

Surgical Procedures, Mechanics, and Problems in Recovering 51 Impacted Maxillary Canines for 46 Patients with the OBS-3D Lever Arm Appliance

Abstract

Objective: Assess recovery for consecutive impacted maxillary canines (I-U3s).

Materials and Methods: Based on three-dimensional (3D) imaging, 51 I-U3s were recovered from 46 patients: 11 male, 35 female, mean age 16.5 years (range 10-36 yr). Orthodontics prepared a path for movement of the I-U3s as needed. Minimally invasive surgery uncovered the I-U3s and removed bone to the level of CEJ. 3D anchorage was provided with a 2mm diameter stainless steel (SS) OrthoBoneScrew® (OBS). A rectangular slot secured a custom SS wire segment (OBS-3D lever arm) to align the I-U3.

Results: Impaction locations were according to side (22 right, 29 left), and surface (32 labial, 19 palatal). I-U3s were optimally aligned in an average of 11.7 months (M), but six more severe labial impactions required up to 17M, and six complete transpositions required 27-30M. Moderate root resorption (<2mm) on the adjacent lateral incisor was noted for four I-U3s (3 labial, 1 lingual). Gingival recession affected 19 recovered canines (11 labial, 8 palatal); all were moderate (Miller Class I) except for one severe problem (Miller Class III).

Conclusions: The OBS-3D lever arm is a biomechanic system that enhances the probability of success by controlling treatment duration and complications. Root resorption on adjacent lateral incisors is best avoided by not bonding a bracket on them during the recovery process. (*J Digital Orthod* 2020;59:24-33)

Key words:

Maxillary canine, impaction, transposition, bone screw, 3D lever arm, gingival recession, root resorption

Introduction

Dental nomenclature for this report is a modified Palmer notation, i.e. quadrants are upper right (UR), upper left (UL), lower right (LR) and lower left (LL), and permanent teeth in each quadrant are numbered 1 to 8 from the midline. In 1975, Archer¹ defined an impacted tooth as completely or partially unerupted with an unfavorable position relative to an obstacle (*tooth, bone, or soft tissue*) that probably prevented eruption. With the exception of third molars, maxillary permanent canines (U3s) are the most common impactions. There is a variable

prevalence among ethnic groups from 0.27% in Japanese² to as much as 2.4% in Italians.³ Females are 2-3 times more frequently affected than males.³⁻⁶ Early diagnosis and treatment is recommended to avoid severe displacement and complete transposition.^{5,6} Abnormal position and/or lack of a canine eminence between age 8-10 years are early signs of potential impaction.⁷

Closed eruption and an apically positioned flap are viable approaches,^{5,6} but using an archwire as anchorage can result in distortion of the arch,

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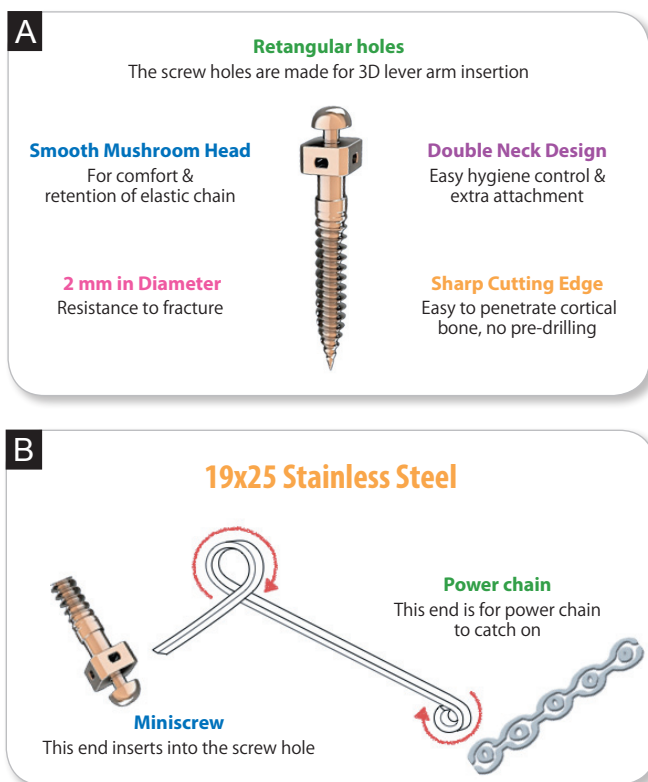
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particularly if the canine is or becomes ankylosed.⁸ A stainless steel (SS) endosseous OrthoBoneScrew® (OBS) (iNewton, Inc., Hsinchu City, Taiwan) has a rectangular hole (tube) to receive a 0.019x0.025-in SS wire (OBS 3D lever-arm) (Fig. 1). The purpose of this study was to assess the OBS 3D lever arm appliance relative to treatment time, success rate, and complications for a consecutive series of impacted upper canines (I-U3s).

