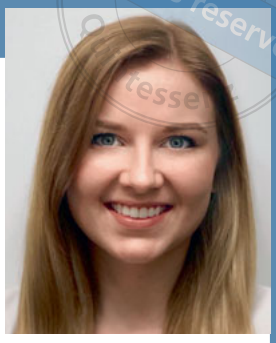

Lindsay Robertson

Lindsay Robertson, David Lee, Hazem Eimar, Tarek El-Bialy

Treatment of a challenging Class III malocclusion case using Invisalign clear aligners and micro-osteoperforation: a case report

Key words *chin deviation, Class III skeletal, clear aligners, functional shift, malocclusion, micro-osteoperforation*

Class III malocclusion cases can be some of the most difficult cases to treat, especially in non-growing patients. Many patients prefer to avoid surgical treatment if possible, and are interested in more conservative treatment options if available. In this case report, a Class III malocclusion was treated using the Invisalign appliance in combination with auxiliary devices as well as micro-osteoperforation to facilitate first molar space closure. The challenges of this Class III case include skeletal mandibular unilateral prognathism, missing mandibular left first molar, chin deviation, as well as lateral functional shift. Detailed diagnosis including cone beam computed tomography and clinical examination, as well as alternative treatments, are discussed. The results showed improvement in the patient's profile and occlusion as well as closure of the space of the mandibular left first molar. Limitations and criticism of the treatment outcome are also discussed.

Lindsay Robertson, BSc, DMD
Third year orthodontic graduate student, University of Alberta, Edmonton, Canada

David Lee, DDS, MSc
Former Orthodontic graduate student, University of Alberta, Edmonton, Canada

Hazem Eimar, DDS, MSc
Former Orthodontic graduate student, University of Alberta, Edmonton, Canada

Tarek El-Bialy, PhD, FRCD(C), EMBA, ABO, Dr. Med. Dent.
Professor of Orthodontics and Biomedical Engineering, University of Alberta, Edmonton, Canada

Correspondence to: Professor Tarek El-Bialy, 7-020D Katz Group Centre for Pharmacy and Health Research, University of Alberta, Edmonton, Alberta T6G 2E1, Canada. Email: telbialy@ualberta.ca

Introduction

Clear aligners may now be an additional treatment modality to consider when treating malocclusions nonsurgically. The Invisalign system has had continual developments, such as improvements in attachment design, addition of power ridges[1] and development of virtual bite ramps[2]. As the Invisalign system and other clear aligner systems continue to improve, they can be considered as treatment options for a wider range of malocclusions. It is also possible to use auxiliary appliances in combination with clear aligner systems to achieve the desired treatment results.

Clear aligners can provide a viable treatment option in treating Class III malocclusion cases. Clear aligner therapy may be more accepted by patients, particularly adult patients, due to the enhanced aesthetics[3] and improved oral hygiene[4] throughout treatment. A thorough diagnosis and understanding of the clear aligner system and auxiliary devices can ensure that a predictable treatment outcome can be achieved. Class III malocclusion cases can be among the most challenging cases to treat orthodontically. In certain cases, orthognathic surgery in combination with orthodontic treatment is the optimal treatment plan for these patients. In other Class III cases, a dental camouflage approach may be utilised to improve the dental malocclusion on an underlying Class III skeletal pattern. The decision between orthodontic camouflage and combined orthodontic-orthognathic treatment for Class III malocclusions can be a

Fig 1a to h Initial clinical photographs with patient biting in centric occlusion showing concave profile and deviated chin to the patient's right side as well as anterior crossbite with mandibular midline shift to the patient's right side 5 mm. The mandibular left first molar extraction space is preserved partially using a band and loop space maintainer.

difficult or challenging decision for clinicians[4-7]. The decisions involved in treatment planning these cases involve a comprehensive diagnosis, and thorough discussions with the patient about their goals and treatment preferences as well as risks and benefits of each treatment modality.

