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Class III malocclusion with traumatic unilateral maxillary central incisor loss treated using orthodontic miniscrews: a case report

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The present article reports the successful non-extraction orthodontic treatment using miniscrew anchorage in a patient who presented with maxillary left central incisor loss and unstable jaw movements. The chief complaints of the 23-year-old female patient were her protruding teeth and crowding of the mandibular anterior segment. The patient lost her maxillary left central incisor as a result of a traumatic injury during childhood. However, the crown was saved and attached to the adjacent teeth. The patient was diagnosed with a skeletal Class III and Angle Class III dental malocclusion. The jaw movements determined by a 6 degrees of freedom jaw movement recording system were unstable and irregular. Miniscrew anchorage was applied for distalisation of the maxillary right dentition and the mandibular dentition during non-extraction treatment. The maxillary left dentition was mesialised using miniscrew anchorage to close the space as a result of the lost maxillary left central incisor. After an active treatment duration of 36 months, the patient achieved a Class II molar relationship on the left side, a Class I on the right side, an optimal overjet and overbite, and a pleasing facial profile. Despite the asymmetric molar relationships, functionally stable and smooth jaw movements were established. The skeletal, occlusal and functional stability remained satisfactory after a 2-year retention period. In conclusion, miniscrew anchorage was valuable in supporting asymmetric tooth movement during non-extraction appliance treatment in a patient who presented with traumatic unilateral tooth loss.
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Introduction

Dental trauma is more likely during the active period of childhood, and the most common trauma site is the maxillary anterior teeth.[1] If the traumatised tooth has a poor prognosis and cannot be preserved, autologous tooth transplantation, bridges, dentures, dental implants, or orthodontic tooth movement can be used to manage the defect. Orthodontic tooth movement for space closure has been associated with a good long-term prognosis.[2,3]

However, the mechanics of orthodontic treatment with asymmetric space closure are extremely complicated and may lead to deviated upper and lower dental midlines and canting of the occlusal plane.[4,5] The use of miniscrews provides effective anchorage for orthodontic treatment,[5–9] and enables asymmetric tooth movements as well as aesthetic, morphological and functional improvements.[10]

In the following case and because of the traumatic loss of the maxillary left central incisor, asymmetric space

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Figure 1. Pretreatment facial and intraoral photographs.

closure was performed using miniscrew anchorage. An aesthetically and morphologically sound occlusal relationship can be achieved despite the asymmetric mechanics. Furthermore, functionally stable and unhindered jaw movements can be obtained despite the asymmetric relationship of the molars.

Diagnosis and etiology

A female, aged 23 years and 1 month, presented to the outpatient clinic of Tohoku University Hospital, Japan, with chief complaints of protruding teeth and crowding of the mandibular anterior segment. At 12 years of age, the patient fell and suffered trauma to the maxillary incisors. Her maxillary left central incisor was avulsed and could not be saved. Extraoral photographs showed facial symmetry and a straight profile (Fig. 1). Intraoral photographs and a dental cast analysis revealed Angle Class III molar relationships on both sides, and a 3.8 mm overjet and a 1.3 mm overbite. Mild crowding was present involving the maxillary and mandibular incisors. Arch length discrepancies of –1.0 mm and –2.0 mm were measured in the maxilla and mandible, respectively (Figs. 1 and 2). The crown of the maxillary left central incisor was attached to the adjacent teeth, and the maxillary left lateral incisor margin revealed a fracture (Figs. 1 and 2). A panoramic radiograph identified maxillary and mandibular third molars on both sides. The maxillary left central incisor was absent and the maxillary left lateral incisor was non-vital (Fig. 3). In comparison with Japanese norms,[11] a lateral cephalometric analysis showed a skeletal Class III skeletal relationship, an ANB angle of –2.3°, a low mandibular plane angle (MP-SN) of 26.9° and a normal gonial angle of 117.5° (Fig. 3, Table I). A long mandibular ramus height (Ar-Go) of 54.6 mm and a long mandibular body length (Go-Me) of 77.0 mm were noted (Fig. 3, Table I). The maxillary right central incisor was significantly inclined labially (U1-SN: 125.1°), but the mandibular central incisors were normally inclined (L1-Mp: 92.5°) (Fig. 3, Table I). The upper and lower lips protruded with respect to the E-line (E-line to upper lip: 0.5 mm; E-line to lower lip: 3.3 mm). A posteroanterior cephalometric analysis revealed that the upper dental midline coincided with the facial midline, but the lower dental midline had shifted to the left by 1.5 mm

