Case Report

Orthodontic management of a dental anomaly pattern (DAP) including mandibular canine transmigration: A case report
A challenging treatment but worth it!

William Northway[a]

ABSTRACT
Orthodontic technology has advanced to the point where management of cases with multiple dental anomalies should be within an orthodontist's daily armamentarium. A patient with bilateral agenesis of lower second premolars, delayed development, and transmigration of a mandibular canine was treated with the aid of hemisection, indirect/closed exposure, application of continuous force, targeted delivery, and strict attention to keeping the roots as much in bone as possible. This was accomplished without implants or flattening the facial profile, yet with excellent periodontal status and a fully functioning occlusion. (*Angle Orthod.* 2019;89:149–162)

KEY WORDS: Transmigration; Hemisection; Biomechanics; Guided eruption; CML5; DAP

INTRODUCTION

When a tooth erupts outside of its normal sequence, it is said to be transposed, which means the position of two contiguous teeth has changed. It is a form of ectopia usually resulting from polygenic, multifactorial expression of development.[1,2] In some situations the anomaly is more advanced; perhaps an adjacent tooth is submerged or angulated in such a way that the ectopia is extended beyond a single tooth displacement. This happens almost exclusively in the mandible, generally involving the lower premolar or canine. When the ectopia occurs to premolars, the teeth almost always go toward the distal; the canines go toward the mesial. Exaggerated ectopia can engage in a form of intraosseous migration and can even result in a premolar reaching the ramus or the canine crossing the midline, or farther.[3–5] If the tooth crosses the midline, the process is termed "transmigration."

While the first documented case was published by Rohrer[6] in 1929, Ando et al.[7] were the first to use the term "transmigration." Transmigration is a rare phenomenon. While estimates of the frequency of impacted maxillary canines are between 2.06* and 3.53%,[6,7] estimates of the frequency of mandibular transmigration range from 0.075* to 0.34%.[6,7–11]

According to Cakan et al.,[12] transmigration is a dental phenomenon of "partly environmental and partly genetic" etiology. The polygenic nature of dental manifestations makes linkage to just one defect impossible. When variations are seen among the members of a family, they often express different intensities of related aberrations. As technology continues to improve, the recommendation of genetic consultation becomes more plausible, in fact, more advised.[12] Many additional articles may be helpful and can be recommended, each of which has aided in understanding etiologic factors,[13–16] but the focus of this article is the resolution of the condition.

THE HISTORY OF MANAGING TRANSPOSED MANDIBULAR CANINES

From 1929, when transmigration was first described, the treatment of choice for this condition was "extraction or observation." In 1976, Howard[17] suggested transplantation, but no records were presented affirming this treatment. In 1993, when Brezniak et al.[18] documented a transmigrated canine that had erupted into the space between the lower central incisors, his treatment involved reshaping the tooth where it erupted, which made it look like an incisor.

In 1994, Wertz[19] described three cases in which the canines were severely malpositioned. Initially, teeth were exposed and "packed for 5 months" to encourage eruption. In each case, efforts were made to construct

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Figure 1. Pretreatment photos.

a stable appliance to facilitate directed movement. When the teeth failed to erupt, a pin and eyelet were inserted into the crown portion of the impacted canines to facilitate guidance. These may be the first published cases of forced or guided eruption. One of these cases required endodontic restoration, and one was deemed untreatable, so extraction ensued. No specific description was made of the mechanics involved. In 2012, Mazinis et al.[20] described six cases. In one, a 16-year-old had her canine forcibly erupted and finished with orthodontics; no postoperative records were shown. In 2012, Verma et al.[21] published the case of a patient treated by autogenic dental transplantation. The "surgical repositioning" was done along with apicoectomy and immediate endodontics; 1-year follow up showed radiolucency at the apex.[21]

Finally, in 2016, Cavuoti et al.[22] published a case that depicted the treatment of a lower right transmigrated canine that was exposed and brought back across the midline, into its appropriate position through guided eruption. The case was similar to the one presented by Wertz[29] but exhibited greater control and concluded with excellent alignment.

CASE PRESENTATION

Sierra presented at age 11 years, 7 months with irregular alignment of the upper incisors and an abscess over the upper right second primary molar (Figure 1). She had Class I interdigitation, slightly exaggerated overbite and overjet, and a rather convex facial profile; there were no significant functional discrepancies. A panoramic x-ray indicated that she was congenitally missing both lower second premolars, and the upper second premolars (especially the right) were delayed in development and eruption. Even though the roots of the lower second primary molars were unremarkable in terms of form and length, the occlusal tables were beginning to show signs of infraocclusion. The lower right canine had transmigrated to the point that the incisal tip was distal to the apex of the left lateral incisor and its precursor had not exfoliated (Figure 2). A lateral cephalogram showed that the canine was lying in the symphysis, labial to the lower incisor apices. A mixed dentition analysis revealed that there was adequate space in each quadrant, even if the lower second premolars had been present.

Figure 2. Pretreatment radiographs.

From a cephalometric perspective, Sierra presented a rather full facial profile (regrettably, her lips were not closed during the x-ray) (Figure 3). The lower lip was ahead of the esthetic plane; the lower incisor was 1.6 mm ahead of A-Pogonion and was proclined to 96.4° relative to the mandibular plane. The overjet measured 4.2 mm, and the overbite was 4.8 mm (all cephalometric measurements were rendered by digitization in Dentofacial Planner Plus, version 2.6, Dentofacial Research Inc, Aurora, Canada).

Sierra's mother asked if this could have been inherited, as she was congenitally missing multiple teeth (both upper lateral incisors, both lower second premolar, and others). Sierra's younger sister presented for consultation missing both maxillary lateral incisors. Their brother had bilateral ectopia of the upper first molars, delayed eruption of the upper right central incisor due to an odontoma, and lower canines that were erupting profoundly toward the mesial, so much so as to cause the apices of the lower incisors to converge. The unusual list of orthodontic problems presented by this family is not surprising in the context of malocclusions characterized by dental anomaly patterns (DAP).[16] This phenomenon has been identified as being primarily of genetic origin and is seen frequently in families.