Alikhani et al[8] introduced the micro-osteoperforation technique in 2013 to accelerate tooth movement by inducing local micro-fractures in the alveolar bone and thus increasing blood flow to the area and subsequently increase bone remodelling. Since then, a few other reports presented the technique efficacy, as well as its effect on root resorption of the involved teeth[9-12]. This case report describes a Class III malocclusion of a late adolescent female patient who was treated using Invisalign in combination with selected auxiliary devices.

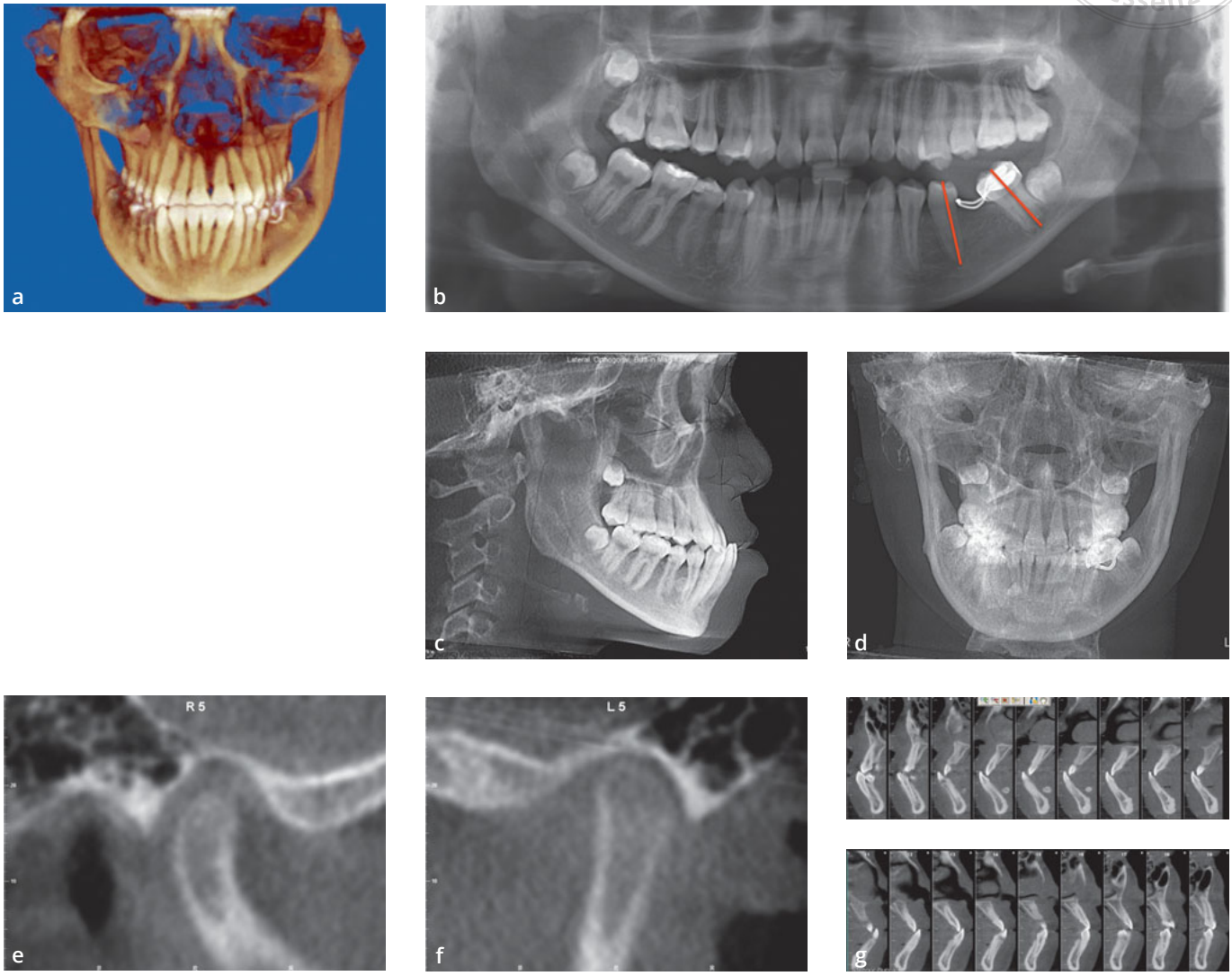

Fig 2a to g Initial cone beam computed tomography (CBCT) imaging. **(a)** Initial CBCT confirms chin deviation of the patient to the right side. **(b)** Initial CBCT driven panoramic radiograph showing midline deviation and space of extracted mandibular left first molar. **(c)** Initial CBCT driven lateral cephalometric radiograph showing concave profile and prominent chin. **(d)** Initial CBCT driven frontal cephalometric radiograph showing chin deviation to patient's right side. **(e and f)** Right and left temporomandibular joint (TMJ) imaging before treatment. **(g)** Initial CBCT driven labiolingual-sagittal screen of the anterior teeth showing the narrow alveolar bone widths and anterior crossbite.

Case presentation

Diagnosis

A 16 year and 2 months old female patient presented as seen in Figure 1. She was a nongrower as per physical and maturity, and she had no change reported on her bite or jaw position over the last year before starting treatment. She presented with a Class III skeletal and dental malocclusion with a prognathic mandible and skeletal asymmetry to the right side (Tables 1 and 2). The clinical diagnostic findings included a concave facial profile, maxillary skeletal deficiency and mandibular skeletal prognathism, chin deviation 5 mm to the right side, decreased maxillary incisor display on smiling, anterior crossbite, previously extracted mandibular left first molar with band and loop space maintainer, mandibular dental midline deviated to the right side, and an anterior functional shift. Incidental findings included a sialolith on the floor of the mouth on the right side which