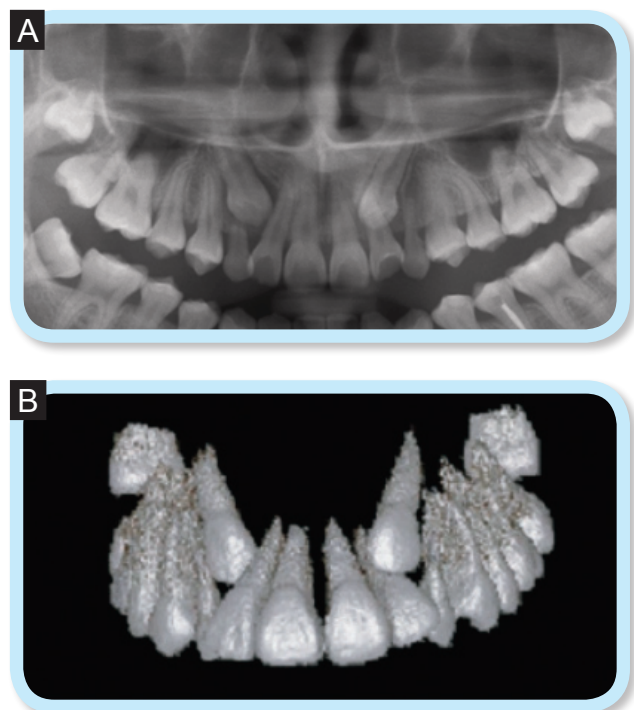
Material and Methods

The Institutional Review Board (IRB) of Taiwan Medical Research Ethics Foundation (protocol number: MIC1/19-S-004-1) approved this retrospective study that resulted in 46 consecutive patients with 51 I-U3s. They were treated from 2013-2016 and were all evaluated with cone-beam computed tomography (CBCT) (Fig. 2). The OBS 3D lever arm appliance (Fig. 3) was used for all patients, but the



■ Fig. 1:

- A. A 2x14-mm SS bone screw has a rectangular hole (tube) designed to insert a 3D lever arm.
 B. A 3D lever arm is formed from a 0.019x0.025-in SS wire as shown.



■ Fig. 2:

- A. A panoramic radiograph is a 2D image that is unreliable for determining the relationship of impactions to the roots of adjacent teeth.
 B. A CBCT image shows important details in 3D for locating, uncovering, and applying mechanics to recover I-U3s.