Treatment Options

Today's mechanics offered myriad clinical options. The first option was to simply align all teeth in both arches (the primary canine appeared to have an adequate root and might survive) and lengthen the second primary molars with resin if they became submerged to the point where they presented an occlusal disturbance. If they failed later, they could be replaced with bridges or implants. Consideration could be given to extracting the transmigrated canine or it could be observed. With option 2, the lower second primary molars and the lower right canine could be extracted, along with the retained primary canine, and replaced with implants, or this could be extended as options if or when necessary. With option 3, the second primary molars could be extracted and replaced by closing spaces where the lower premolars were missing, and the transmigrated lower right canine could be retrieved via guided eruption and put into its appropriate location. These options were discussed with the family and their dentist, and the third option was pursued.

Clinical Management

Treatment was started by hemisecting the lower second primary molars and removing the distal halves. Once the extraction decision was made, the hemisection approach provided a number of benefits to the process of space closure as well as maximizing the periodontal outcome. First, temporarily maintaining the mesial portion of the second primary molar would help to sustain the width of the alveolus, avoiding the need to protract the permanent molar through alveolar bone when the cortical plates would be constricting (it collapses much more aggressively if the entire primary

Sierra 11y 8m 09/11/06 PreTx

SN - MP	36.0	(0.0)
FMA	29.3	(0.0)
Nasion- Sub-ANS	52.5	(0.0)
Sub-ANS - Me	65.3	(0.0)
N - Me	117.0	(0.0)
LFH : TFH %	55.8	(0.0)
SNA	80.3	(81.4)
A Pt to N Perp	-3.1	(0.4)
Co - A pt	91.7	(0.0)
SNB	76.6	(77.7)
Co - Gn	116.1	(0.0)
Pg to N Perp	-9.8	(-1.8)
Angle of Convex	4.5	(0.0)
ANB	3.7	(3.7)
WITS A pt FOP	1.0	(0.0)
L Incis to MP	97.4	(91.4)
Lower 1 to A-Pg	1.6	(2.7)
Lower 1 to NB	27.7	(26.5)
Lower 1 to NB m	5.2	(5.0)
Upper 1 to NA	18.2	(24.2)
Upper 1 to NA m	4.5	(4.3)
Interincisal A	130.4	(125.5)
Incis Overjet	4.2	(2.5)
Incis Overbite	4.8	(2.5)
Molar Relation	-1.3	(-3.0)
Lower Lip to EP	1.4	(-2.4)
Lower Z Angle	61.8	(0.0)
Mx Unit Length	91.8	(85.0)
Md Unit Length	116.1	(105.0)
Unit Difference	24.3	(20.0)

D.E. Extrax Anal		
Nasolabial	96.4	(102.0)
Y Axis to SN	67.3	(67.0)
Upper Lip to E	-3.0	(-4.0)
Lower Lip to EP	1.4	(-2.4)
Lower Z Angle	61.8	(0.0)

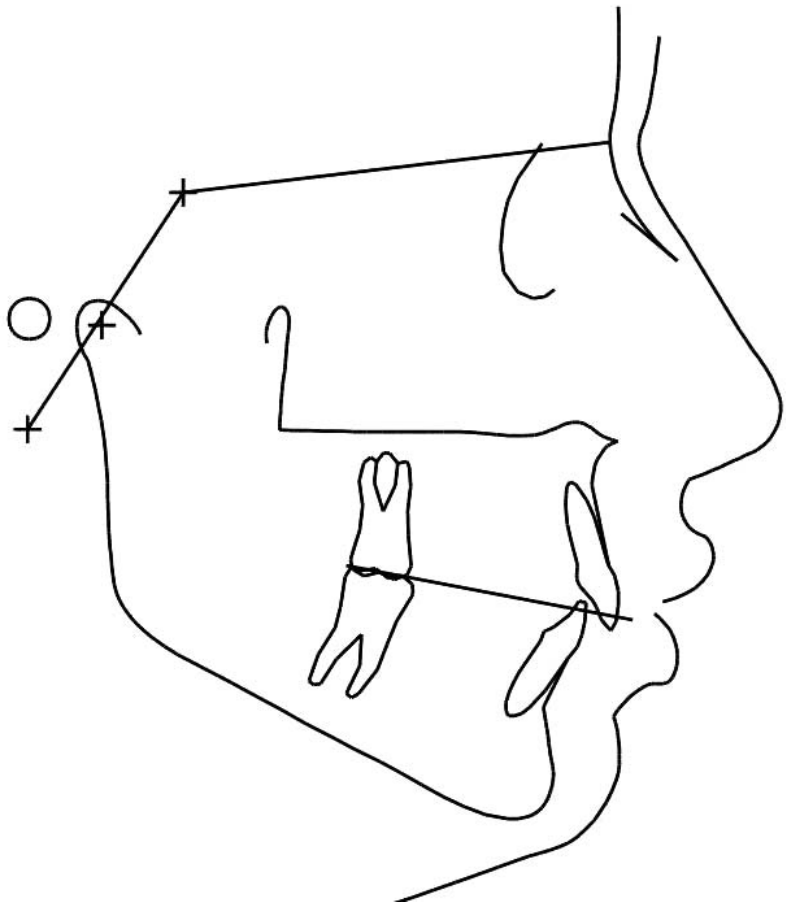

Figure 3. Pretreatment tracing.

molar is removed). As a result, the tooth moves more readily through the extraction site and provides a healthier final periodontal contour, especially at the mesial buccal root. Second, the presence of the mesial portion provides anchorage to the anterior teeth, facilitating the protraction of the molar. This profoundly benefits the facial profile by diminishing the extent to which the lower incisors are dumped toward the lingual.[23,24] Third, once that distal root space is closed, removal of the residual mesial portion reinvigorates the

Figure 4. Indirect exposure system.