Fig 3a to j Clinical initial photographs and radiographs. **(a to h)** Clinical initial photographs at the initial teeth contact. **(i)** Lateral cephalometric radiograph in initial contact. **(j)** Initial CBCT-driven cephalometric with visualised treatment objective surgical prediction of maxillary advancement and mandibular set back.

Table 1 Lateral cephalometric analyses before and after treatment

Measurement	Norm	Before	After
SNA (degrees)	82.0	88.1	88.4
SNB (degrees)	80.9	89.2	89.1
SN.GoGn (degrees)	32.9	30.4	35.0
FMA (MP-FH) (degrees)	23.9	24.5	27.1
ANB (degrees)	1.6	–1.1	–0.7
U1–NA (mm)	4.3	5.8	5.4
U1–SN (degrees)	102.8	117.5	110.9
L1–NB (mm)	4.0	9.1	2.7
L1–GoGn (degrees)	93.0	83.6	80.9
Lower lip to E-plane (mm)	-2.0	7.1	3.9
Upper lip to E-plane (mm)	-6.0	–0.1	1.2
Lower face height (ANS-Me) (mm)	65.0	57.8	59.5
Wits appraisal (mm)	–1.0	–6.9	–6.5

SN.GoGn, sella-nasion to gonion-gnathion angle; FMA (MP-FH), Frankfort to mandibular plane angle (mandibular plane to Frankfort horizontal); ANS, anterior nasal spine; Me, menton

Table 2 Frontal cephalometric analyses before and after treatment

Measurement	Norm	Before	After
Molar relation, left (mm)	1.5	4.2	1.8
Molar relation, right (mm)	1.5	–1.1	4.3
Intermolar width, mandibular (mm)	54.5	61.2	52.5
Intercanine width, mandibular (mm)	27.5	33.0	28.0
Denture midline discrepancy (mm)	0.0	3.8	0.0
Frontal convexity, left (mm)	10.0	12.1	10.5
Frontal convexity, right (mm)	10.0	8.9	12.0
Maxillo-mandible midline (mm)	0.0	–12.6	–7.8
Occlusal plane tilt (degrees)	0.0	–13.3	2.2
Molar to jaw, left (mm)	11.1	12.3	10.0
Molar to jaw, right (mm)	11.1	12.9	13.8
Denture to jaw midline (mm)	0.0	–0.6	1.7
Postural symmetry (degrees)	0.0	–13.5	4.8
Maxillary width (mm)	61.9	71.4	64.6
Mandibular width (mm)	76.2	93.6	83.3