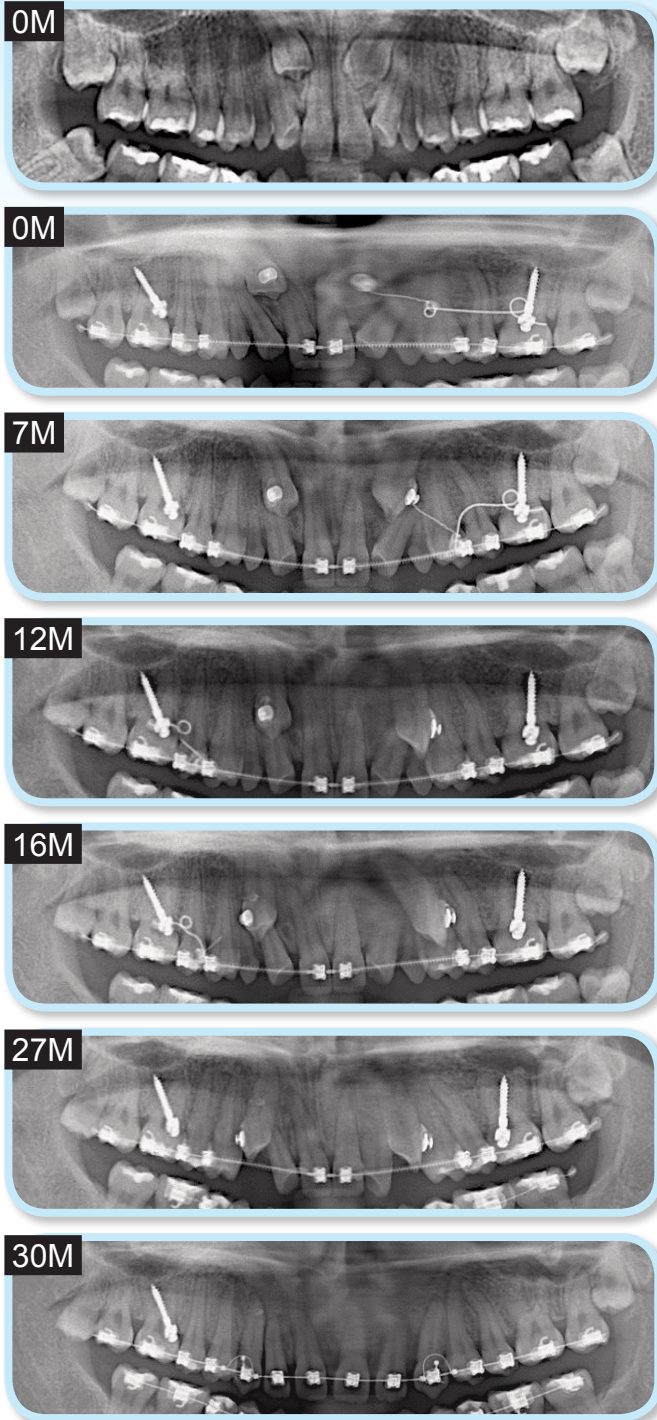


Fig. 3:
A vertical panel of progressive panoramic radiographs documents the recovery of I-U3s from the upper pretreatment image (0M) and the immediate post-operative view (second 0M) to the completion of active treatment at thirty months (30M). Note there are no brackets bonded on the maxillary lateral incisors until after 27 months (27M) to avoid root resorption. See text for details.

surgical exposure varied depending on the location and orientation of the impaction. Pretreatment consultation included a thorough discussion of potential problems such as swelling, temporary facial disfigurement (Fig. 4), and root resorption (Fig. 5).

Palatal impactions were managed conventionally,⁶ but labial impactions were exposed with the vertical incision subperiosteal tunnel access (VISTA).⁹ The crown of an endosseous I-U3 was located with a surgical explorer.¹⁰ After the crown was exposed, an eyelet was bonded at least 2mm occlusal to the cemento-enamel junction (CEJ),¹¹ and all overlying bone was carefully removed to the level of the CEJ (Fig. 6).¹² At the planned location on the infra-zygomatic crest (IZC), a 2x14-mm OBS was installed with the desired orientation of the rectangular tube (Figs. 1b and 3). The custom lever arm was activated in the prepared plane¹³ with a power chain from the



Fig. 4:
A. A postoperative complication is shown after a complex surgical intervention to initiate recovery of a transposed I-U3. Note the lip, cheek, and orbital swelling with discoloration one week post-operatively. No additional treatment was indicated.
B. One week later, the complications were almost resolved.

impaction to the distal end of the 3D lever arm and both ends were retained with polymerized resin. After activation, the soft tissue flap was closed, and a post-operative panoramic radiograph was exposed (Fig. 3). Details for the surgical and mechanical

procedures are published.¹⁴⁻¹⁷ All clinical procedures for the current sample were performed by the senior author.

