonk, N.Y.). The $P < .05$ level of significance was chosen for all tests.
RESULTS

The ICC measurement indicated excellent reliability with a mean ICC value of .907 (.81–.92).

The rank sum test indicated a significant difference between the impacted and homonym tooth in root length for all groups after treatment ($P < .05$) (Table 3). In addition, as shown in Table 4, although the root length of the impacted and homonym tooth and alveolar bone loss on the lingual side showed no significant difference between the two groups, the $D$-value of the root length and alveolar bone loss on the labial side of the impacted tooth was significantly different between the early-treated and later-treated groups ($P < .05$) and relatively less significant in the early-treated group.

Spearman rank correlation analysis showed that there was a positive correlation between treatment timing and the $D$-value ($r = .623$, $P < .05$).

Although the alveolar bone thickness showed no significant difference between the two groups, the chi-square test for the morphology of root apex revealed that the incidence of direction of the root apex is significantly different, showing that most were inclined toward the palatal side or parallel to the long axis in the early-treated group rather than located toward the labial side as seen in the later-treated group (Tables 4 and 5 and Figure 7).

DISCUSSION

Each type of malocclusion has its suitable treatment timing to achieve better results, such as arch expansion for constricted maxillary arch. Thus suitable treatment timing is critical for treating the labial inversely impacted maxillary central incisors. In our previous study, we found the following features of impacted teeth: (1) the root length of impacted teeth was significantly shorter than that of homonym teeth, and the root length was positively correlated to dental age; (2) dilacerations occurs in most cases and mainly in the later-age dental group; and (3) the dilaceration root clings to the palatal cortical bone. Therefore, we suggested that this type of malocclusion needs an early treatment, thus creating more space for root development and facilitating future treatment.

The root length, alveolar bone thickness, alveolar crest height, and morphology of root apex are significant for assessing long-term stability and the preserving rate and effectiveness of treatment. These measurement variables were also used to evaluate the treatment efficacy of impacted teeth.

As shown in Tables 3 and 4, the root length of the impacted teeth were shorter than that of the homonym tooth with a significant difference between the two groups ($P < .05$), and there were smaller $D$-values in the early-treated group when compared with the later-treated group ($P < .05$). At the same time, Spearman rank correlation analysis also showed that the $D$-values were positively related to treatment timing. These indicate that the root of impacted teeth could
achieve better development if treated early. Based on these findings, it is suggested that the earlier the treatment, the better the root development.

Previous studies have demonstrated that 2-mm height from cement-enamel junction (CEJ) to the alveolar crest (AC) is considered normal. The distance from CEJ to AC represents the vertical height. It is evident that the significantly reduced vertical height and horizontal thickness explains the risks of periodontal problems. In our study, the lingual alveolar bone losses showed no difference between the early-treated and later-treated groups. As to the labial side, the AC was higher at 3.30 mm ± 1.18 mm (Table 4) in the later-treated group. Generally, the root apex inclines to the palatal side or is parallel to the long axis, and when located in cancellous bone it was more conducive to root health and stability when compared with the labial side. An analysis of the morphology of an impacted root apex after treatment revealed that the direction of the root apex was more parallel to the long axis or pointed to the palatal side and located at the cancellous bone in the early-treated group, whereas it was pointed to the labial side and faced to or penetrated the cortex of the labial alveolar bone in the later-treated group (Table 5, Figure 7). In sum, little alveolar bone loss in the labial side and better morphology of the root apex as seen in the early-treated group provides positive signs for achieving better root health and stability.

The present study strongly suggests that early treatment timing has the potential to change the location relationship between the root and the palatal cortical bone. If the root is freed from the restrictions of the palatal cortex, it would obtain more space for growth with further development in the cancellous bone. These findings confirm previous studies. McNamara and Topouzelis stated that early treatment might lead to Hertwig’s epithelial root sheath to be reoriented, allowing the root to grow in the proper direction relative to the long axis of crown and the formed root, which may lead to normal development of the root. Because the impacted tooth still has growth potential after early treatment, its root can continue to grow in a normal position.

Some researchers have found that a tooth with an underdeveloped root will have a low root resorption rate because of the low level of calcification. They undergo a second dilaceration from the new bending of the epithelial root sheath during orthodontic traction and continue their root development protected from orthodontic root resorption in a better environment. Also, the force attached to the tooth may be helpful for further growth and development during the orthodontic treatment. On the contrary, later-treated teeth would not have any chance to improve their root shape because they will suffer from root resorption more than the teeth that are not fully developed. They also may result in abnormal growth or even root dilacerations because of either poor growth potential or restriction from the palatal cortex. It may also lead to delayed eruption, with the space becoming occupied with adjacent teeth, a midline shift, or different levels of alveolar height. These possibilities may increase treatment difficulty.

