

Article Title:

Canine-Lateral Incisor Transposition: Controlling Root Resorption with a Bone-Anchored T-Loop Retraction

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Canine-Lateral Incisor Transposition: Controlling Root Resorption with a Bone-Anchored T-Loop Retraction

Abstract

Introduction: A 12-yr old female presented with a Class II division 1 malocclusion, complicated by a complete transposition of the maxillary left canine, into the position normally occupied by the left lateral incisor. Dental and medical histories were noncontributory. **Methods:** Brackets were bonded on all maxillary teeth, from first molar to first molar, except for the left lateral incisor. Because the lateral incisor was not engaged on the archwire, the tooth was free to physiologically move out of the path of canine root movement. To prepare the site for canine retraction, a coil spring was used to open space between the left central incisor and first premolar. A 2X12mm stainless steel miniscrew was placed in the infrazygomatic crest (IZC), labial to the mesiodistal cusp of the left maxillary first molar. **Results:** A 0.019 X 0.025" titanium-molybdenum alloy (TMA) T-loop, anchored by the miniscrew, was used to retract the canine root over the labial surface of the root of the distally positioned lateral incisor. **Conclusions:** In 24 months, this difficult malocclusion with a Discrepancy Index (DI) of 18 was treated to a cast-radiograph evaluation (CRE) score of 26.

Introduction

Tooth transposition is defined as a change in position of two adjacent teeth within the same quadrant, but the clinical presentation may be quite variable.¹⁻⁵ It is identified as complete transposition, when the crowns and the roots of the involved teeth exchange places in the dental arch, and as an incomplete transposition when the crowns are transposed but the roots remain in their normal positions.¹ The prevalence of transposition is about 0.4%.⁶ Tooth transpositions occur more commonly in the maxilla than the mandible,^{6,7} and the maxillary permanent canine is the most frequently involved tooth.^{6,8}

Tooth transpositions are more commonly observed in females^{2-4,7-9} and may occur unilaterally or bilaterally.¹⁰ There is a greater frequency of unilateral transpositions on the left side.^{2,3,6-8,11} Transpositions are often associated with peg-shaped or congenitally missing upper lateral incisors, retention of deciduous canines, mal-posed adjacent teeth, and rotations.^{2,4,6-9}

Several etiologic factors are proposed: 1. genetics,^{2,4,6,12,13} 2. interchange in the position of the developing tooth buds,^{11,14} 3. trauma,^{3,10,15,16} 4. mechanical interferences,^{2,8,9,11} 5. early loss of primary teeth,^{3,16,17} 6. prolonged retention of primary teeth.⁸ However, the latter is more often a sequelae of transposition rather than an etiologic factor.

Peck and Peck³ classify transpositions as follows:

1. Maxillary canine-first premolar (Mx.C.P1)
2. Maxillary canine-lateral incisor (Mx.C.I2)
3. Maxillary canine to first molar site (Mx.C to M1)
4. Maxillary lateral incisor-central incisor (Mx.I2.I1)
5. Maxillary canine to central incisor site (Mx.C to I1)
6. Mandibular lateral incisor-canine (Mnd.I2.C)

The present patient presented with a complete transposition of the left maxillary canine and lateral incisor, which is classified as Mx.C.I2.

DIAGNOSIS AND ETIOLOGY

The clinical examination of this 12-year-old girl in the permanent dentition revealed an Angle Class II molar malocclusion with a complete transposition of the maxillary left canine and lateral incisor (*Figs. 1 and 2*). The ectopic eruption of the left maxillary canine positioned it high in the vestibular fold between the central and lateral incisors (*Figs. 3 and 4*).

From the patient's perspective, the anomaly was camouflaged by normal midlines and a functional deciduous canine, so the chief complaint was crowding of the upper arch. The asymmetric overjet had a maximum of 5mm, but the lateral facial profile was acceptable. A mild mandibular tooth size to arch length discrepancy was noted. An intraoral examination revealed that the right maxillary 2nd molar was partially erupted, but the other three 2nd molars were unerupted.

A panoramic radiograph documented that all permanent teeth, including the third molars, were present (*Fig. 5*). Cephalometric analysis was consistent with a Class II skeletal pattern and a mild tooth size arch width discrepancies (*Fig. 6*). There was increased axial inclination of both the maxillary and mandibular incisors. The cephalometric measurements are summarized in *Table 1*.