Results

From 2013-2016, 46 consecutive patients (11 male, 35 female, mean age 16.5yr, range 10-36yr) presented with 51 impacted maxillary canines: 41 unilateral, 5 bilateral; 22 right side, 29 left side; and 32 labial, 19 palatal. Surgery was uneventful for all patients except one who sustained facial bruises and swelling that resolved in 7 days (Fig. 4). All 51 I-U3s were successfully recovered and optimally aligned in occlusion. Treatment time after the initial alignment of the I-U3 was a mean of 11.7M (Fig. 7), but the more difficult problems like labial impactions with complete transposition required up to 37M of comprehensive treatment. Four I-U3 patients (3 labial, 1 palatal) experienced mild root resorption (<2mm) on the adjacent lateral incisor. Gingival recession occurred on 19 canines (11 labial and 8 palatal impactions); all were modest (Miller Class I),¹⁶ but one was a Miller Class III (Fig. 8).

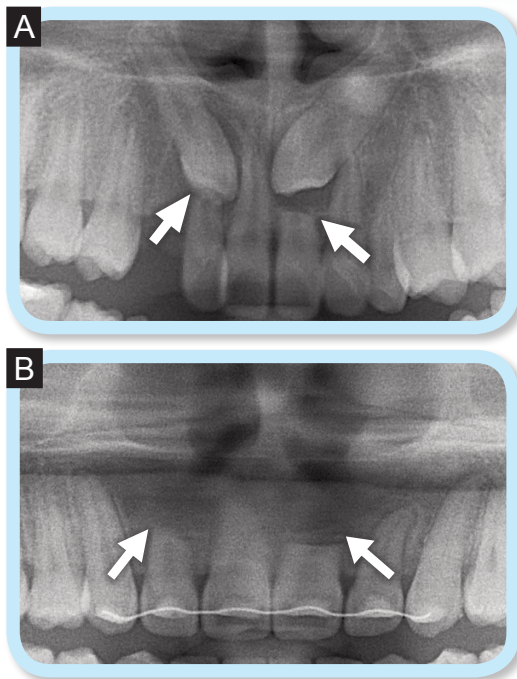


Fig. 5:
A. Pre-treatment radiography shows that I-U3s are associated with extensive root resorption (white arrows) on the UR2 and UL1.
B. Post-treatment radiography reveals that the root resorption is arrested but the loss of root structure is permanent (white arrows).

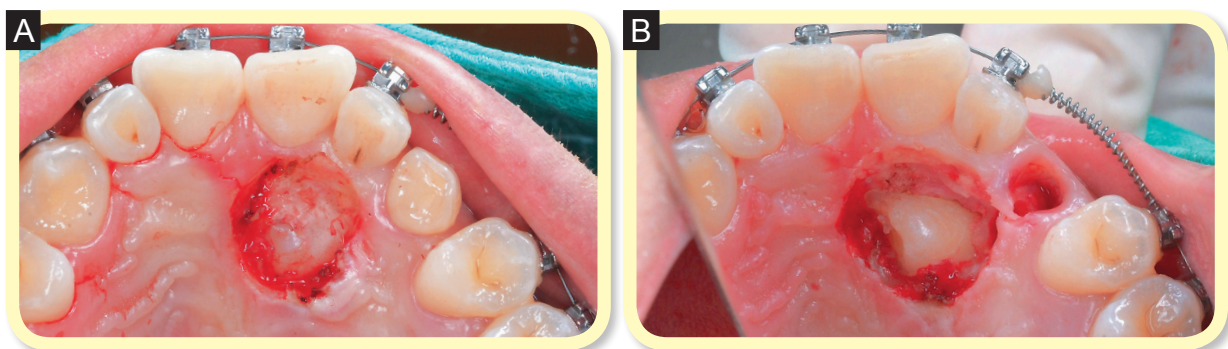
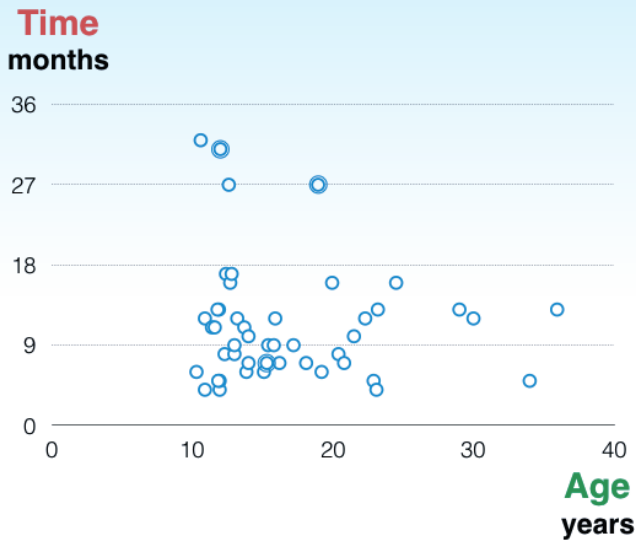