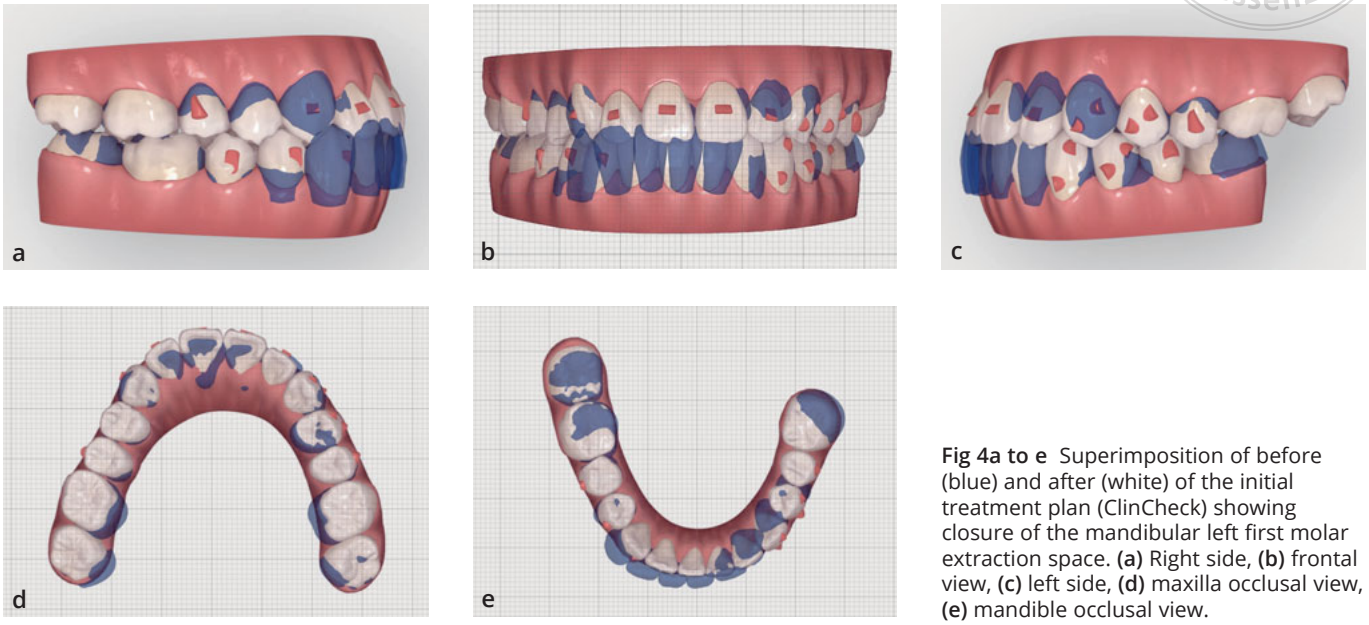

Fig 4a to e Superimposition of before (blue) and after (white) of the initial treatment plan (ClinCheck) showing closure of the mandibular left first molar extraction space. **(a)** Right side, **(b)** frontal view, **(c)** left side, **(d)** maxilla occlusal view, **(e)** mandible occlusal view.

was confirmed by a radiology report. Cone beam computed tomography (CBCT) imaging, initial panoramic radiograph, and temporomandibular joint imaging from the CBCT confirmed mandibular skeletal prognathism and skeletal mandibular asymmetry to the right side (Fig 2).

An anterior functional shift was noted clinically, therefore additional records were taken in the initial contact position (Fig 3). In this position there was an improvement in facial profile, anterior edge to edge dental relationship, lateral posterior open bites, and deviation of mandibular dental and skeletal midline to the right side. Figures 3i and 3j compare the lateral cephalometric radiographs in centric relation and centric occlusion.