TREATMENT OBJECTIVES

- Establish a functional Class I molar and canine relationship
- Correct the transposition and restore natural tooth order
- Create an ideal overbite and overjet
- Correct incisor inclinations and root angulations
- Improve facial esthetics

TREATMENT ALTERNATIVES

Compared to the mandibular arch, there are more therapeutic options for the maxillary dentition because the supporting bone is less dense. Esthetically and functionally it is generally preferable to move transposed teeth to their normal positions in the arch.¹

Consistent with the treatment objectives, the most conservative treatment plan was non-extraction alignment of the mal-posed teeth. Bilateral infrazygomatic crest (IZC) bone screw anchorage was indicated to retract the transposed canine, and correct the Class II malocclusion. To avoid root interference or resorption during the retraction process, the transposed canine was maintained in a high position as it was retracted to take advantage of the tapered root structure of adjacent teeth.

A second treatment plan was to extract the transposed canine and substitute the first premolar for the canine. Although this approach is less challenging technically, there are multiple compromises in outcomes associated with retaining Class II buccal segments: esthetics, periodontal and functional.

The third treatment option was to extract the left permanent and deciduous canines and restore the canine with a dental implant. Considering the growth potential of this young patient, an osseointegrated implant was an undesirable choice. After carefully considering all the options, the first treatment plan was selected: correct the canine transposition and Class II buccal relationship with IZC bone screw anchorage.

TREATMENT PROGRESS

Treatment was started in the upper arch, with a 0.022-inch passive self-ligation system (Damon 3mx[®], Ormco, Glendora, CA); low torque brackets were placed on the incisors. An open coil spring was placed between the left central incisor and the first premolar to create space. One week later, the primary canine was extracted, and two 2x12mm OrthoBoneScrews[®] (OBS) with .022x.028" rectangular openings (Newton's A, Hsinchu, Taiwan) were inserted bilaterally in the IZCs, buccal to the maxillary first molars. Low tension (2oz) power chains were attached from first premolars to the screws bilaterally (*Fig. 7*).

A T-loop of 0.019x0.025" TMA was inserted in the hole of the left OBS, and activated to retract the left canine. As designed, the T-loop retracted the transposed canine while maintaining its position high in the vestibular fold. After one month, a power tube was activated from the left first premolar to the canine. When activated the T-loop produced a root distal moment on the canine (*Fig. 8*). After 3 months of traction, the transposed canine was translated ~4mm distally (*Fig. 9*).

It is important to note that no bracket was bonded on the left maxillary lateral incisor, so it could react as a free body and move out of the path of canine retraction. As the canine moved distally, the crown of the adjacent lateral incisor was physiologically tipped in a distal and palatal direction, as the canine root passed over the labial surface of its root. This free body effect decreased the chance of root resorption, compared to engaging the lateral incisor on the archwire.

In the 8th month, a low torque bracket was bonded on the left lateral incisor and a power chain was applied to the adjacent central incisor to close the anterior space (*Fig. 10*). One month later, the left canine was engaged with a 0.014” CuNiTi continuous archwire (*Fig. 11*).

In the 11th month, a panoramic radiograph was exposed to check the root angulation of the transposed canine (*Fig. 12*). The mandibular arch was bonded, and Class II elastics (Parrot 5/16” 2 oz) were applied (*Fig. 13*). Bite turbos were bonded on the lingual surface of the central incisors to open the bite and intrude the incisors (*Fig. 14*).

In the 19th month, a torquing spring was attached to the maxillary 0.014x0.025” CuNiTi archwire for delivering labial root torque to the left lateral incisor (*Fig. 15*). Triangular elastics (Monkey 3/8” 3.5 oz) were applied in the 23rd month to seat (settle in) the occlusion (*Fig. 16*). After 24 months of active treatment, all appliances were removed, and anterior fixed retainers were bonded: upper 2-2 and lower 3-3. A clear overlay retainer was delivered for the upper arch and the patient was instructed to wear it full time for the first 6 months and nights only thereafter.

TREATMENT RESULTS

The transposed canine was successfully retracted to the ideal position in 5 months. The keratinized gingival tissue on the canine was normal; there was no gingival recession or dehiscence. The nasolabial angle was maintained and a pleasant facial profile was achieved after 24 months of orthodontic treatment. The canine and molar relationships were corrected to Class I, and the upper, lower and facial midlines were coincident (*Fig. 21*). A functional occlusion was established with stable posterior support and proper anterior guidance (*Figs. 17 and 18*).

The superimposition of cephalometric tracings before and after treatment showed that treatment goals were achieved (*Fig. 19*). Note that the retraction of the whole maxillary arch resulted in a near ideal overjet and Class I molar relation. The panoramic radiograph obtained at debonding showed the entire dentition had proper root parallelism, including the root of the transposed canine (*Fig. 20*). There was some distortion in the left upper and lower canine areas, but the post-treatment records (*Figs. 17 and 18*) document the near ideal alignment of the entire dentition.

The CRE (Cast-Radiograph-Evaluation) score was 26 as shown in the subsequent work sheet. Most of the points deducted were due to the mal-posed 2nd molars, which had not been bonded and aligned. The three-year follow-up records reveal a stable result (*Fig. 22*). *Figure 23* offers a comparison of before, after, and three-year follow-up. Gingival tissue and occlusion relationships remained healthy and stable.