Figure 5. Direct exposure system.

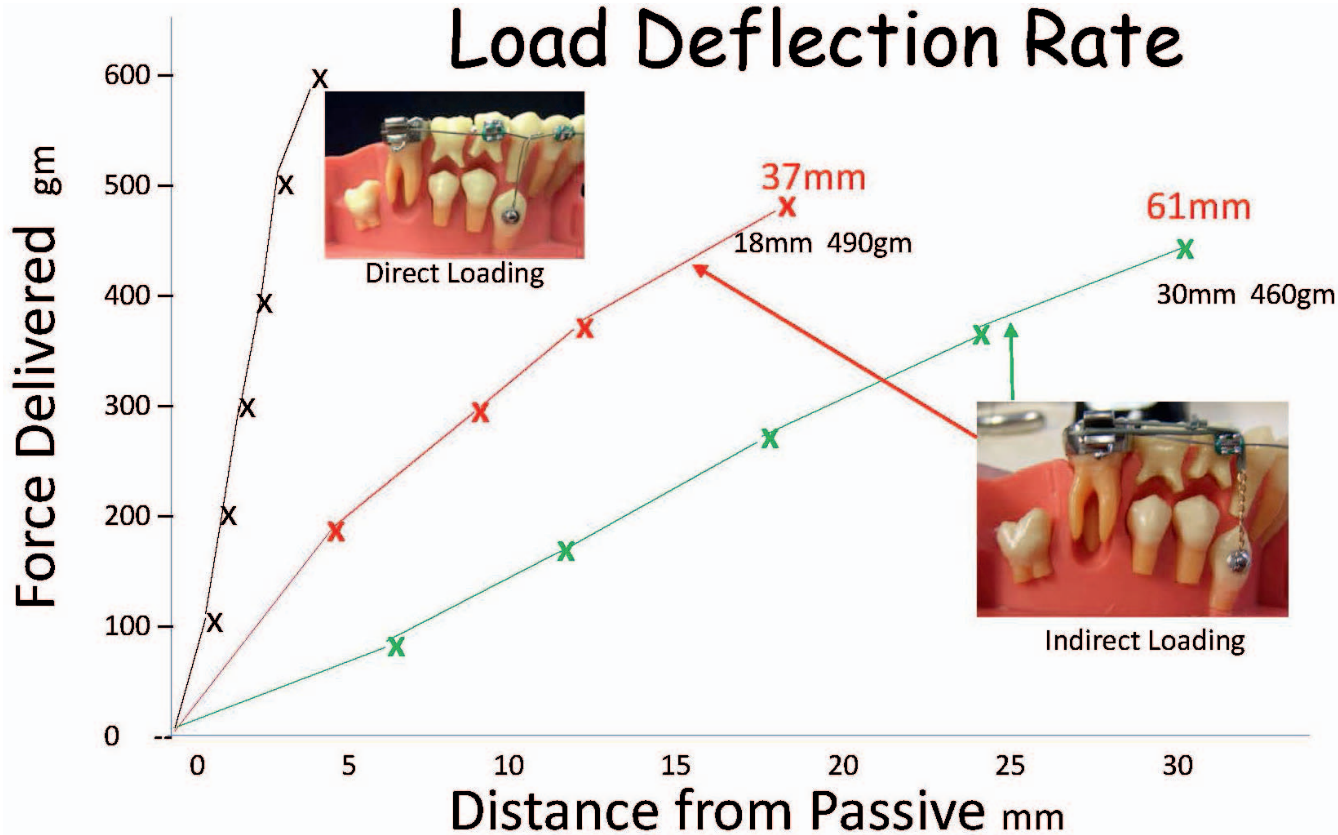

Figure 6. Load deflection rate.

regional acceleratory phenomenon, thereby boosting the rate of further space closure.[25]

Fixed appliances were placed with 0.022″ × 0.028″ brackets. Once leveling commenced and the orthodontic treatment had advanced to the point where a sufficiently heavy wire (perhaps a 0.016″ × 0.022″ either nickel titanium or stainless steel) could be placed, the canine was exposed. A button with loop was bonded to the crown of the canine. Placement strategy of the attachment needed to be discussed with the surgeon. Also, extreme care had to be exercised to avoid exposing any of the surgical site to etchant other than the small area of the enamel crown where the bracket would be bonded. Contact with the surrounding alveolar bone or periodontal ligament could cause damage that might provoke ankylosis.[26]

A fine gold chain was connected to the attachment, long enough to reach the vestibule and be accessible within the oral cavity. With access to the first link above the gingiva, power thread was fed through the link, passed over a nearby bracket, extended around the most distant attachment, and finally returned back to the other end where it was tied (Figure 4). In so doing, the stretched power thread was extended about 20 mm from the chain to the most distal extension, or a 40-mm round trip. As the tooth erupted the 1–2 mm length required to reach the next link of gold chain, the power thread would have only lost about 25% of its active component, or approximately 50 g.

The orthodontic literature has numerous examples where direct fixation was used (Figure 5). This involves an attachment on the impacted tooth being fixed directly to the archwire by a metal ligature; the force is dictated by the tightness of ligation. Once the wire achieves its passive form, all force is lost. When providing guided eruption, it will not take long to render the system passive. Maintaining continuous force will undoubtedly require extremely brief appointment intervals. The in vitro evaluation comparing the two systems of guided eruption, direct vs indirect, which is depicted in Figure 6, demonstrates a much-reduced rate of force degradation when power thread is incorporated.

