ORTHODONTICS & CRANIOFACIAL RESEARCH

ORIGINAL ARTICLE

DOI: 10.1111/j.1601-6343.2011.01516.x

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Predictors of surgical-orthodontic treatment duration of unilateral impacted maxillary central incisors

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Structured Abstract

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Objectives – To determine independent predictors of duration of surgical-orthodontic treatment of impacted maxillary central incisors.

Setting and Sample Population – The Department of Dentistry at Show Chwan Hospital, Changhua, Taiwan. Eighty patients with unilateral osseous impacted maxillary central incisors receiving a surgical-orthodontic treatment.

Material and Methods – This is a retrospective observational study. Treatment duration and its predictors were abstracted from the patients' charts and pre-treatment cephalometric radiographs. Predictors included demographics, crown angle, crown height, crown depth, and root dilacerations.

Results – The mean age of the cohort was 9.2 ± 2.3 years (6.4–20.6 years), and 60% were women. The mean orthodontic traction time was 8.0 ± 4.5 months (2.0–24.1 months). Using multiple linear regression analysis, the independent predictors of treatment duration for an impacted maxillary central incisor were age (β = 0.9, $p < 0.001$), crown height (β = –0.2, $p < 0.05$), and root dilacerations (β = 3.8, $p < 0.001$).

Conclusions – Duration of surgical-orthodontic treatment of an impacted maxillary central incisor varied widely. Predictors of longer treatment time were older age, high impacted tooth, and dilacerated incisors.

Key words: cephalometry; impacted incisors; predictors; surgical-orthodontic treatment; treatment duration

Introduction

In the anterior maxillary region, the maxillary canine is the most frequently impacted tooth with an incidence of 1–3% (1). Most often, the canine is impacted palatally. The second most common maxillary impaction is the central incisor. Usually, central incisors are not impacted palatally.

The presence of maxillary central incisors is a key esthetic factor and of great concern of dentists and patients. An impacted maxillary central incisor is a management challenge for the dentist. As an alternative approach to extraction, attempts have been made to surgically expose impacted central incisors and orthodontically guide the incisors to their

Dates:
Accepted 7 May 2011

To cite this article:
Ho KH, Liao YF:
Predictors of surgical-orthodontic treatment duration of unilateral impacted maxillary central incisors
Orthod Craniofac Res 2011;**14**:175–180

final position in the dental arch. With current fixed orthodontic appliance techniques, it is now possible to align an impacted maxillary central incisor from a difficult position, as determined from radiographs.

Impacted teeth are reportedly more difficult to treat in adults. Becker and Chaushu (2) stated that the success rate for palatally impacted maxillary canines among patients over 20 years of age was 69.5%, whereas the success rate for those younger than 20 years of age was 100% in their sample. The higher frequency of failures in adult patients should be taken into consideration in the orthodontic decision-making process from the beginning. Surgical extraction and implant placement are valid alternatives for adults, because the high success rate of single-tooth replacement by osseointegrated implants (90–97%) compares favorably with the success rate of forced eruption in difficult adult cases (3).

Reliable pretreatment estimates of orthodontic treatment duration and success rate would be helpful in the decision-making process for patients with impacted teeth and in providing accurate information to the patient about the cost of the treatment. However, no data are currently available in the literature concerning the treatment duration or possible factors influencing the duration after a combined surgical-orthodontic treatment for impacted maxillary central incisors. We therefore aimed to 1) evaluate the duration required by a combined surgical-orthodontic treatment of patients with impacted maxillary central incisors and to 2) identify its predictors.

Material and methods

This retrospective observational study analyzed patient records from the Department of Dentistry, Show Chwan Hospital, Changhua, Taiwan, over a period of 20 years (1988–2008). The local Ethical Committee approved the study protocol. Patients were selected according to the following criteria: 1) unilateral osseous impacted maxillary central incisor treated by a surgical-orthodontic approach; 2) complete diagnostic and treatment notes; 3) pre-treatment and post-treatment panoramic radiographs, lateral cephalometric radiographs, photographs, and models; and 4) no mechanical obstacle to the eruption, such as supernumerary teeth, tumors, odontoma, or cysts.