DISCUSSION

A successful orthodontic result is often predicated on the design of the force system.¹⁸ The IZC is a convenient placement site in the maxilla for orthodontic miniscrews or miniplates.¹⁹ It has been used successfully to provide skeletal anchorage for retraction of canines and incisors, both individually and en masse, as well as intrusion of the maxillary posterior teeth.²⁰⁻²⁵ For the present

patient, an OBS in each IZC was used to retract the entire maxillary arch to correct the Class II relationship, as well as provide anchorage to retract the transposed left canine.

A 2x12 mm stainless steel OBS was selected. Setting the screw head at the level of the archwire helped avoid a vertical component of force on the maxillary molars. The left OBS had a specially designed .022x.028" rectangular opening just beneath the screw head, that allowed for the insertion of a T-loop made with .019x.025" TMA.

The T-loop spring was introduced in 1960 by Dr. Stoner,²⁶ as an effective application of a frictionless retraction spring loop device.²⁷ A T-loop is controlled by the load-deflection rate of the spring, position of the activation bends, amount of T-loop activation, and the position of the loop relative to the inter-bracket distance. The clinical use of a T-loop with osseous anchorage simplifies the reactive mechanics, and also increases the distance between the anchorage screw and the bracket on the transposed canine. An adequate space is helpful for controlling the activation and eccentricity of the loop.

For retraction, a T-loop is positioned more anteriorly to increase the alpha moment and more posteriorly to enhance the beta moment. For the present patient, the T-loop was positioned close to the transposed canine, to increase the alpha moment (*Fig. 8*) to move the root of the transposed canine distally. The horizontal force retracted the canine, and the vertical position of the loop, relative to the bracket on the transposed canine, resulted in translation without undesirable extrusion (*Figs. 22 and 23*). The material for the T loop spring was TMA, which simplified the design and provided excellent mechanical properties with good formability.²⁸ According to Maya et al.,²⁹ TMA and stainless steel springs of the same dimension have similar spring characteristics, but TMA springs have a considerably lower load-deflection rate.

Kozlowski³⁰ proposed four advantages for using bite turbos in orthodontic treatments: 1. protect the enamel from bracket wear or accidental debonding, 2. improve the effect of light wires for arch development, 3. enhance the effect of early light elastics for anterior-posterior, vertical, and transverse correction, and 4. correct excessively low or high mandibular plane angles (brachyfacial or dolichofacial patients).

Anterior bite turbos were used in the 11th month to facilitate arch development of the mandible, intrude lower incisors, and flatten the Curve of Spee. With the teeth disarticulated, a light archwire expanded the arch efficiently for resolution of mild crowding of mandibular dentition. The original lower incisor to mandibular plane angle (L1 to MP angle) was 101°, and more incisal flaring was expected as the crowding was resolved. The anterior bite turbos were placed, on the same day that the lower arch was bonded, to help control the incisor axial inclination and the overbite. They also provided a light intrusive force. Thus, the L1 to MP angle was reduced to 98°, and the overbite decreased to 2mm.

Opinions vary concerning treatment timing,³¹⁻³³ but for the present patient it was advantageous to delay full fixed appliance treatment until the permanent buccal segments erupted. It was important for the transposed canine to be adequately exposed for bonding and retraction, but its high position in the vestibular fold was an additional advantage. Babacan et al.²⁷ prefers to avoid correcting transposed teeth in the permanent dentition, because of the potential risk of damaging teeth and/or supporting structures. Maia³¹ favors early treatment to decrease the risk to the dentition and supporting tissues.^{3,14,and 33}

In considering the timing of treatment for transposed teeth, clinicians must carefully consider esthetics, occlusion discrepancy, the root apex positions, expected duration of treatment, patient cooperation, periodontal support, and age of the patient. In addition to inadequate eruption of the transposed tooth, the main disadvantage of early treatment with fixed appliances is an inferior result.³⁴ For the present patient treatment was accomplished in only 24 months, but it may have been wise to extend active treatment to bond and align the second molars. Over half of the deducted points in the CRE were due to inadequate alignment of the 2nd molars.

SUMMARY AND CONCLUSIONS

A complete maxillary canine transposition is a complex anomaly that presents a significant orthodontic challenge. Conservative correction of the problem entails risks that require carefully controlled appliances. Segmented mechanics are optimal for individualized movement of target teeth. On the contrary, the use of continuous archwires for correction of a transposition invites adverse effects, particularly root resorption. For the present patient, skeletal anchorage provided an independent force system for retracting the transposed canine as well as for correcting the Class II relationship of the entire maxillary arch. The mechanical advantages of a T loop spring anchored with a bone screw were effective for the efficient correction of a complete canine transposition, superimposed on a Class II malocclusion.