As Proffitt and Sellers[27] stated, force duration is more important than magnitude. In the cases where we have failed to achieve complete eruption it has been my experience that it is related to progress having become stalled, typically for an extended period of time. In 1961, Burstone et al.[28] referenced Storey and Smith,[29] Reitan,[30] and Begg[31] when they described the desirability of employing orthodontic appliances that are capable of delivering light

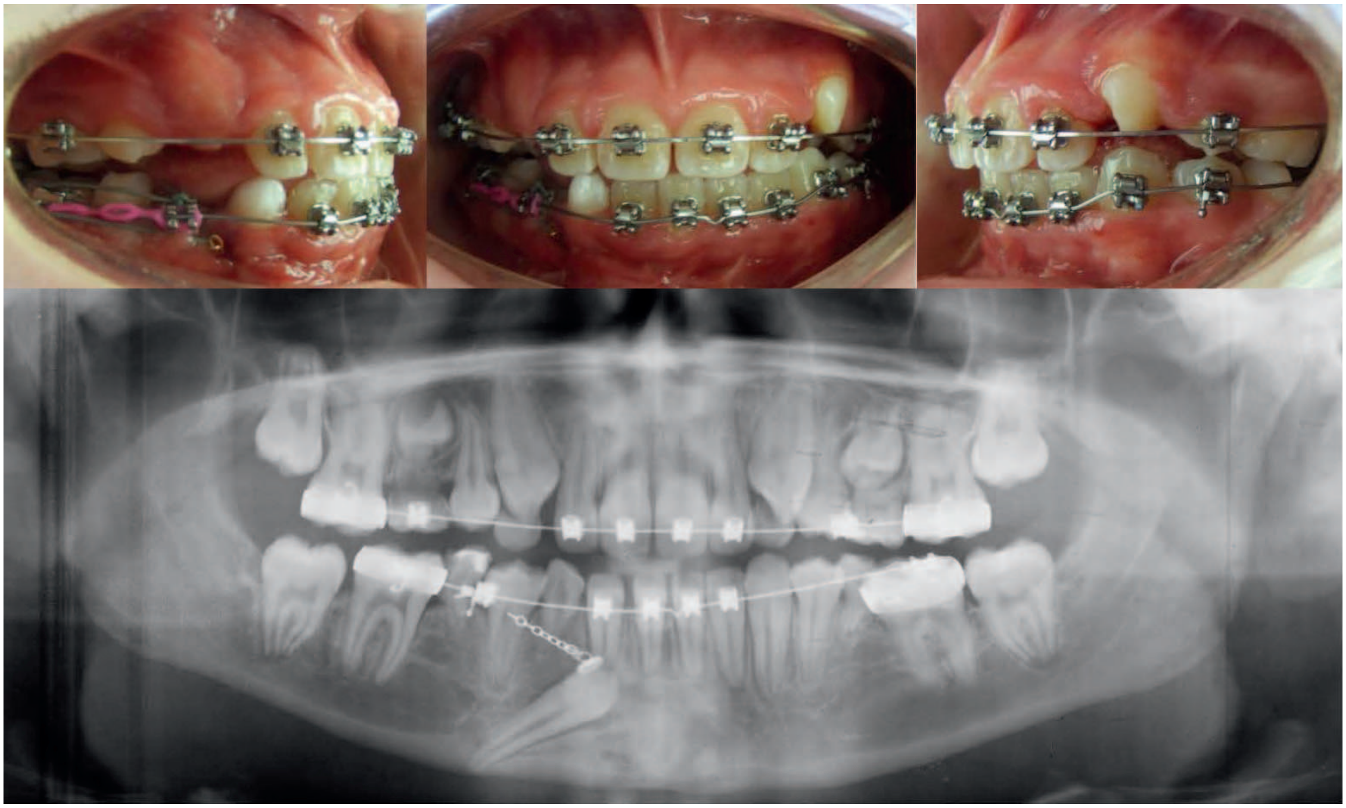

Figure 7. Sixteen-month progress.

continuous force. They contended that the greatest potentiality in altering spring properties was found in the linear configuration of the wire. By adding more wire (in this case, adding power thread) where the activation was critical, the load could be sustained over a greater distance.

Vermette et al.[32] compared 30 cases, 18 patients treated with apically positioned flaps (APF) and 12 patients with what they called closed-eruption (CE). They found that that the CE group had more esthetic gingival contours and crown lengths that better matched those of the contralateral controls. They also found that 61% of the APF group experienced some amount of intrusive relapse toward the end of treatment. They speculated that the CE group more closely mimicked natural tooth eruption, whereas the APF group might have been compromised because the flap was sometimes healing to the adjacent mucosa. Likewise, there might have been a similar response when the pack was placed at the time of exposure, rather than bonding immediately and placing the tooth in traction.[32]

Fourteen months into treatment, we requested removal of the mesial halves of the second primary molars, along with the retained primary canine. In the meantime, Class II elastics were promoted to reduce the overjet and improve interdigitation (Figure 7).

Twenty-five months into treatment, with the canine just beginning its ascent into its proper site, the button failed, so the mechanics were changed to a rolled vertical loop at the time of repair. This system consisted of an 0.018 round wire with a vertical loop standing up in the plane of the archwire but rolled to the lingual as it was tied to the erupting tooth. In this way the trajectory of eruption was changed more toward the lingual, aiming for the band of keratinized gingiva on the alveolar crest. The objective was to achieve a more favorable periodontal environment (Figure 8).

Forty months into treatment, with the canine fully erupted, the upper second premolars were extracted. Spaces were closed with progressive power chain and asymmetric elastics, Class III right and Class II left, which helped correct the midlines (Figure 9). The total length of treatment was 52 months (final photos are shown in Figure 10). A hinge-axis based positioner was used for retention on a progressively diminishing basis.