Fig. 6:
A. The crown of an impacted canine is evident after the overlying soft tissue is removed.
B. All bone was carefully removed down to the CEJ in the path of expected tooth movement.



■ Fig. 7:

Treatment time in months after the bracket is bonded in the ideal position or on a previously impacted U3 is plotted relative to the age of the patient. See text to details.

Discussion

Recovering complex I-U3s may be associated with migration of neighboring teeth, loss of arch length, dentigerous cysts, and external root resorption of the impaction or neighboring teeth (Fig. 5).^{6,8,12} Extracting I-U3s presents another array of undesirable outcomes such as asymmetry, lack of desired canine function, occlusal interference, eccentric mandibular closure, temporomandibular joint disorder, compromised dental esthetics, and/or unstable dental alignment.^{6,8,10-12} The OBS-3D lever arm method was designed to simplify the mechanics and limit undesirable outcomes.¹³ IZC OBSs are reliable fixtures (*failure rate* ~7%),¹⁷ and case reports have established the principles for OBS-3D lever arm mechanics, but the performance of the method for a series of complex I-U3s is unknown.

Intuitively, more rapid I-U3 recovery is expected in younger patients,¹⁸ but the current study revealed

that the average treatment time (11.7 months) was similar for children and adults (Fig. 7). In contrast to a previous report with a smaller sample ($n=30$) of primarily palatal impactions,¹⁸ the current study found that the position of the I-U3 was the prime determinant for duration of treatment. The current sample ($n=51$) was primarily labial impactions (32), which are usually more difficult than palatal impactions and are prone to complications,^{5,6,8,10-12} particularly for a transposition.¹⁹⁻²²⁻²⁴ Patients with complete transpositions were consistently more difficult to treat, and required extended treatment duration (>17 months) (Fig. 7).

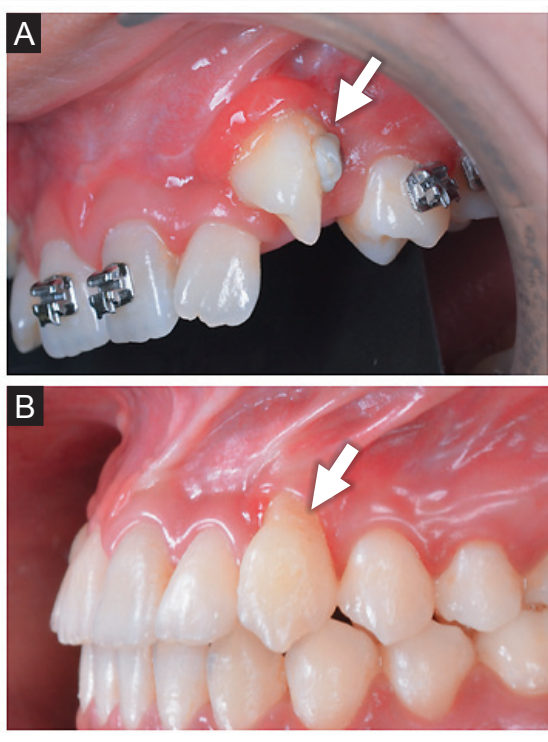
Most prevalence studies report about two-thirds of I-U3 are palatal.²⁰ However, I-U3s in Chinese are two-thirds labial (*facial*), which probably reflects a high prevalence for midface deficiency.²¹ In 1995, Peck²² reported an international sample of transposed I-U3s as: 1) first premolar 71%, 2) lateral incisor 20%, and 3) all other teeth 9%. Tooth transposition is almost always in the maxilla, and it affects ~0.4%²⁴ of the population worldwide, but the anomaly is more common in Europeans (2%)²⁵ and Chinese (0.81%).²¹ In comparison, 67% of the current Taiwanese sample ($n=51$) showed multiple types of I-U3 transposition: coronal (21), radicular (2), and complete (11).²³ Transposition with the lateral incisor (17) was the most common,²⁴ but 12 involved both the central and lateral incisors, and 5 were transposed with the first premolar. The high prevalence of difficult I-U3 transpositions suggests preferential referral to the senior author's clinic.