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FIGURE LEGENDS

Fig. 1. Pretreatment facial and intraoral photographs

Fig. 2. Pretreatment study models (casts)

Fig. 3. The buccal view of the left maxillary canine shows it was displaced facially.

Fig. 4. The labial view shows the left maxillary canine is fully erupted but displaced high in the vestibular fold.

Fig. 5. Shows a completely transposed left canine in the maxilla. Pretreatment panoramic radiograph

Fig. 6. Pretreatment lateral cephalometric radiograph shows a Class II skeletal pattern.

Fig. 7. After the extraction of the primary canine, Damon 3mx[®] (Ormco, Glendora, CA) brackets were bonded to the entire maxillary arch with the exception of the left lateral incisor which was to allow it to react as a free body during the retraction of the transposed canine. An open coil spring was placed between the central incisor and 1st premolar to create space. Two OrthoBoneScrews (Newton's A, Hsinchu, Taiwan) were inserted in the bilateral infrazygomatic crest to provide anchorage for retraction. An activated T loop spring made of 0.019x0.025" TMA was connected between the transposed canine and OBS to retract the canine without extruding it.

Fig. 8. The activated T loop spring is placed in the bracket of the canine to provide a clockwise moment.

Fig. 9. After 3 months of treatment (3m) the transposed canine was translated distally ~4mm.

Fig. 10. In the 8th month (8m), a low torque bracket was bonded to the left lateral incisor. A power chain moved the lateral incisor mesially, and also assisted in delivering a distal force on the 1st premolar without excessive flaring of the central incisor.

Fig. 11. The previously transposed canine is engaged with a 0.014" CuNiTi wire at 9 months (9m) into treatment.

Fig. 12. After 11 months (11m) of treatment, the panoramic radiograph shows that the completely transposed canine was moved to its normal position.

Fig. 13. At 11 months (11m), light Class II elastics were worn bilaterally 24 hours/day to correct the buccal relationships.

Fig. 14. Bite turbos are bonded on the lingual surface of the central incisors to disarticulate the occlusion and provide an intrusive load on the incisors.

Fig. 15. At 19 months (19m) a torquing spring was placed on the left lateral incisor to tip the crown palatally.

Fig. 16. At 23 months (23m) the occlusion was seated with finishing elastics (Monkey 3/8" 3.5 oz).

Fig. 17. Posttreatment facial photographs and intraoral photographs

Fig. 18. Posttreatment study models (casts)

Fig. 19. Superimpositions of the initial (black) and finish (red) cephalometric tracings, superimposed on the anterior cranial base (ACB), maxilla (MX) and mandible (MD), demonstrate the entire maxillary arch was retracted and the mandible grew 3mm in length. Note the uprighting of the upper incisors due to the retraction by the IZC screws.

Fig. 20. Posttreatment panoramic radiograph and lateral cephalometric radiograph

Fig. 21. Posttreatment intra oral pictures show excellent alignment. The patient's lateral profile is improved.

Fig. 22. The left buccal views before (Pre-Tx), after (Post-Tx), and three-year follow up (3-year F/u) demonstrate that gingival tissue and occlusion were optimally corrected and remained stable.

Fig. 23. Sequential buccal and occlusal views of the transposed canine show its progressive retraction and alignment from 1-9 months (1m-9m).