The diagnosis of unilateral impaction was clinically evaluated when one of the permanent maxillary central incisors was absent in the dental arch after the expected time of eruption and the contralateral central incisor was erupted for at least 6 months. The diagnosis of impaction and root dilacerations (i.e., angulations between crown and root) was then confirmed by panoramic, lateral cephalometric, or periapical radiographs.

The study population consisted of 80 patients, 32 men and 48 women, ranging in age from 6.4–20.6 years. None had suffered a traumatic injury to the anterior region of the oral cavity. Five had supernumerary teeth, and two had odontomas removed at least 6 months before surgical-orthodontic treatment. The clinical characteristics are described in Table 1.

Surgical-orthodontic treatment

Impacted maxillary central incisors were always treated with the standardized combined surgical-orthodontic approach by the same orthodontist (KH Ho) and two

Table 1. **Patients' summary**

	Patients (n = 80)
Gender, n (%)	
Male	32 (40)
Female	48 (60)
Mean age (SD) (range), year	9.2 (2.3) (6.4–20.6)
Location of impaction, n (%)	
Right	35 (44)
Left	45 (56)
Root dilaceration, n (%)	
Yes	16 (20)
No	64 (80)
Surgical exposure technique, n (%)	
Open eruption	51 (64)
Closed eruption	29 (36)
Orthodontic treatment phase, n (%)	
One stage	16 (20)
Two stage	64 (80)
Mean orthodontic traction time (SD) (range), month	8.0 (4.5) (2.0–24.1)
Mean follow-up time (SD) (range), month	21.8 (28.6) (6.0–146.1)

periodontists. All patients received standard fixed appliances with a 0.018-inch slot. The incisors were exposed by means of a flap (closed- or open-eruption technique). For deeply impacted incisors, a closed-eruption technique was used. For labially and not far apically impacted incisors, an open-eruption technique was used. The bonded attachment device was applied during surgery, and orthodontic traction force was applied 1–2 weeks after the surgery (suture removal at seventh postoperative day) to guide the impacted central incisor toward the center of the alveolar ridge. The traction force was approximately 100 g.

Patients were recalled every 4 weeks to adjust their appliance and monitor their oral hygiene. A 0.017 × 0.022-inch Elgiloy wire with 2-L loops was sometimes necessary to tip and torque the root of the incisor to attain proper root and crown angulation. For dilacerated incisors, special care was taken not to expose the root despite an insufficient torque. When the erupting incisor was properly aligned within the dental arch, the patients were discharged with Hawley's retainers. During the follow-up period, the patients were recalled every 3–6 months for professional hygiene and orthodontic control.

Cephalometric evaluation

All pre-treatment cephalometric radiographs were viewed under standardized conditions and traced on acetate tracing paper with a 0.3-mm-diameter pencil by an experienced orthodontist. The tracing papers were then scanned and digitized. The following variables were measured (Fig. 1) (4):

1. Crown angle: angle between the crown axis of the maxillary central incisor and the palatal plane (from the ANS to the PNS), to determine the inclination of the maxillary central incisor;
2. Crown height: distance between the incisal tip of the maxillary central incisor and the palatal plane. Positive and negative signs indicate the incisal tip located below and above the palatal plane, respectively;
3. Crown depth: distance between the incisal tip of the maxillary central incisor and the facial plane (from the point N to the Pog). Positive and negative signs indicate the incisal tip located in front of and behind the facial plane, respectively.

