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Periodontal Outcomes of Impacted Maxillary Central Incisors in 80 Patients Treated with a Combined Surgical-orthodontic Approach

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Abstract

Background: Impaction of maxillary central incisors can result in aesthetic problems. The aim of this retrospective study was to examine the periodontal outcomes of impacted maxillary central incisors after surgical exposure and orthodontic extrusion compared to naturally erupted, contralateral incisors (control). Methods: Patients (N=80, 80 central incisors), who had been treated by a surgical-orthodontic approach, underwent a periodontal examination after 6 to 146 months. Periodontal parameters (crown length, keratinized gingival width, gingival scar, and bone loss) of the orthodontically extruded incisors were scored and compared with those of the naturally erupted contralateral incisors (control) in a masked set-up. Results: The extruded maxillary central incisors had longer crowns (Δ = 0.6 mm, $p < 0.001$), narrower keratinized gingival widths (Δ = - 0.9 mm, $p < 0.001$), higher incidence of gingival scars (Δ = 14%, $p < 0.001$), and lower bone levels (Δ = 0.4 mm, $p = 0.001$ and Δ = 0.5 mm, $p < 0.001$; respectively for mesial and distal sides) than the controls. Conclusions: The data indicate that surgical-orthodontic treatment of impacted maxillary central incisors does not jeopardize their periodontal health but compromised periodontal aesthetics. This surgical-orthodontic approach should be advocated as the treatment of choice, even for dilacerated incisors in the absence of ankylosis. However, additional periodontal surgery might be needed to improve appearance.

Keywords

impacted teeth, surgery, periodontal, prognosis, orthodontic, outcome

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INTRODUCTION

In the anterior maxillary region, the most frequently impacted tooth is the maxillary canine, with an incidence of 1% to 3%.[1] The second most common maxillary impaction is the central incisor. Canines are most often impacted palatally, but not usually central incisors.

The presence of maxillary central incisors is a key esthetic factor and of great concern to dentists and their patients. An alternative approach to extraction has been to surgically expose impacted central incisors and orthodontically extrude them to their final position in the dental arch. Aligning an impacted maxillary central incisor from a difficult radiographic position is now possible with current fixed orthodontic techniques. However, the therapy can be considered successful only if the forced eruption and subsequent alignment lead the central incisor to a stable position in the dental arch along with a healthy and aesthetic periodontium.

The periodontal status of impacted maxillary central incisors following surgical-orthodontic treatments has been reported for small samples (N=12 - 30).[2-6] However, a large sample is needed to evaluate the success of periodontal therapy for impacted central incisors, not only from an orthodontic perspective but also in terms of periodontal health and aesthetics. Thus, the aims of this study were to (1) evaluate and (2) compare the periodontal outcomes (crown length, keratinized gingival width, gingival scar, and bone loss) of unilateral osseous impacted maxillary central incisors treated by combined surgery (flap approach) and orthodontic treatment (direct traction to the center of the alveolar ridge) with those of normally erupted incisors on the contralateral side.

MATERIALS AND METHODS

Study sample

The sample was selected from a population of 119 patients with impacted maxillary central incisor/s who visited the Department of Dentistry at Show Chwan Hospital, Changhua, Taiwan over 20 years. Patients were enrolled in the study if they had unilateral osseous impaction of the maxillary central incisor, were indicated for and willing to undergo direct orthodontic traction of the impacted central incisor to the center of alveolar ridge, and had complete pretreatment and posttreatment records.

These criteria were met by 82 patients (82 unilateral impacted maxillary central incisors). During the treatment, 2 cases were excluded due to lack of movement of the impacted incisor (ankylosis). Therefore, 80 patients with 80 unilateral osseous maxillary central incisor impactions were included in the study sample.

The impacted maxillary central incisors were included in the test group, and the naturally erupted incisors were enrolled in the control group. The two groups were compared in terms of crown length, keratinized gingival width, gingival scar, and bone loss.

Diagnosis of impaction

Unilateral impaction was clinically diagnosed when one permanent maxillary central incisor was absent in the dental arch after its expected eruption time, and the contralateral central incisor had been erupted for at least 6 months.