A surgical treatment plan was completed (Fig 3c) and presented to the patient; however, the patient declined surgery and was not concerned about the mandibular skeletal asymmetry to the right side. Therefore, a dental compensation treatment plan with Invisalign was planned and accepted by the patient. This treatment plan would improve the dental relationships while maintaining the underlying Class III asymmetric skeletal pattern. Invisalign was presented as a viable treatment option because in the centric relation initial contact position, the patient could achieve an edge to edge anterior dental relationship with improvement in the facial profile.

Treatment objectives

Treatment objectives included accepting the prognathic mandible and mandibular deviation to the right side, improvement in the facial profile, improved incisor display on smiling, correction of the anterior crossbite, space closure in the area of the missing mandibular left first molar, substitution of the mandibular left second molar for the mandibular left first molar, improvement in the mandibular dental midline, and elimination of the functional shift.

Treatment plan

The initial ClinCheck included distalisation of the mandibular left buccal segment to correct the anterior crossbite, improve the mandibular midline, and close the mandibular left first molar space by sequentially distalising the mandibular left premolars, canines, and incisors to the left side. Extrusion of the maxillary anterior teeth was planned to increase the incisal display on smiling, and the posterior open bites were closed by extrusion of the posterior teeth. Precision cuts were placed for Class III elastics, optimised attachments were used, and interproximal reduction was planned as needed. Figure 4 presents the superimposition of the patient's digital treatment plan (ClinCheck) of the teeth positions before (blue) and after (white) treatment, showing closure of the mandibular left first molar extraction space with distal movement of mandibular left pre-

Fig 5a to h Progress clinical photographs after 10 months in treatment.

molars, canine, and incisors. In addition, maxillary arch expansion was planned to be coordinated with the mandibular arch after mandibular left premolars and canine distalisation (Fig 4d). Moreover, maxillary incisors inclination was planned to help with anterior crossbite correction. Because maxillary incisors were initially proclined (U1–SN angle was 117.5 degrees), maxillary incisors extrusion was planned to help possible open bite creation due to mandibular posterior distalisation and maxillary molars extrusion, as well as to correct maxillary incisors angulation to SN. It was hypothesised that extrusion of the maxillary incisors using labial attachments with the line of action of the extrusion force passing labial to the centre of resistance of the maxillary incisors, would rotate the maxillary incisors lingually, thus, correcting their axial inclination to SN.

Treatment progress

After 10 months of treatment, positive overbite and overjet was achieved with improvement of the dental midlines and sequential distalisation of the left buccal segment was in progress (Fig 5). At month 11, two segmental brackets were placed on the mandibular left second premolar and mandibular left second molar to assist with uprighting the roots

Fig 6a to e Intraoral progress photographs after 14 months in treatment showing partial fixed appliance in the mandibular left quadrant and the micro-osteoperforation performed.