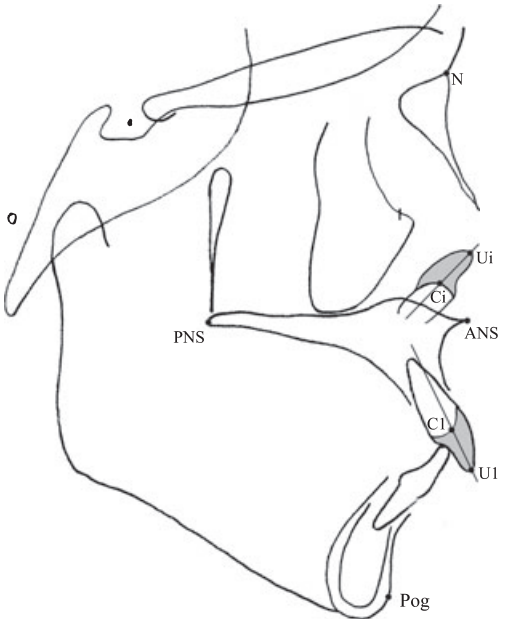

Fig. 1. Landmarks and reference lines used on a lateral cephalometric radiograph. Ui–Ci and U1–C1 = crown axes of the impacted and erupted maxillary central incisors, respectively. Ui and U1 = incisal tips of the impacted and erupted maxillary central incisors, respectively. Ci and C1 = centers of crown cervices of the impacted and erupted maxillary central incisors, respectively. ANS, anterior nasal spine; PNS, posterior nasal spine; N, nasion; Pog, pogonion.

To reduce method error, the tracing, scanning, and digitization were repeated on three separate occasions by the same investigator at 1-week intervals, and the values were averaged.

Statistical analysis

Descriptive statistics were expressed as means ± SD for metric variables and as frequency and percentage for nominal variables.

Multiple linear regression analysis was carried out to evaluate the role of the demographics and pre-treatment radiographic factors on the treatment duration by using SPSS software version 17.0 (SPSS Inc, Chicago, IL, USA). All p values reported are two tailed, with statistical significance set at 0.05.

Results

None of the patients complained of significant discomfort. All 80 impacted central incisors were successfully moved and aligned in the dental arch with no loss of pulp vitality. The duration of the orthodontic

traction time (calculated as the time elapsed between the application of the traction device and the good alignment of the impacted incisor in the dental arch) was 8.0 ± 4.5 months.

Linear regression analysis revealed that treatment duration was related to age ($\beta = 0.9$, $p < 0.001$), crown height ($\beta = -0.2$, $p < 0.05$), and root dilacerations ($\beta = 3.8$, $p < 0.001$) (Table 2).

Discussion

Previous studies on the duration of orthodontic treatment found that some of the most important factors that related to treatment time include the number of treatment phases, pre-treatment skeletal pattern (ANB angle, mandibular plane angle), and number of negative chart entries regarding oral hygiene, missed appointments, replaced brackets and bands (5, 6). Literature also suggests that the duration of treatment for orthodontic patients that involves impacted canines takes an average of 18–30 months, with a wide range for individual cases (7, 8).

The role of age in determining the treatment duration for impacted teeth has been acknowledged. Zuccati et al. (9) suggested that treatment duration for impacted canines might be remarkably longer in patients over 25 years of age. Becker and Chaushu (2) reported that adults showed significant increases in the treatment duration for impacted canines in both the simple and the difficult cases. Our study also confirms a strong positive relation between treatment duration and patient age. When 10 years of age (the age for completion of root formation in maxillary central incisors) was used as a cutoff, we further found treatment that began before 10 years of age took an average of 6.9 ± 2.6 months. Treatment that began at the age of 10 years or older averaged 11.3 ± 6.8 months ($p < 0.05$, Table 3). The residual eruptive potential and the proper bone density in the younger patients might have facilitated the forced eruption of the early-treated impacted incisors.

In the study of Stewart et al. (8), the age/duration relationship was surprisingly inverse: the younger the patient, the longer the orthodontic treatment. Treatment that began before 12 years of age took an average of 35 months. Treatment that began at 18 years or later averaged 20.8 months. This result is contrast with other studies. The discrepancy might be explained because Stewart et al. (8) considered the overall treatment duration without separating the traction phase from the treatment of the concomitant malocclusion. In our study, the focus was on potential predictors of treatment duration for impacted central incisors. Therefore, only the duration of the traction phase was considered.