The diagnosis of osseous impaction and root dilacerations (i.e., angulations between crown and root) were then confirmed by conventional panoramic, lateral chephalometric, or periapical radiographs.

Surgical-orthodontic treatment

All patients consecutively underwent the standardized combined surgical-orthodontic treatment by the same orthodontist (KHH) and two periodontists. All received standard orthodontic appliances with a 0.018-inch slot. The impacted central incisors were exposed by a flap (closed- or open-eruption technique), and orthodontic traction was applied to guide the impacted central incisor towards the center of the alveolar ridge.

The overall combined treatment was divided into three phases: initial orthodontic treatment, surgical exposure, and orthodontic traction.

Phase 1. The goal of the initial orthodontic treatment was to create sufficient space for the impacted central incisor by the edgewise technique.

Phase 2. The impacted incisors were surgically exposed by two techniques: closed eruption and open eruption. The closed-eruption technique was used for deeply impacted incisors. A full-thickness flap was elevated by making an incision within a sulcus. To facilitate the flap elevation, two vertical-releasing incisions were sometimes made. After the incisor crown was exposed, a small attachment with a wire chain of rings was bonded to the crown. The flap was then re-positioned and sutured into its original site. The chain emerged from the gingival tissue at an incision in the middle of the alveolar ridge.

The open-eruption technique was used for incisors that were impacted labially and not far apically. A split-thickness flap, slightly wider than the width of the impacted incisor, was prepared from the edentulous area. Besides the crestal incision, two vertical-releasing incisions were made extending into the vestibule to apically reposition the flap. After the incisor crown was exposed, the flap was sutured to leave one-half to two-thirds of the crown exposed. At the same time, a bracket or small attachment was bonded to the exposed crown.

Phase 3. Orthodontic traction began 1 to 2 weeks after the surgery with the goal of guiding the impacted incisor directly towards the center of the alveolar ridge. A rectangular arch wire was used to obtain adequate anchorage and maintain sufficient space in the dental arch. Anchorage was sometimes reinforced using a Nance appliance. The impacted incisor was guided toward the center of the alveolar ridge using a NiTi round wire or elastics. In cases of labial impaction, the traction was directed palatally; in cases of palatal impaction, the traction was directed labially. For dilacerated incisors, special care was taken not to expose the root despite an insufficient torque. An orthodontic force of approximately 100g was applied.

Patients were recalled every 4 weeks to adjust their appliance and monitor their oral hygiene. When the extruded incisor was well aligned within the dental arch, the patients were discharged with Hawley's retainers. During the follow-up period, patients were recalled every 3-6 months for professional hygiene and orthodontic control.

Photographic evaluation

After treatment, a single periodontist photographically evaluated the following clinical variables: 1) keratinized gingival width (measured with a digital caliper) (Fig. 1) and 2) presence of gingival scar. In addition, the crown width of the control incisor (Fig. 1) was measured and used as a normalization factor to account for different angulation and magnification between photographs.

Radiographic evaluation

The posttreatment periapical radiographs were scanned and viewed at double magnification on a large color monitor with 0.25 dot pitch fitness. A single orthodontist measured the following radiographic variables: 1) bone loss (Fig. 2), and 2) presence of periapical radiolucency.

Dental cast evaluation

The posttrreatment dental cast was measured by a single orthodontist with a digital caliper to obtain the following dental cast variables: 1) crown length (Fig. 3), 2) presence of vertical positional relapse, and 3) crown width of the control incisor (Fig. 3). The control incisor width was used as a normalization factor to account for different angulation and magnification between periapical radiographs. Thus, keratinized gingival width or bone loss in the test and control incisors were calculated (Fig. 4).

To reduce methodological error, all measurements were repeated on three separate occasions by the same investigator at 1-week intervals, and the nearest two values were averaged.

Statistical analysis

Descriptive statistics were expressed as means±SD for metric variables and as frequency and percentage for nominal variables. Differences in periodontal parameters between the test and control central incisors were analyzed by paired t or chi-square tests when indicated. Statistical analyses were carried out using SPSS v 17.0 (Chicago, IL, USA). P-values were two-tailed and significant if $p<0.05$.