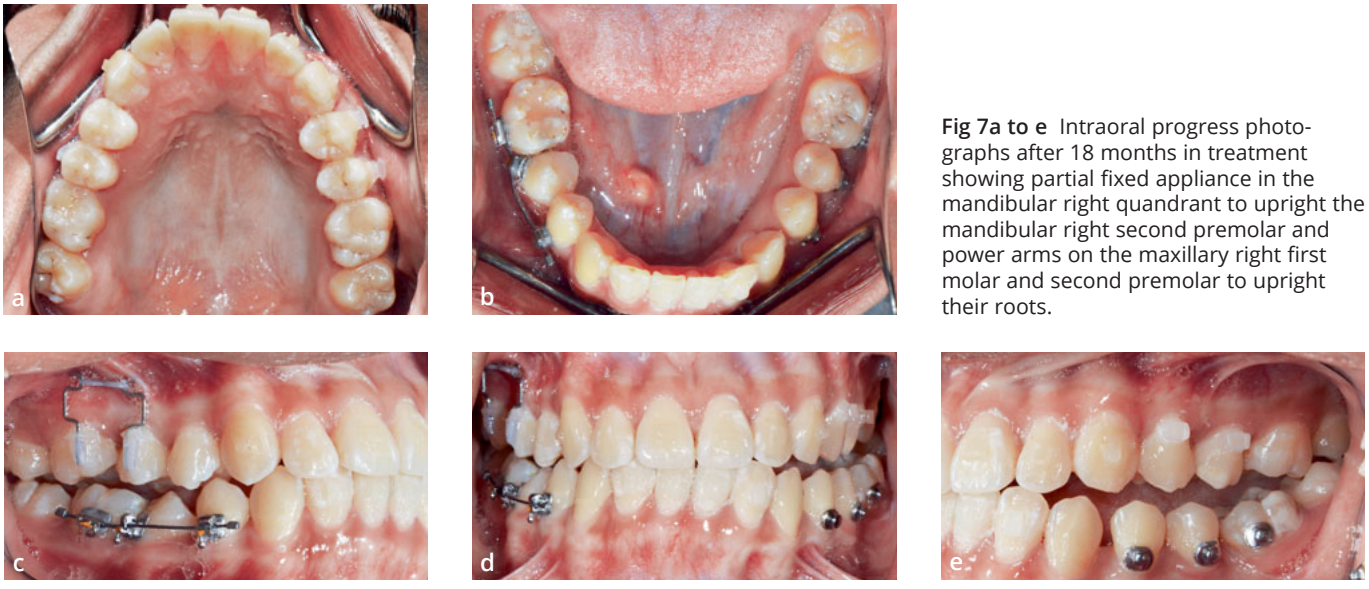

Fig 7a to e Intraoral progress photographs after 18 months in treatment showing partial fixed appliance in the mandibular right quandrant to upright the mandibular right second premolar and power arms on the maxillary right first molar and second premolar to upright their roots.

of these teeth (Fig 6). To accelerate tooth movement, the Propel System was used at month 14 and month 15 in the mandibular anterior and posterior segments. During month 17, the segmental brackets were removed on the mandibular left side and replaced with buttons for elastics to assist with closing the posterior open bite. At month 18, segmental brackets were placed on the mandibular right first premolar, second premolar, and first molar to assist with the severe rotation of the mandibular right second premolar (Fig 6). At this time, power arms were placed on the maxillary right first molar and second premolar to assist with paralleling the root of these teeth (Fig 7).

Final result

The treatment was completed after 46 months. The final result after 7 months of retention is displayed in Fig 8 and 9. The treatment objectives that were outlined were achieved. An additional refinement scan was proposed for uprighting the mandibular incisors and further settling the posterior occlusion on the right side; however, the patient declined this be-

Fig 8a to h Final clinical photographs after completion of treatment.

cause she was already very happy with the result. The temporomandibular joint (TMJ) imaging in Fig 9f shows an improvement in the position of the right condyle, likely due to eliminating the functional shift. The lateral cephalometric analysis and superimposition of before and after treatment (Fig 10) shows a downward and backward rotation of the mandible. According to Peck et al[13], anterior cephalometric tracings superimpositions show improvement in the patient facial asymmetry and midline corrections (Table 2 and Fig 11). Figure 12 shows clinical photographs of the patients at 10 months in retention showing settling of the posterior teeth.

The number of aligners used to treat this patient included the following:

- first ClinCheck (maxillary 25 aligners and mandibular 63 aligners)
- second ClinCheck (first refinement included 34 additional aligners for both maxillary and mandibular arches)
- third ClinCheck (second refinement included additional 24 aligners for both maxillary and mandibular arches)
- final refinement included additional 22 aligners for both maxillary and mandibular arches.

In total, 105 maxillary and 143 mandibular aligners were used.