The location of impacted teeth is also supposed to have a major role in determining treatment duration. Zuccati et al. (9) reported a direct correlation with the distance between the canine cusp tip and the occlusal plane and the zone: mesially located cusps required longer duration. A weaker inverse correlation was found with the angle between the canine and lateral incisor axes. The results of our study confirm the role of the location of the impaction on treatment duration. The dilacerated incisor was the most correlated variable with the duration; the crown height was also significantly correlated. This might be partly explained by the fact that impacted incisors

Table 2. **Linear regression model for the treatment duration in months for the 80 treated patients**

	Treatment duration			
Independent variables	Regression coefficient	Standard error	95% Confidence limit	*p*
Intercept	−4.1	1.7	(−7.4, −0.8)	0.02†
ΔCrown angle*, degree	−0.01	0.01	(−0.04, 0.02)	0.5
ΔCrown height*, mm	−0.2	0.1	(−0.4, −0.03)	0.03†
ΔCrown depth*, mm	−0.04	0.1	(−0.3, 0.2)	0.8
Age, year	0.9	0.2	(0.6, 1.2)	<0.001†
Gender	−0.4	0.7	(−1.8, 0.9)	0.5
Root dilaceration	3.8	1.1	(1.7, 6.0)	<0.001†
Exposure technique	0.6	0.7	(−0.8, 2.0)	0.4

Crown angle: angle between the incisor crown axis and the palatal plane.
Crown height: distance between the incisor tip and the palatal plane.
Crown depth: distance between the incisor tip and the facial plane.
Age: age at the beginning of the traction of the impacted tooth.
Gender: 1, male; 0, female.
Root dilaceration: 1, dilacerations; 0, no dilacerations.
Exposure technique: 1, closed eruption; 0, open eruption.
*Impacted – erupted.
†Significant differences.

Table 3. **Comparison of demographics, radiographic features, and treatment duration between age subgroups**

	<10 years of age (n = 60)		≥10 years of age (n = 20)		
	Mean	SD	Mean	SD	p
Age, year	8.2	0.8	12.1	2.8	<0.001*‡
Treatment duration, month	6.9	2.6	11.3	6.9	0.01*‡
Crown angle, degree	166.7	47.7	170.1	57.0	0.8*
Crown height, mm	10.2	6.2	10.1	7.5	0.9*
Crown depth, mm	7.0	5.3	6.6	5.3	0.8*
	Frequency	Percentage	Frequency	Percentage	
Gender					
Male	26	81	6	19	0.3†
Female	34	71	14	29	
Location of impaction					
Right	28	80	7	20	0.4†
Left	32	71	13	29	
Root dilaceration					
Yes	11	69	5	31	0.5†
No	49	77	15	23	
Surgical exposure technique					
Open eruption	37	73	14	27	0.5†
Closed eruption	23	79	6	21	

*Independent *t*-test.
†Chi-square test.
‡Significant differences.

with root dilacerations were more highly impacted than those with no root dilacerations. Impacted central incisors with root dilacerations required, on average, about 4 months longer to treat than did those with no root dilacerations. The higher the position of an impacted incisor, the longer the duration of orthodontic treatment.

The type of surgical exposure might affect treatment duration, but the available evidence is conflicting (7, 10–13). In agreement with Iramaneerat et al. (7), our study revealed no difference in the treatment duration after surgical exposure with open- vs. closed-eruption methods. Possible explanations were that in this sample, 1) the surgical approach was planned depending on the location of the impaction and 2) the orthodontic traction force was routinely applied 1–2 weeks after surgical exposure. Therefore, the location of the impaction, instead of the surgical approach, was found to be a predictor.

Conclusions

Duration of surgical-orthodontic treatment of an impacted maxillary central incisor varied widely. Predictors of longer treatment time were older age, highly impacted tooth, and dilacerated incisors. These predictors may help to inform the patient and family.

Clinical relevance

To predict surgical-orthodontic treatment duration for impacted maxillary central incisors would be helpful to find predictors that could be assessed at the pretreatment radiographic features. This study showed that predictors of longer treatment time were older age, highly impacted position, and dilacerated incisors. These predictors may help to inform the patient and family.

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