Complications associated with the surgically-assisted I-U3 recovery include gingival recession,²⁶ ankylosis,^{8,27} root resorption,²⁸ and poor control

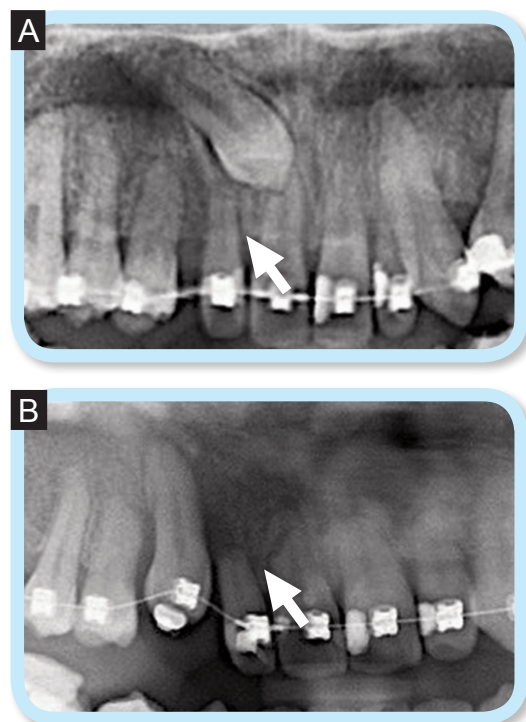
of axial inclination.^{6,18} Inadequate torque control is a common problem when an I-U3 is aligned. Bracket torque selection is helpful, but torquing auxiliaries are commonly required. One of the more refractory complications is the control of soft tissue inflammation.^{20,26,27} Oral hygiene is very difficult particularly for patients with high impactions and unfavorable soft tissue contours (Fig. 8). Plaque accumulation produces inflammation and the soreness discourages effective hygiene. Persistent inflammation results in gingival recession. In addition, the problem may be associated with positioning the eyelet too near the CEJ (Fig. 8). Moderate recession can usually be restored with periodontal surgery, but severe recession and loss

of labial bone threatens the long-term outcome for a recovered canine.^{26,27} The only patient in the present series with severe gingival recession (*Miller Class III*)¹⁶ was a labial impaction with massive loss of buccal bone. The recession was noted at the time the impacted tooth was surgically uncovered (Fig. 8). Despite severe gingival recession at the end of treatment, the affected U3 was well aligned and functioned normally, but soft tissue correction⁹ may be necessary in the future.

Root resorption associated with U3 impactions in Asians has a high incidence, up to 49.5%.²⁸ The adjacent lateral incisor root is the most commonly affected tooth (Fig. 9).²⁹ In comparison,



■ **Fig. 8:**
 A. Plaque accumulation leads to inflammation (red) of the marginal gingiva particularly near an attachment (white arrow).
 B. Gingival recession (white arrow) is noted on the labial surface of the UL3. See text for details.



■ **Fig. 9:**
 A. UR1 and UR2 (white arrow) are bonded with brackets and engaged on the archwire.
 B. Severe root resorption (white arrow) is noted on the UR1 and UR2 after the impacted UR3 is retracted and extruded into the arch. See text for details.

the prevalence of lateral incisor resorption for the present sample was much lower (4/51 or 7.8%). This positive outcome was associated with not engaging a tooth near an impaction on the archwire (Fig. 3), so the root is free to move out of the way as the impaction is recovered.²⁴ Once the canine is properly positioned in the arch, then a full fixed appliance is indicated to achieve final alignment.