Table 3. Root Length of Impacted and Homonym Tooth After Treatment (n = 28)∗

<table>
<thead>
<tr>
<th>Group</th>
<th>Impacted Tooth, Mean (SD)</th>
<th>Homonym Tooth, Mean (SD)</th>
<th>Mean Difference, Mean (SD)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early-treated group (n = 14)</td>
<td>8.78 (1.94)</td>
<td>10.14 (2.01)</td>
<td>1.36 (1.05)</td>
<td>&lt;.001***</td>
</tr>
<tr>
<td>Later-treated group (n = 14)</td>
<td>8.39 (1.21)</td>
<td>10.75 (0.60)</td>
<td>2.36 (1.12)</td>
<td>&lt;.001***</td>
</tr>
</tbody>
</table>

* The Wilcoxon signed rank test was used for comparisons between the impacted and homonym teeth.

Table 4. Mean Values of Measurement Variables Used in This Study (n = 28)∗

<table>
<thead>
<tr>
<th>Measurement Variables</th>
<th>ICCa</th>
<th>Early-Treated Group (n = 14), Mean (SD)a</th>
<th>Later-Treated Group (n = 14), Mean (SD)b</th>
<th>Total (n = 28), Mean (SD)b</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Root length of impacted tooth, mm</td>
<td>.85</td>
<td>8.78 (1.94)</td>
<td>8.39 (1.21)</td>
<td>8.58 (1.60)</td>
<td>.476</td>
</tr>
<tr>
<td>Root length of homonym tooth, mm</td>
<td>.81</td>
<td>10.14 (2.01)</td>
<td>10.75 (0.60)</td>
<td>10.44 (1.49)</td>
<td>.730</td>
</tr>
<tr>
<td>D-value of root length, mm</td>
<td>.82</td>
<td>1.36 (1.05)</td>
<td>2.36 (1.12)</td>
<td>1.86 (1.18)</td>
<td>.024*</td>
</tr>
<tr>
<td>Alveolar bone loss in labial side, mm</td>
<td>.87</td>
<td>2.14 (1.22)</td>
<td>3.30 (1.18)</td>
<td>2.72 (1.32)</td>
<td>.013*</td>
</tr>
<tr>
<td>Alveolar bone loss in lingual side, mm</td>
<td>.92</td>
<td>1.72 (1.19)</td>
<td>2.33 (1.41)</td>
<td>2.02 (1.32)</td>
<td>.198</td>
</tr>
<tr>
<td>Alveolar bone thickness in labial side, mm</td>
<td>.84</td>
<td>2.19 (1.15)</td>
<td>1.61 (1.93)</td>
<td>1.90 (1.59)</td>
<td>.133</td>
</tr>
<tr>
<td>Alveolar bone thickness in lingual side, mm</td>
<td>.90</td>
<td>7.09 (1.02)</td>
<td>8.00 (1.65)</td>
<td>7.54 (1.42)</td>
<td>.141</td>
</tr>
</tbody>
</table>

* The Wilcoxon Mann-Whitney test was used for comparisons between the early-treated and later-treated groups.

a ICC indicates intraclass correlation coefficient; SD, standard deviation.

b P < .05.
During treatment, the impacted teeth must move into alignment with a long distance and large angle. If the root length is short, the center of resistance is closer to the cervix of tooth, thus the rotation center moves toward the tooth cervix. As a result, the rotation of the incisor would be much easier with a much shorter moving distance. Therefore, it is recommended that the impacted teeth should be treated early when it has a shorter root length.

Orthodontic anchorage is a noteworthy question during early treatment for impacted teeth. Because the impacted tooth moves a long distance with a large angle of rotation during treatment, maximum anchorage is needed. However, the adjacent permanent teeth have not erupted completely when the treatment begins, so the deciduous anterior teeth have to be used for the anchorage. This could produce some undesirable effects such as intrusion and mesial and labial inclining. In our study, the Guide rod appliance was used for orthodontic traction. This appliance uses first molars and anterior-palate mucosa as anchorage to maximize anchorage. The position and direction of the traction device can be adjusted according to the movement of the impacted teeth, providing better traction to the impacted crown in 3D. Reasonable traction will lead to an appropriate force for correction, that is, slow impacted tooth movement with no adjacent tooth damage and minimal undesirable movement under conditions of reasonable traction force.

Group assignment should be done randomly in a prospective study. However, because we did not have the right to control treatment timing for the patients we did not consider random group assignment realistic for our research design. Therefore, the patients were assigned to the early-treated or later-treated groups according to the existing root development at the time of study examination.

CONCLUSIONS

- The maxillary labial inversely impacted central incisors should be treated early in consideration of its particular location and morphology.
- Early treatment may promote root development to achieve a better morphology of root apex.
- Early treatment may reduce the risk of alveolar bone loss on the labial side.

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REFERENCES


Figure 7. A different morphology of root after treatment: most in the early-treated group (A) and most in the later-treated group (B).