Treatment Results

An appropriate final result was accomplished in that the patient achieved adequate interdigitation with six healthy teeth in each quadrant. While the upper right

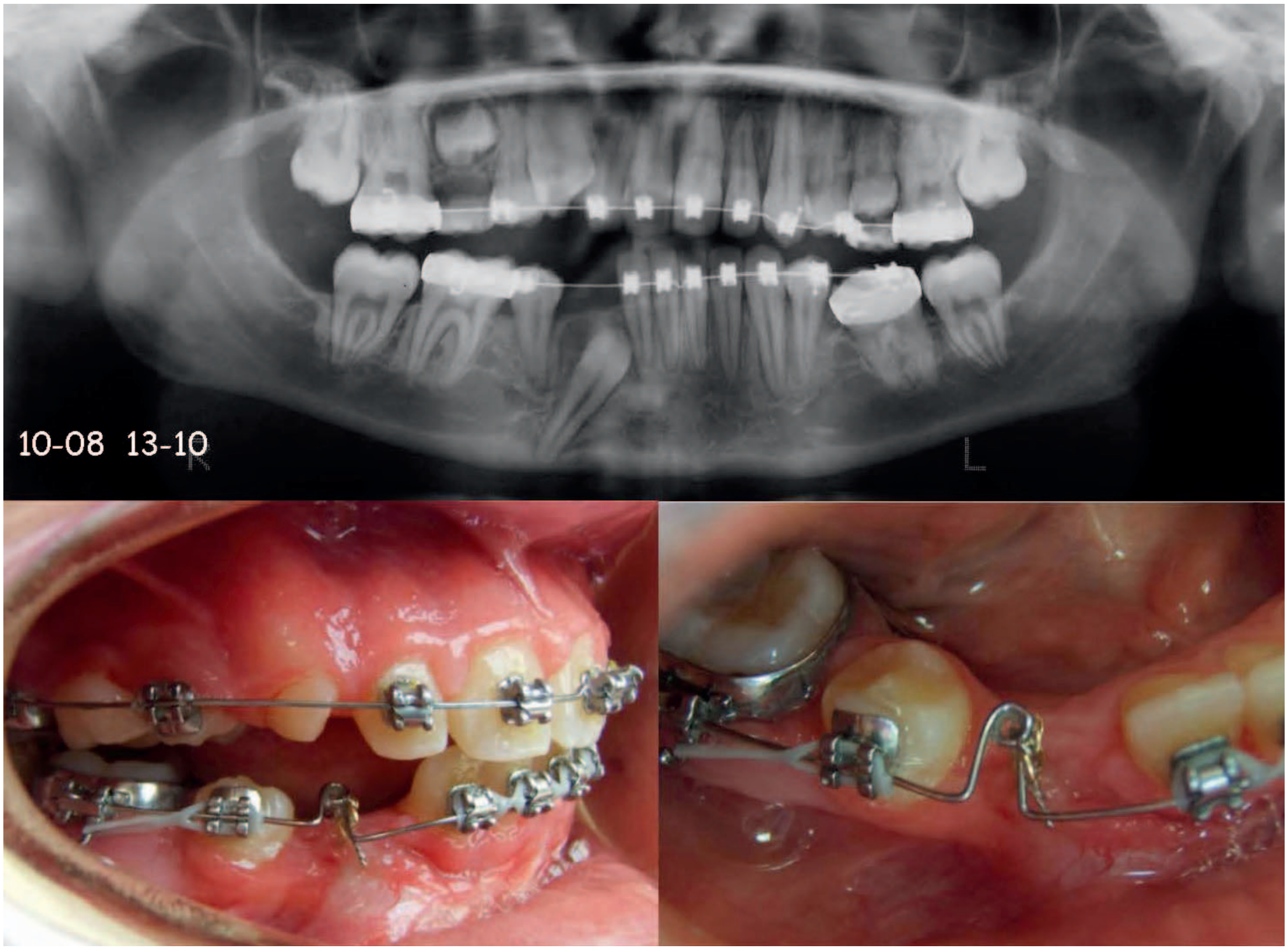

Figure 8. Rolled vertical loop.

first and second molars were not sufficiently to the buccal to completely straddle the lower buccal cusps, it turned out to be wide enough so that there was no transverse relapse over the ensuing seven years. While the upper midline was 1 mm off to the patient's right side, the anterior occlusion was excellent in terms of overbite, overjet, coupling, and cuspid protected occlusion (Figure 11). She has had no problems with discomfort or function. A comparison of her lateral cephalograms showed an improvement in overbite, overjet, angle of convexity, and related reduction in Frankfort mandibular plane angle (posttreatment radiographs, Figure 12).

Avoiding Implants

Extracting and closing spaces where the lower second premolars were congenitally missing and retrieving the transmigrated canine allowed for avoidance of three implants. While treatment took more than 4 years, all teeth were supported on the patient's own

Figure 9. Asymmetrical elastics.

Figure 10. Final photos.

natural roots, and there is no reason to anticipate future problems.

Hemisection

The approach using hemisections provided a number of benefits. First, the lower incisors were not excessively retroclined; lower incisor to mandibular plane was essentially unchanged, as was lower incisor to A-Pogonion; the lower incisor to NB showed the incisor going backward by only 1.4 mm to a very acceptable 3.8 mm. Second, the labial profile flattened, both in the upper and lower lip, to age-appropriate fullness. Third, the overbite and overjet ended up at about 2 mm each, enabling excellent coupling of the incisors. Fourth, there was no evidence of diminished alveolar contour in the extraction sites mesial to the lower first molars (superimpositions, Figure 13; segmental superimposition, Figure 14),

Periodontal Contour

The efforts taken to bring the transmigrated canine into the keratinized portion of the alveolus and then to place the tooth more onto bone did not pay immediate dividends. At the final records appointment, the gingival height at the lower right canine was about 3 mm lower than that on the left side. However, there was a conspicuous improvement in the ensuing 7 years. The uprighting of the teeth, placing the roots more on bone, was further benefited by the removal of fixed appliances and time (7-year follow-up photos, Figure 15; radiographs, Figure 16; and superimposition, Figure 17A through C).[33]

CONCLUSIONS

- A description of transmigration was provided along with the history of its clinical management. This anomaly is thought to be one of many that are caused by a mutation of the MSX1 gene and has been treated sparingly until recently. An appropriate method of treatment was demonstrated, along with that of bilateral agenesis of lower second premolars, in a way that avoided costly prostheses, preserved fullness of the facial profile, and did so in a manner that ensures maximized periodontal stability.