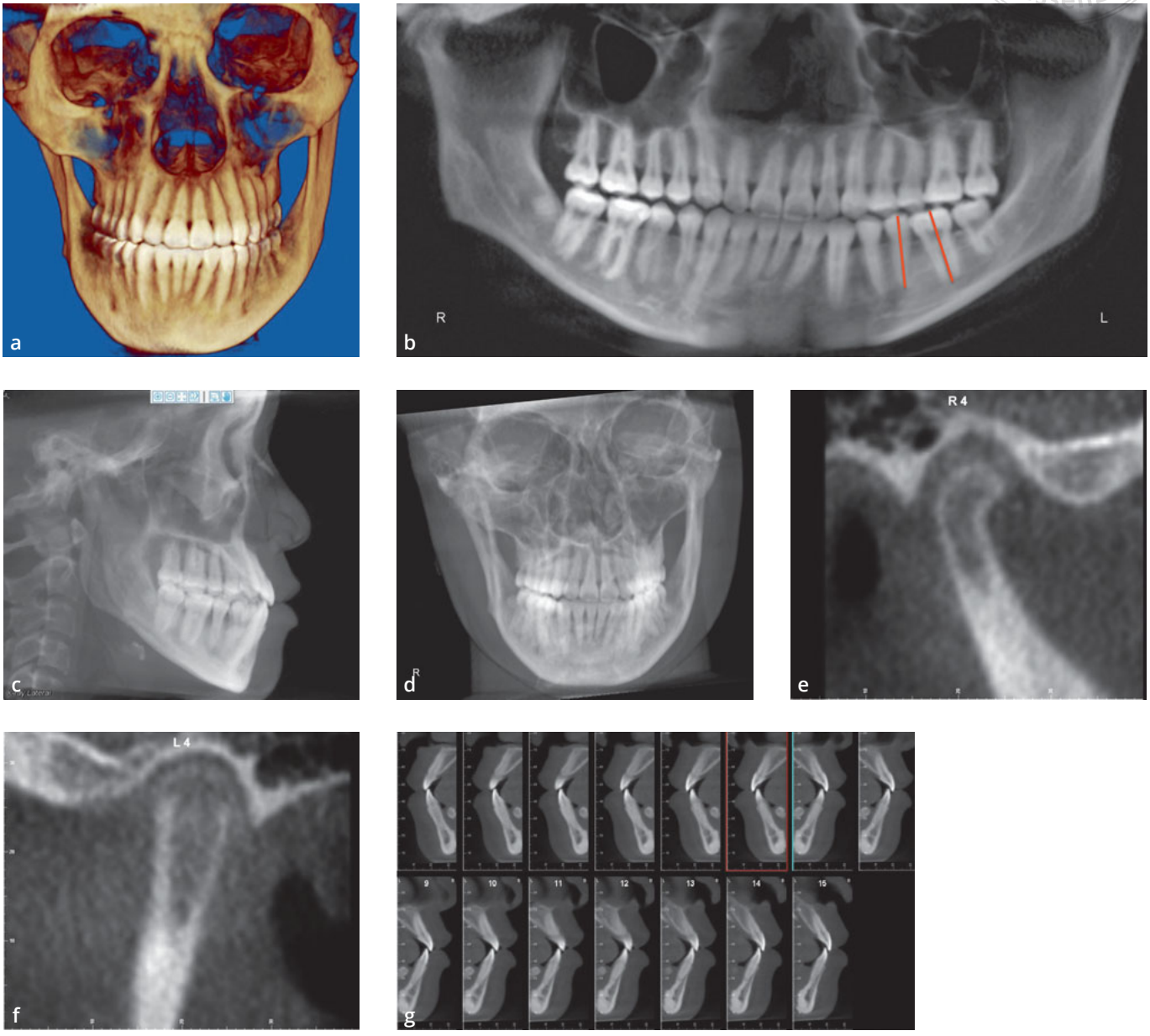

Fig 9a to g Final cone beam computed tomography (CBCT) imaging. **(a)** CBCT driven frontal image. **(b)** CBCT driven panoramic radiograph showing parallelism of the roots of the mandibular left second premolar and mandibular second molar, **(c)** CBCT driven lateral cephalometric projection, **(d)** CBCT driven frontal cephalometric projection, **(e and f)** Right and left CBCT driven temporomandibular joint imaging after treatment showing more uprighting of the right condyle than before treatment, **(g)** CBCT driven labiolingual-sagittal screen of the anterior teeth showing uprighting of mandibular incisors and correction of the anterior crossbite.