RESULTS

The study sample consisted of 80 patients, 32 males and 48 females, with a mean age of 9.2±2.3 years (range 6.4 - 20.6). None had suffered a traumatic injury to the anterior region of the oral cavity. Five had supernumerary teeth and two had odontomas removal at least 6 months before surgical-orthodontic treatment. The sample's characteristics are described in Table 1.

None of the patients complained of significant discomfort. All 80 impacted central incisors were successfully moved and aligned in the dental arch. None of the teeth had periapical radiolucency, but 4 (5%) showed some vertical relapse.

The mean duration of orthodontic traction (the time between applying the traction device and good alignment of the impacted incisor in the dental arch) was 8.0±4.5 months.

Periodontal evaluation

The periodontal parameters of 80 unilateral impacted maxillary central incisors are summarized in Table 2. The extruded central incisors had a smaller gingival width (Δ = -0.9 mm, $p < 0.001$) and a more apically positioned bone level (Δ= 0.4 mm, $p = 0.001$ and Δ= 0.5 mm, $p < 0.001$, respectively for the mesial and distal sides) than the controls. These differences are generally considered clinically healthy. In addition, the extruded incisors had increased crown length (Δ= 0.6 mm, $p < 0.001$). Eleven extruded incisors (14%) showed a gingival scar.

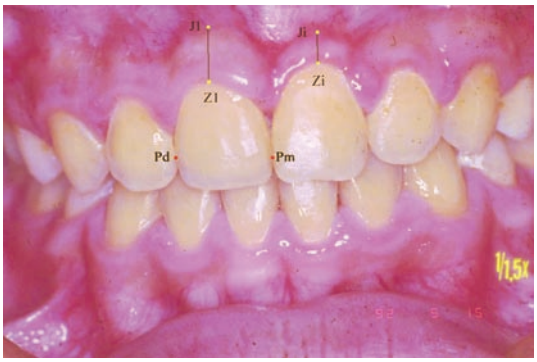

Fig 1. *Clinical photograph of measured keratinized gingival width and crown width. Keratinized gingival widths of the erupted and extruded maxillary central incisors = the distance between J1 and Z1 and between Ji and Zi, respectively. Crown width of the erupted maxillary central incisor = the distance between Pd and Pm. J1 and Ji= mucogingival junction of the erupted and extruded maxillary central incisors, respectively. Z1 and Zi= zenith of the gingival margin of the erupted and extruded maxillary central incisors, respectively. Pd and Pm= distal and mesial contours, respectively, of the erupted maxillary central incisor.*