Figure 11. Gnathologic disposition.

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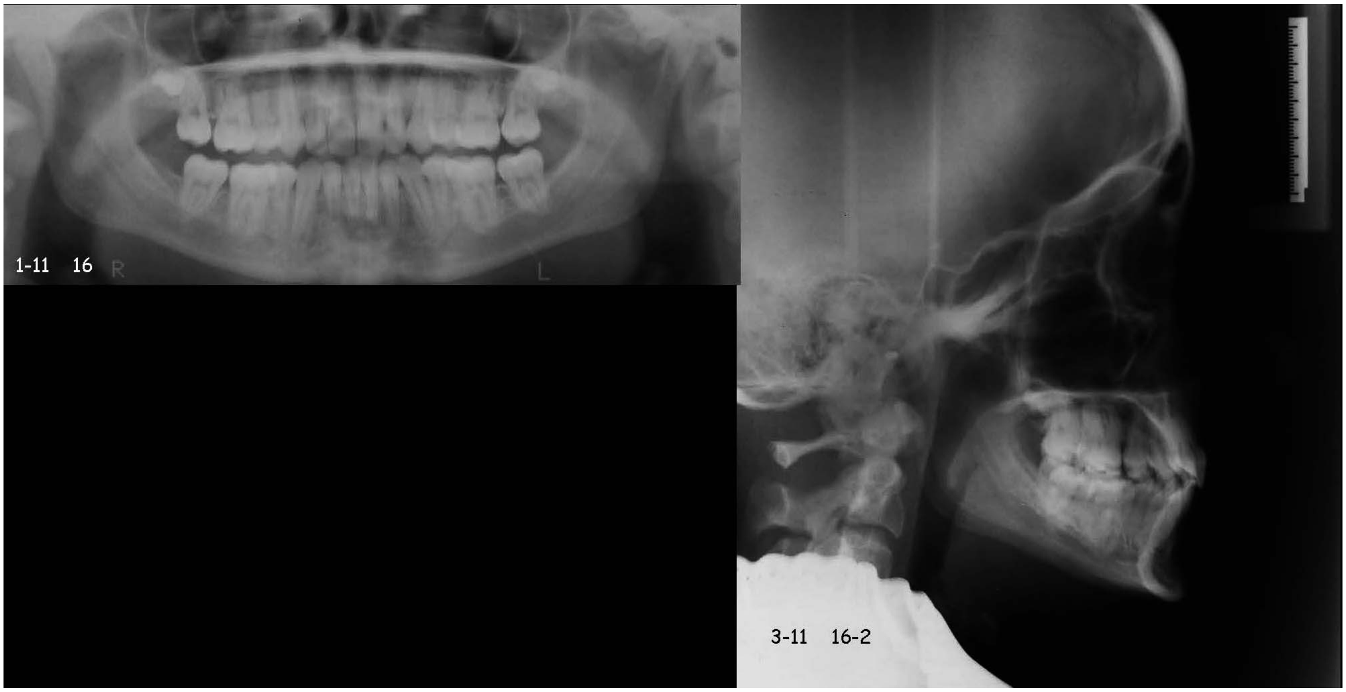

Figure 12. Posttreatment radiographs.

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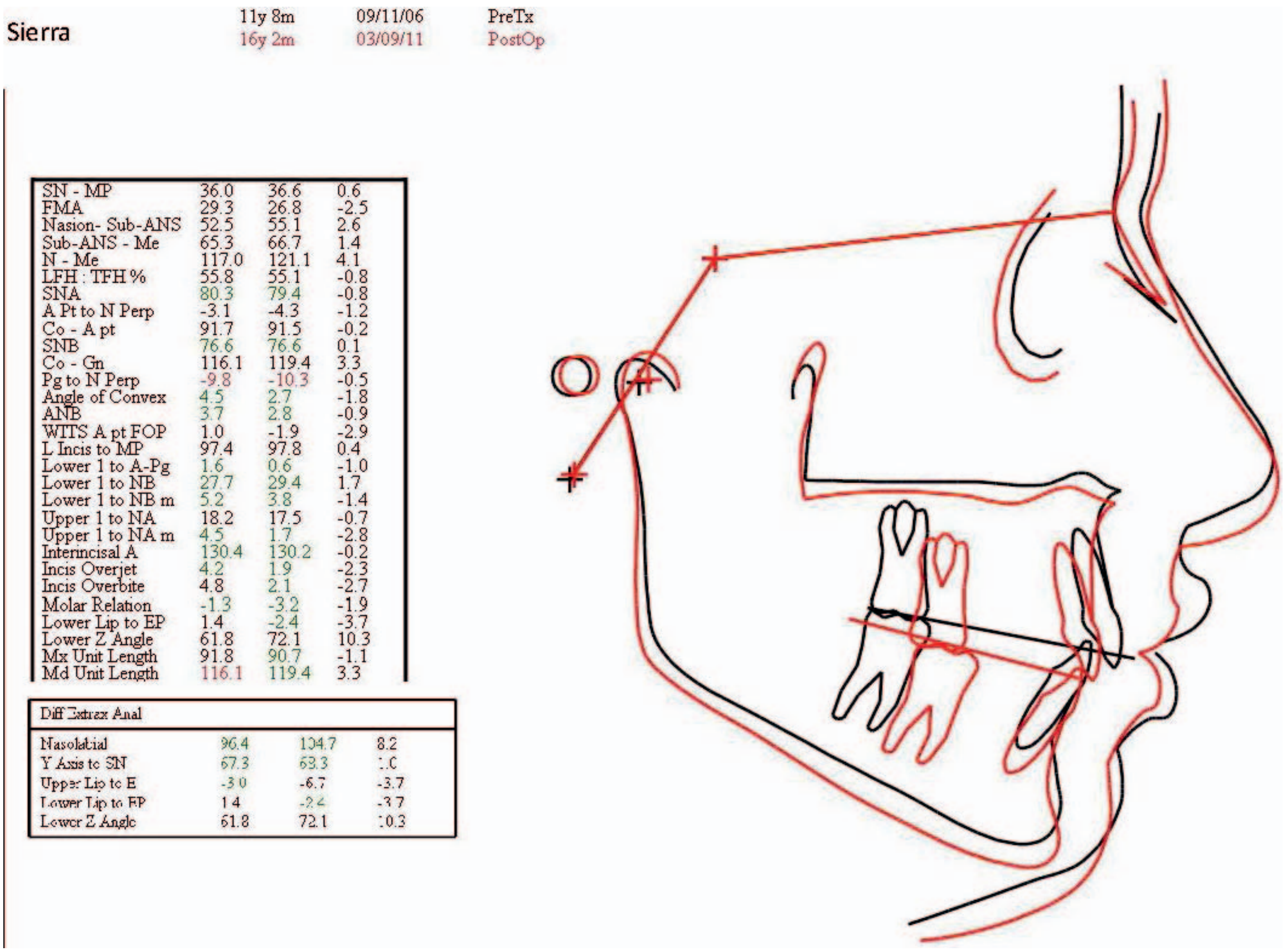