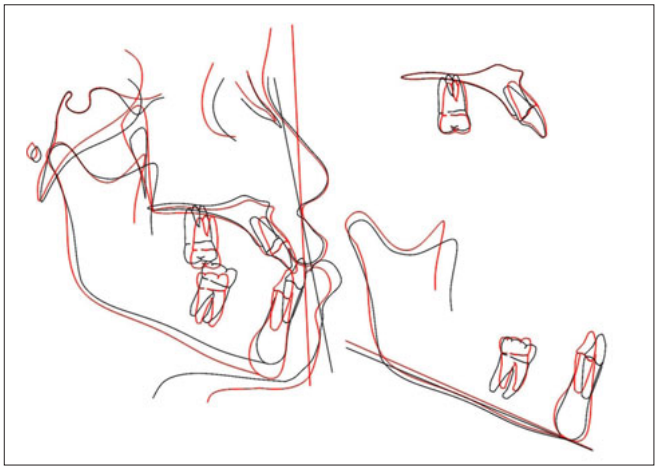

Fig 10 Superimposition of the tracings of the before and after treatment lateral cephalometric radiographs.

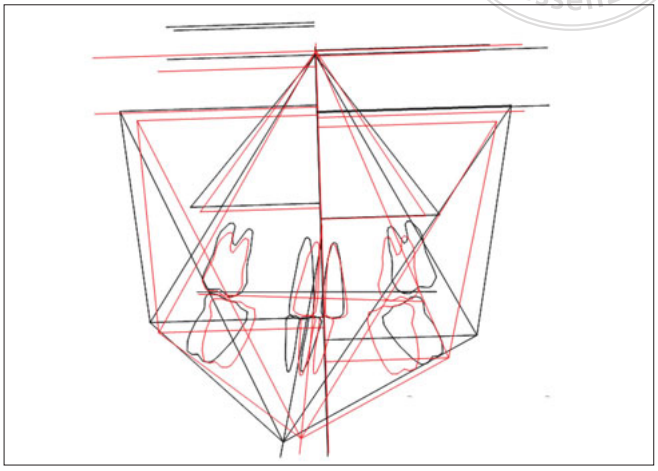

Fig 11 Superimposition of the tracings of the before and after treatment frontal cephalometric radiographs using Peck and Peck technique.

Fig 12a to h Clinical photographs of the patients after 10 months in retention showing settling of the posterior teeth.

Discussion

This case is an example of how clear aligners can be used with auxiliary appliances for nonsurgical treatment of a complex Class III case. In this case, a main factor in the treatment planning was the diagnosis of a functional shift. Invisalign was an effective tool in this case because it allowed the planning of specific tooth movements and the ClinCheck to predict the treatment outcome. For challenging tooth movements such as severe rotations and root uprighting, options such as using a Propel, segmental brackets, and power arms can be useful.

This treatment had a long duration due to the complexity of the case; however, functional occlusion was achieved for the patient without surgery. Although surgical treatment is the ideal treatment plan for certain patients with severe malocclusions, it is a large undertaking for patients[14] and presents with inherent, although infrequent, risks[15,16]. Perhaps there is a certain range of malocclusions that could be treated with combined orthodontic-orthognathic surgery[17-19], or with a more conservative orthodontic camouflage approach[20-23]. It is important to have a comprehensive discussion with the patient to understand their specific treatment goals and expectations.

Conclusions

This challenging skeletal Class III case improved significantly and in particular the patient's profile, anterior crossbite, closure of extraction space of mandibular left first molar and midline deviation without further extraction of teeth or surgical intervention. Patient chin deviation was improved due to correction of functional shift. The patient's final face showed slight chin deviation, which was acceptable by the patient and parents. Clear aligners can be a viable treatment option for appropriately selected Class III malocclusion cases. A comprehensive clinical diagnosis of the patient, thorough understanding of the Invisalign system and auxiliary appliances, and clearly defined treatment goals are important steps in the treatment process.

Acknowledgements

This case was selected and acknowledged to be the best Class III case among North American Universities cases at the Invisalign Ortho Summit, Las Vegas, 2018.

Declaration

The authors confirm there are no conflicts of interest related to this case. There was no financial support in treatment or publication of this manuscript.

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