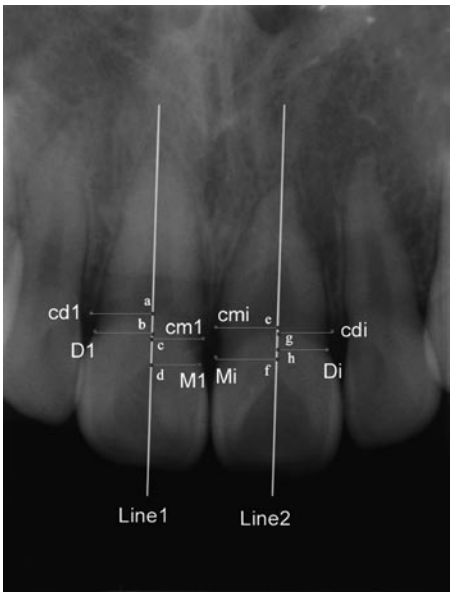

Fig 2. *Periapial radiograph of measured bone loss and crown width. Mesial and distal bone losses of the erupted maxillary central incisor = distance between c and d and between a and b, respectively. Mesial and distal bone losses of the extruded maxillary central incisor = distance between e and f and between g and h, respectively. Line 1 and Line 2 = long axes of the erupted and impacted maxillary central incisors, respectively. a = the intersection of cd1 with Line 1. b = the intersection of D1 with Line 1. c = the intersection of cm1 with Line 1. d = the intersection of M1 with Line 1. e = the intersection of cmi with Line 2. f = the intersection of Mi with Line 2. g = the intersection of cdi with Line 2. h = the intersection of Di with Line 2. M1 and D1= mesial and distal cementoenamel junctions, respectively, of the erupted maxillary central incisor. Mi and Di= mesial and distal cementoenamel junctions, respectively, of the extruded maxillary central incisor. cm1 and cd1= mesial and distal crests of the interseptal bone, respectively, of the erupted maxillary central incisor. cmi and cdi= mesial and distal crests of the interseptal bone, respectively, of the extruded maxillary central incisor. Pd and Pm= distal and mesial contours, respectively, of the erupted maxillary central incisor.*

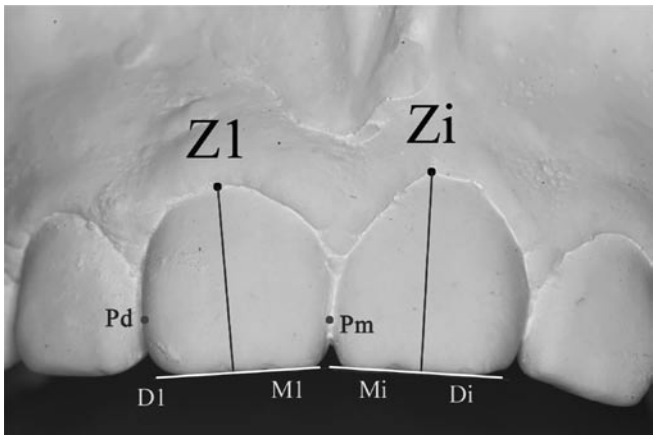

Fig 3. *Dental cast showing the measured crown length and crown width. Crown length of the erupted maxillary central incisor = distance from Z1 to the line D1-M1. Crown length of the extruded maxillary central incisor = distance from Zi to the line Di-Mi. Crown width of the erupted maxillary central incisor = distance between Pd and Pm. Z1 and Zi= zeniths of the gingival margin of the erupted and extruded maxillary central incisors, respectively. Pd and Pm= Distal and mesial contours, respectively, of the erupted maxillary central incisor. D1-M1 and Di-Mi= incisal edges of the erupted and extruded maxillary central incisors, respectively.*

$$KGW = KGW_p \times \frac{CW_d}{CW_p}$$

$$BL = BL_r \times \frac{CW_d}{CW_r}$$

Fig 4. *Formula for calculating the keratinized gingival width or bone loss in the erupted and extruded incisors. KGW = keratinized gingival width. KGWp = keratinized gingival width in the photograph. CWd = crown width in the dental cast. CWp = crown width in the photograph. BL = bone loss. BLr = bone loss in the periapical radiograph. CWr = crown width in the periapical radiograph.*