Figure 13. Cephalometric superimpositions.

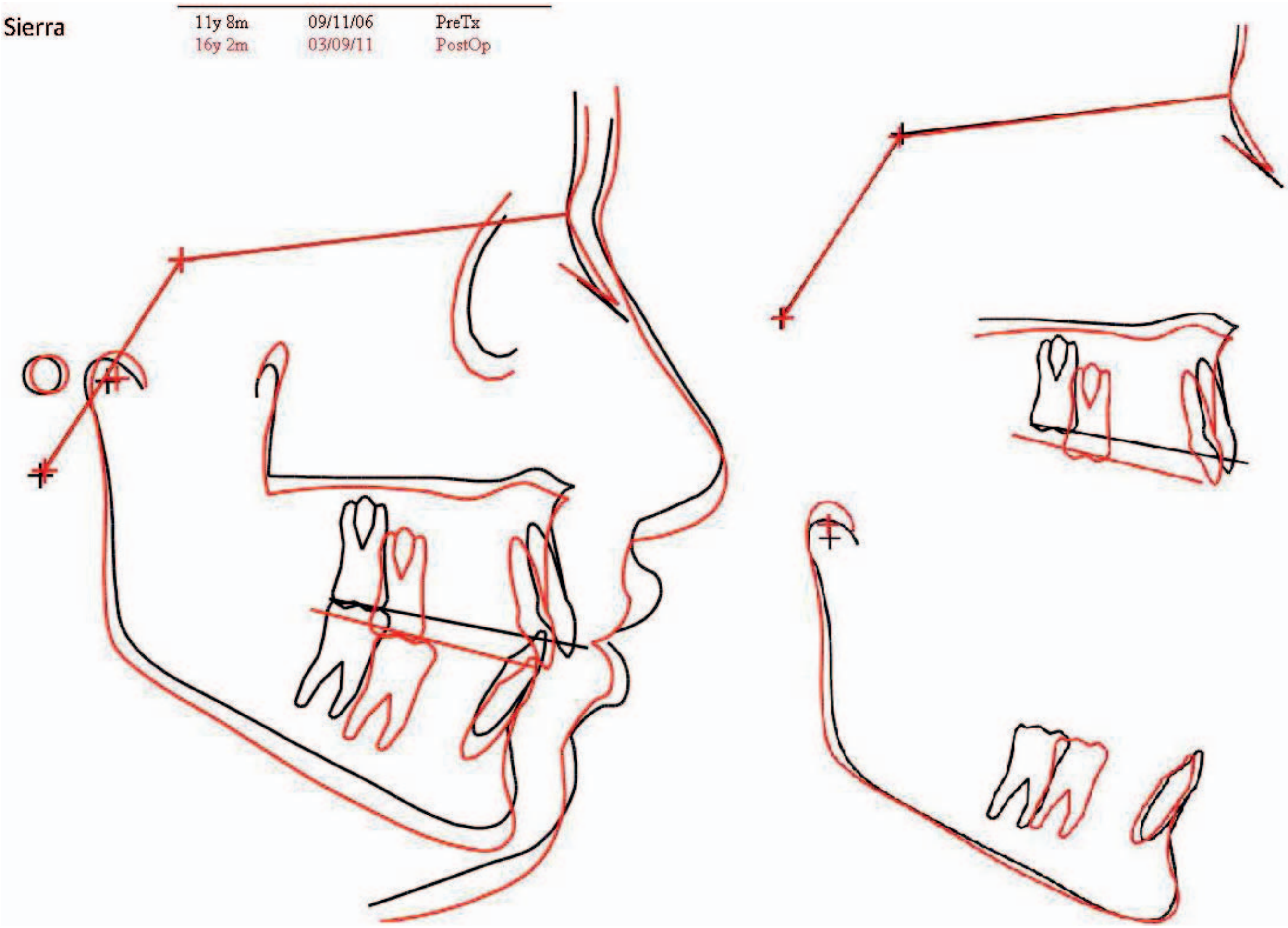
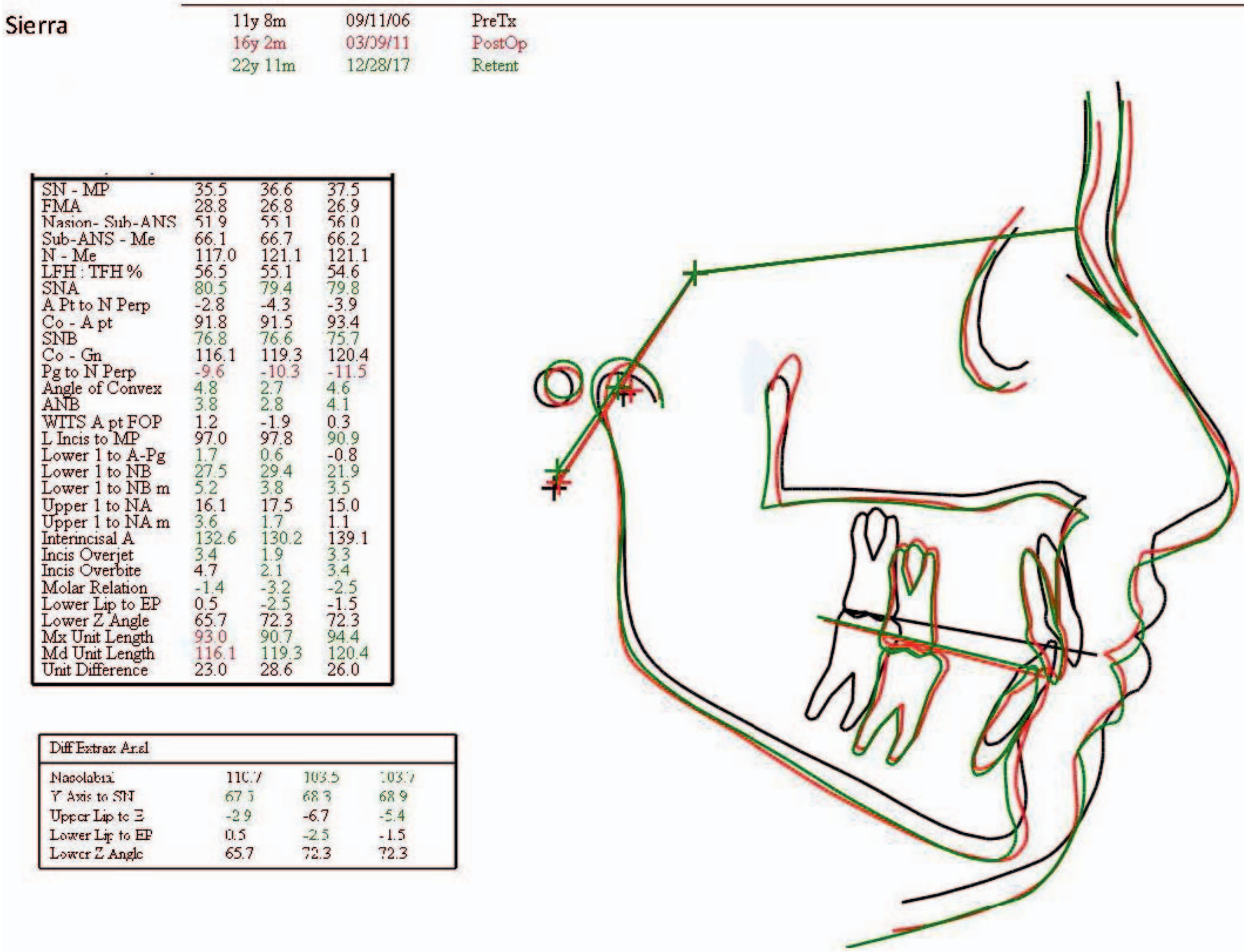