Retention is often a difficult problem for recovered impactions because of a relapse tendency due to stretched gingival supracrestal fibers.³⁰ Supracrestal fiberotomy³¹ and a bonded fixed retainer are recommended for reliable retention.

Conclusions

Surgically assisted recovery of I-U3s with a OBS-3D lever arm is a reliable procedure with few complications. CBCT imaging is used for prospectively planning minimally invasive surgery and applied mechanics. Careful removal of bone to the level of the CEJ is required prior to applying traction. Progress should be carefully monitored radiographically. Retention is best accomplished with supracrestal fiberotomy followed by a fixed retainer.

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Case No.	Sex	Side R or L	Facial (F) or Palatal (P)	Time (month)	Age at surgery	Transpose with	Complications
1	F	L	F	11	13Y7M		gingiva recession I
2	F	R	F	32	10Y6M	4	
3	F	R	F	27	12Y6M	1, 2	gingiva recession I
4	F	L	F	12	22Y3M	4, 5	gingiva recession I
5	F	R	P	16	19Y9M	1, 2	
6	F	R	F	8	12Y3M	2	
7	F	R	P	8	13Y	2	
8	F	R	P	12	13Y2M	1, 2	
9	F	R	P	10	21Y5M	2	
10	F	R	P	7	18Y1M	2	
11	F	L	F	13	11Y1M	1, 2	
		R	F	5	11Y1M	2	UL1, UR2 root resorption (origin, not iatrogenic)
12	F	R	F	4	11Y11M		
13	F	L	F	9	15Y8M		
14	F	L	F	12	10Y9M	2	
15	F	L	P	12	15Y9		
16	F	L	F	27	18Y10M	2	oozing left side gingiva recession I
		R	F	27	18Y10M	2	
17	F	R	P	13	29Y	1, 2	gingiva recession I lateral incisor root resorption
18	F	L	P	6	15Y1M	2	gingiva recession I
19	F	L	F	7	14Y	2	gingiva recession I
		R	F	10	14Y	2	
20	F	R	P	11	11Y4M	1, 2	gingiva recession I
21	F	R	P	5	11Y9M	2	
22	F	L	F	9	17Y2M	1, 2	lateral incisor root resorption
23	F	L	F	5	22Y9M		gingiva recession I
24	F	L	F	9	15Y4M	2	gingiva recession I
25	F	R	F	13	11Y8M	2	

■ Table 1A. (continued on the next page)

51 maxillary impactions in 46 patients are classified according to sex, side (right or left), position (facial or palatal), total treatment time (months), age at time of surgery, transposition with an adjacent tooth or teeth (1-8), and complications including gingival recession (Miller type I, II, or III).

Case No.	Sex	Side R or L	Facial (F) or Palatal (P)	Time (month)	Age at surgery	Transpose with	Complications
26	F	R	F	7	15Y3M		
		L	F	7	15Y3M		gingiva recession I
27	F	R	P	16	24Y5M	1, 2	gingiva recession I
28	F	R	F	4	23Y1M	2	gingiva recession I
29	F	L	F	4	10Y11M		
30	F	R	F	6	10Y3M		gingiva recession lateral incisor root resorption
31	F	L	P	7	16Y2M	1, 2	gingiva recession I
32	F	L	F	6	19Y2M	4, 5	gingiva recession I
33	F	L	P	5	34Y		gingiva recession III
34	F	L	P	7	20Y8M		
35	F	L	P	8	20Y4M	1, 2	
36	M	L	F	17	12Y8M		gingiva recession I
37	M	L	F	17	12Y4M	4	gingiva recession I
38	M	L	P	16	12Y7M		gingiva recession I
39	M	R	F	31	12Y		
40	M	L	F	6	13Y9M		
41	M	L	P	5	11Y11M	1, 2	
42	M	L	F	12	30Y		gingiva recession I lateral incisor root resorption
43	M	L	F	11	11Y6M	4	swelling
44	M	R	F	9	13Y	1, 2	gingiva recession I
45	M	L	P	13	23Y2M	2	
46	M	L	P	13	35Y11M	2	gingiva recession I
Total				598			

■ Table 1B. (continued from the previous page)