Table 1 . Cephalometric summary







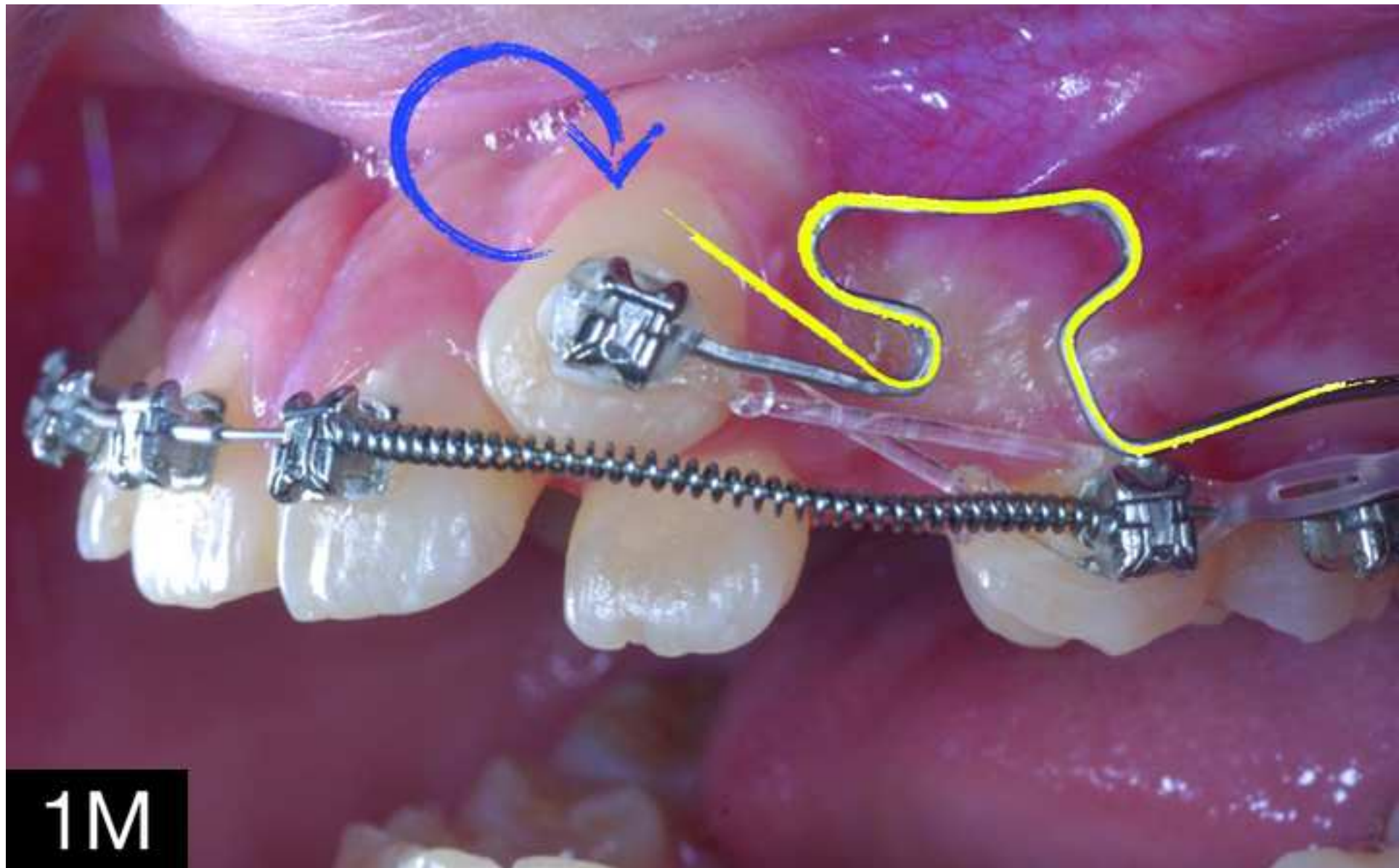




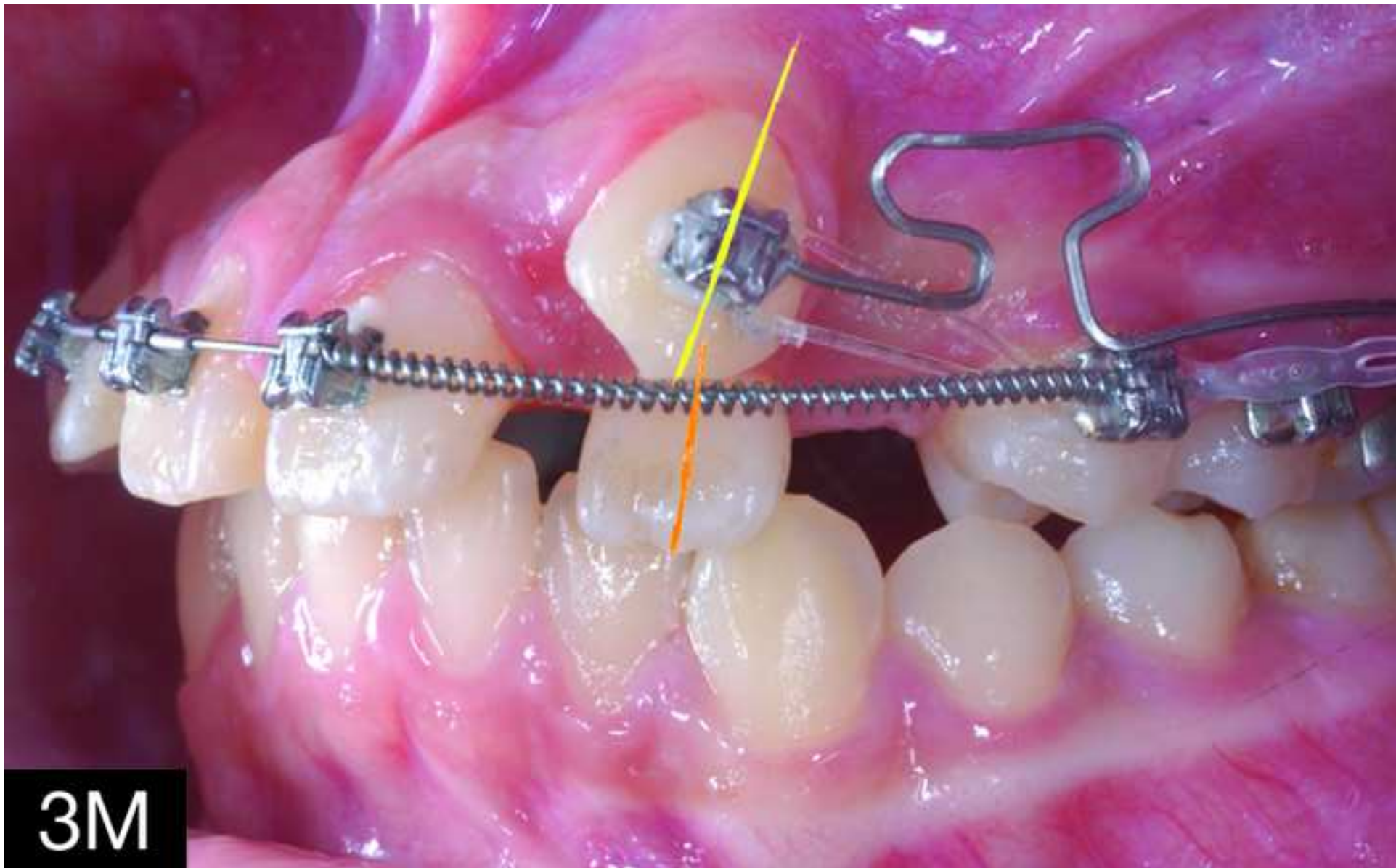




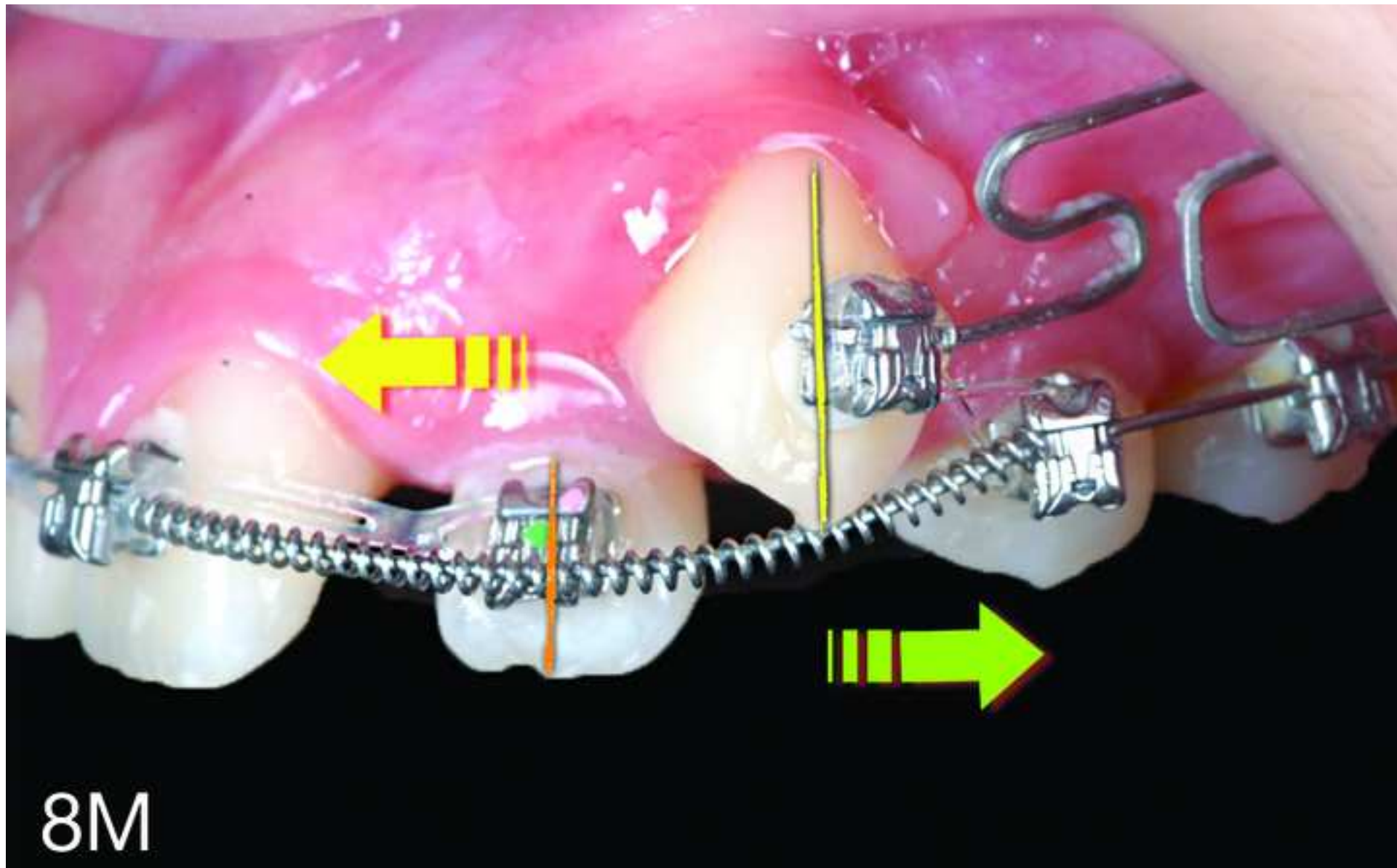