Figure 14. Sectional superimpositions.

Figure 15. Seven-year photos.

Figure 16. Seven-year radiographs.



SN - MP	35.5	36.6	37.5
FMA	28.8	26.8	26.9
Nasion- Sub-ANS	51.9	55.1	56.0
Sub-ANS - Me	66.1	66.7	66.2
N - Me	117.0	121.1	121.1
LFH : TFH %	56.5	55.1	54.6
SNA	80.5	79.4	79.8
A Pt to N Perp	-2.8	-4.3	-3.9
Co - A pt	91.8	91.5	93.4
SNB	76.8	76.6	75.7
Co - Gn	116.1	119.3	120.4
Pg to N Perp	-9.6	-10.3	-11.5
Angle of Convex	4.8	2.7	4.6
ANB	3.8	2.8	4.1
WITS A pt FOP	1.2	-1.9	0.3
L Incis to MP	97.0	97.8	90.9
Lower 1 to A-Pg	1.7	0.6	-0.8
Lower 1 to NB	27.5	29.4	21.9
Lower 1 to NB m	5.2	3.8	3.5
Upper 1 to NA	16.1	17.5	15.0
Upper 1 to NA m	3.6	1.7	1.1
Interincisal A	132.6	130.2	139.1
Incis Overjet	3.4	1.9	3.3
Incis Overbite	4.7	2.1	3.4
Molar Relation	-1.4	-3.2	-2.5
Lower Lip to EP	0.5	-2.5	-1.5
Lower Z Angle	65.7	72.3	72.3
Mx Unit Length	93.0	90.7	94.4
Md Unit Length	116.1	119.3	120.4
Unit Difference	23.0	28.6	26.0

Diff Extrax Anal			
Nasolabial	110.7	103.5	103.7
Y Axis to SN	67.5	68.3	68.9
Upper Lip to E	-2.9	-6.7	-5.4
Lower Lip to EP	0.5	-2.5	-1.5
Lower Z Angle	65.7	72.3	72.3

Figure 17. Total superimposition.