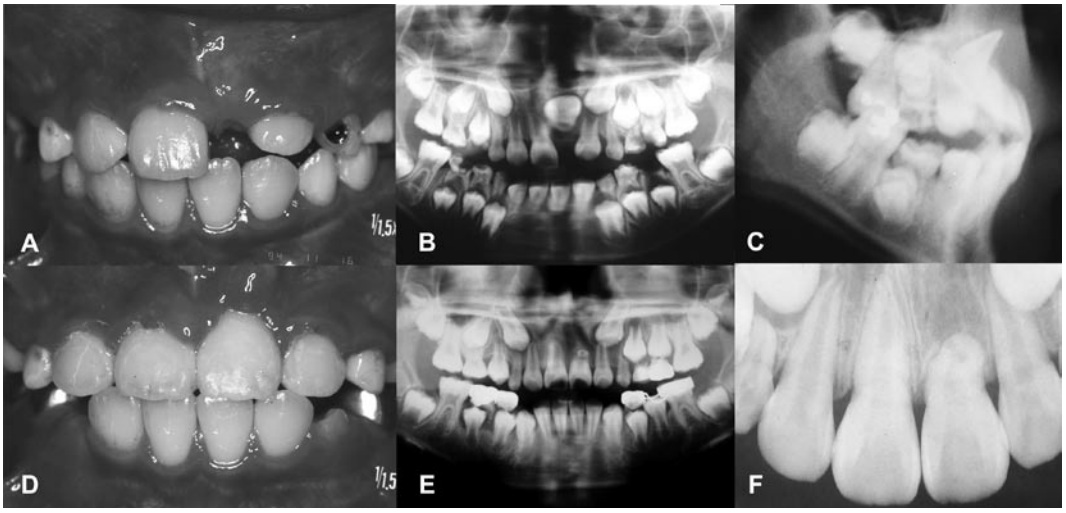

Fig 5. *(A) Frontal view showing absence of left maxillary central incisor with space loss and midline deviation; (B) pretreatment panoramic radiograph of the root dilaceration; (C) pretreatment lateral cephalometric radiograph of the root dilaceration; (D) proper alignment of the left maxillary central incisor; (E) posttreatment panoramic radiograph of the root dilaceration; (F) posttreatment periapical radiograph of the root dilaceration.*

Table 1. *Patient Characteristics (N=80)*

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

Table 2. *Periodontal Outcomes of Extruded and Control Maxillary Central Incisors*

Outcome	Extruded, *n* = 80		Control, *n* = 80		*p*
	Mean	SD	Mean	SD	
Crown length, mm	9.8	1.2	9.2	1.2	<0.001
Gingival width, mm	3.3	1.1	4.2	1.0	<0.001
Mesial bone loss, mm	1.4	0.7	1.0	0.8	0.001
Distal bone loss, mm	1.4	0.7	0.9	0.6	<0.001
	Frequency	Percentage	Frequency	Percentage	
Gingival scar					<0.001
Yes	11	14	0	0	
No	69	86	80	100	

Table 3. *Periodontal Outcomes of Extruded Maxillary Central Incisors Treated by Open- Versus Closed-Eruption Methods*

Outcome	Open, *n* = 51		Closed, *n* = 29		*p*
	Mean	SD	Mean	SD	
Δ Crown length*, mm	0.7	1.4	0.6	1.1	0.6
Δ Gingival width*, mm	-0.9	1.5	-0.9	1.4	0.9
Δ Mesial bone loss*, mm	0.5	1.0	0.1	0.8	0.02
Δ Distal bone loss*, mm	0.7	1.1	0.4	0.7	0.2
	Frequency	Percentage	Frequency	Percentage	
Gingival scar					0.5
Yes	6	12	5	17	
No	45	88	24	83	

** Extruded minus control*

Table 4. *Periodontal Outcomes of Extruded Maxillary Central Incisors with Root Dilaceration versus No Root Dilaceration*

Outcome	Dilaceration,† *n* = 16		No dilaceration, *n* = 64		*p*
	Mean	SD	Mean	SD	
Δ Crown length,* mm	0.3	1.7	0.8	1.0	0.3
Δ Gingival width,* mm	-1.0	1.3	-0.9	1.1	0.7
Δ Mesial bone loss,* mm	0.9	0.7	0.2	0.8	0.007
Δ Distal bone loss,* mm	0.5	1.0	0.5	0.6	0.9
	Frequency	Percentage	Frequency	Percentage	
Gingival scar					0.04
Yes	5	31	6	9	
No	11	69	58	91	

** Extruded minus control*

† *Two teeth had crown angle > 90°*

DISCUSSION

The results of this retrospective study indicate that the combined surgical-orthodontic treatment of impacted maxillary central incisors has no clinically negative impact on the periodontal health of the extruded incisors. Similar results were reported in a retrospective study,[4] which compared the periodontal outcomes of 21 patients whose impacted incisors were surgically exposed (closed-eruption technique) and orthodontically extruded with the naturally erupted contralateral teeth. The gingival width of extruded incisors was only 0.2 mm smaller than the naturally erupted incisors. Furthermore, the reduction of bone support for the extruded incisors was small and similar on both mesial and distal sides (5-6%).[4] Both studies used minimal surgical crown exposure and careful orthodontic tooth movement, which might explain the favorable periodontal health results.