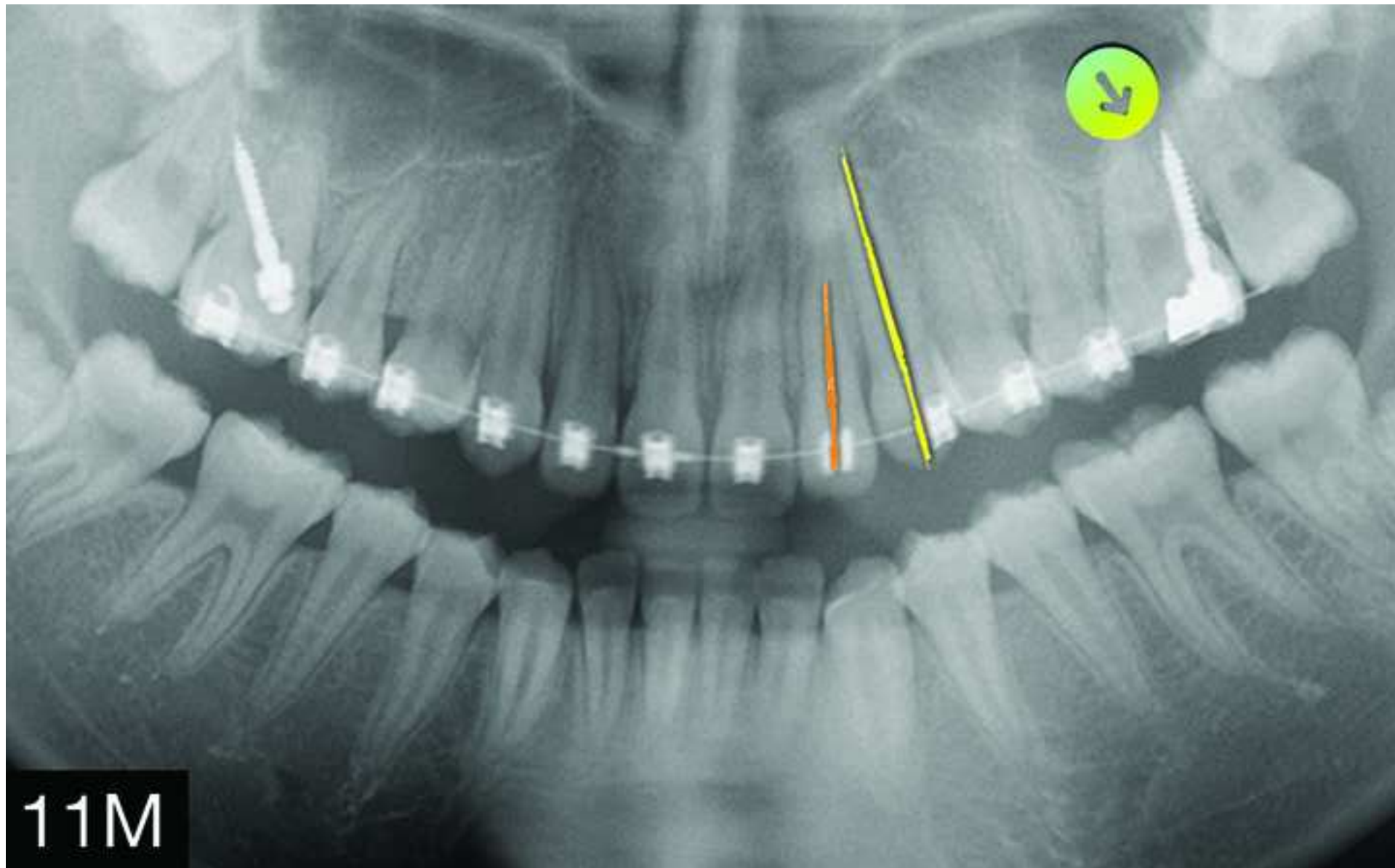
1M



3M









11M



11M



19M

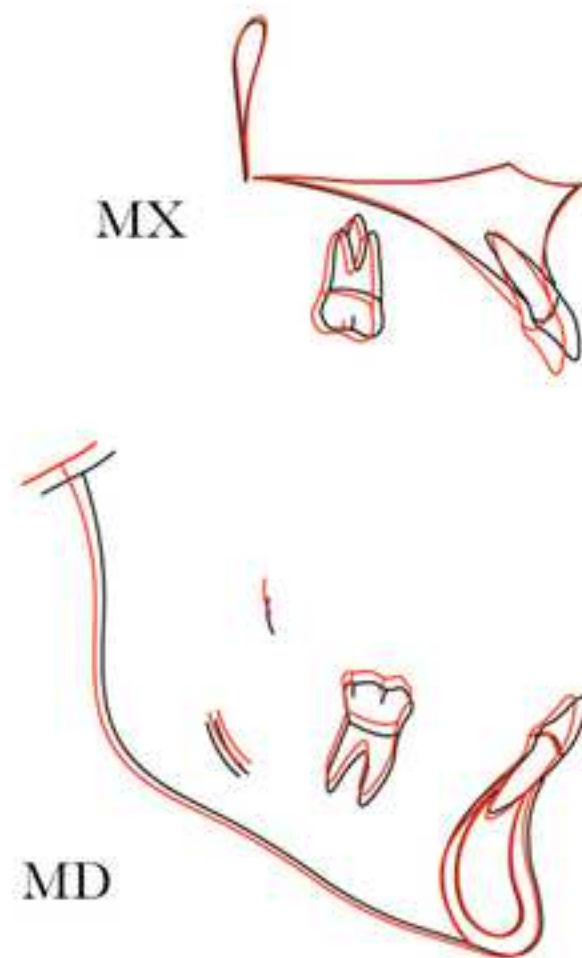
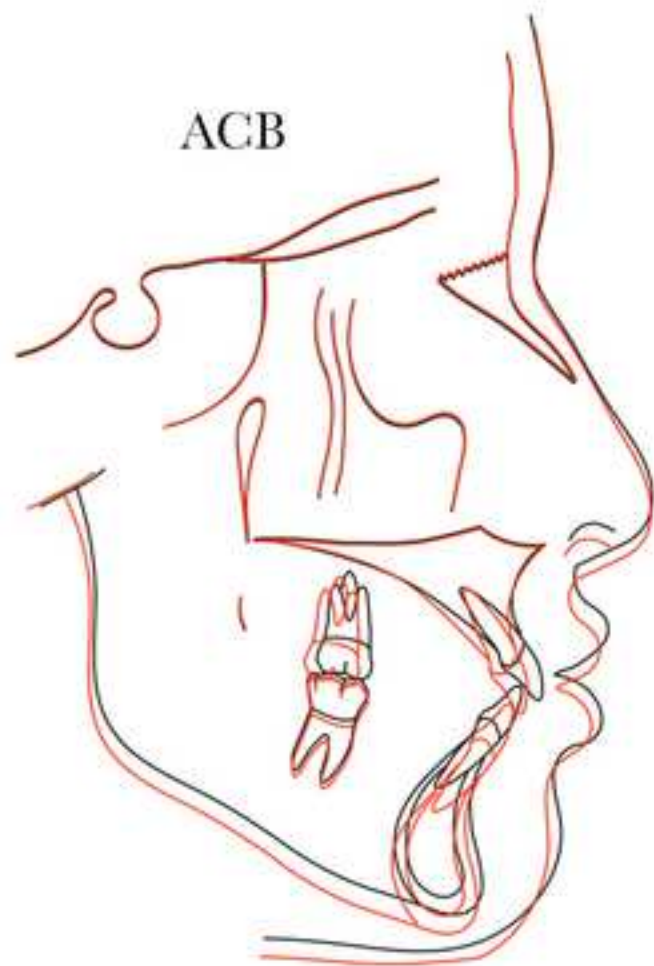


23M

















CEPHALOMETRIC

SKELETAL ANALYSIS			
	PRE-TX	POST-TX	DIFF.
SNA°	81°	80°	1°
SNB°	77°	76°	1°
ANB°	4°	4°	0°
SN-MP°	36°	36°	0°
FMA°	24°	23°	1°
DENTAL ANALYSIS			
U1 TO NA mm	5 mm	1 mm	4 mm
U1 TO SN°	113°	104°	9°
L1 TO NB mm	6 mm	5 mm	1 mm
L1 TO MP°	101°	98°	3°
FACIAL ANALYSIS			
E-LINE UL	-1 mm	-2 mm	1 mm
E-LINE LL	1 mm	0 mm	1 mm
E-LINE LL	-0.5 mm	-2 mm	1.5 mm