The frequency of gingival scars around the extruded incisors was clearly higher than that around the contralateral incisors (Δ=14%). Although the increased crown length around the extruded incisors was small (Δ=0.6mm), the discrepancy was often clinically detectable in patients with a high smile line. These figures were statistically significant and represent a clinically adverse impact on appearance, compromising periodontal aesthetics.

The quality of periodontal outcomes for treated cases has been shown to be affected by different exposure techniques. For example, labially impacted maxillary central incisors were found by Ho et al.[3] to have wider keratinized gingiva after treatment by apically positioned flaps, which is an open-eruption (OE) method, than by a closed-eruption (CE) technique. In contrast, impacted maxillary central incisors were reported by Chaushu et al.[6] to show less mesial bone support (Δ=7.5%) in the OE cases (11 patients) than in the CE cases (11 patients). They concluded that the CE method achieved superior outcomes in terms of periodontal health. In the present study, the increase in crown length was the same for OE and CE cases (Table 3). This result is in contrast to that of Chaushu et al.[6] who showed a larger increase in crown length (Δ=1.4mm) in the OE group. This difference might be due to differences in surgical procedures or to our larger study sample.

Very few studies could be found on dilacerated maxillary central incisors. One older study reported that crown-root angle could serve as a predictor for treatment decisions.[7] More recently, Lin and Lin[8] suggested that dilacerated incisors with a crown-root angle > 90° and crown angle < 100° are more likely to be surgically exposed. However, no data are currently available concerning the success rate or periodontal status of dilacerated maxillary central incisors following surgical-orthodontic treatments. In the present study, the success rate among the 16 dilacerated incisors was 100%. A typical case is shown in Figure 5. Overall good periodontal health was achieved, even though a minor deleterious change was detected in the mesial bone support of the dilacerated incisors (Table 4). Nevertheless, one-third of the dilacerated incisors were characterized by a gingival scar (Table 4), which might simplify identification of the previously impacted tooth.

The results of this study indicate that surgical-orthodontic treatment of impacted maxillary central incisors does not jeopardize their periodontal health but compromised periodontal aesthetics. A surgical-orthodontic approach should be advocated as the treatment of choice even for dilacerated incisors in the absence of ankylosis. However, additional periodontal surgery might be needed to improve patients' appearance.

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indirectly to the scientific work reported in this article.

None of the authors has a financial interest in any of the products, devices, or drugs mentioned in this manuscript.

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阻生上顎正中門牙經由外科暴露配合矯正牽引之牙周療效：80個病例的研究

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背景：上顎正中門牙的阻生會影響顏臉美觀，本篇研究目的在於探討阻生上顎正中門牙經由手術露出合併矯正牽引定位後其牙周狀況與對側正常萌發門牙的差異。
方法：80例（顆）單側阻生門牙以手術露出、矯正牽引定位，在6～146月後回診時施行牙周檢查，採用之牙周參數包括牙冠長度、角化牙齦寬度、牙齦疤痕及齒槽骨喪失，並以對側正常萌發門牙作為對照。
結果：和對側正常萌發門牙比較，阻生門牙有較長的牙冠長度（Δ= 0.6mm, p<0.001）、較窄的角化牙齦（Δ=-0.9mm, p<0.001）、較高的牙齦疤痕發生率（Δ=14%, p<0.001）和較低的骨水平（Δ= 0.4mm, p=0.001，近心側；Δ=0.5mm, p<0.001，遠心側）。
結論：手術露出合併矯正牽引之治療方式並不會傷害阻生門牙之牙周健康，但會形成較不協調的牙周美觀；阻生門牙祇要不是黏連，即使是牙根彎曲，都適宜用這種方式處置，但可能需要作另一次的牙周手術以改善不美觀的牙齦外觀。***(J. Taiwan Assoc. Orthod. 24(3): 14-23, 2012)***

關鍵詞：阻生牙、手術、牙周、預後、矯正、療效

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