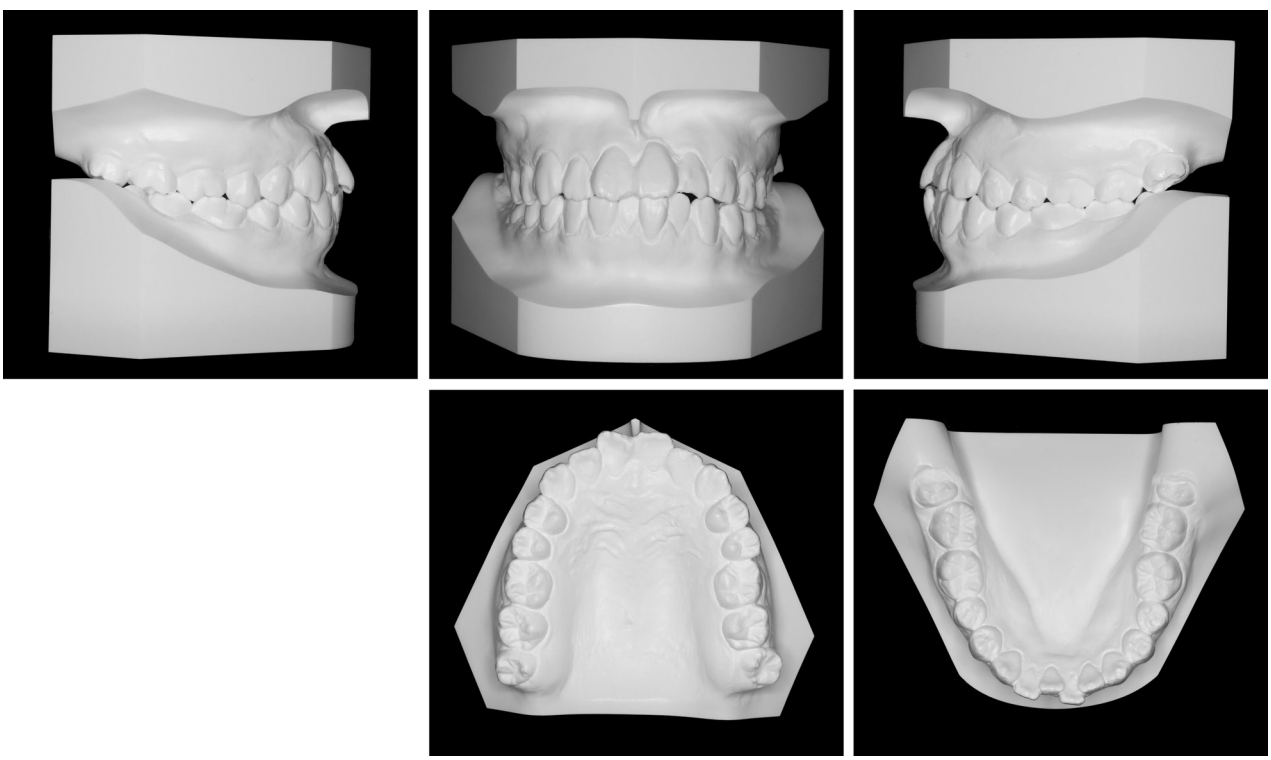


Figure 2. Pretreatment dental casts.

(Fig. 3). No occlusal cant was observed (Fig. 3). There were no clicking sounds in either temporomandibular joint (TMJ) during maximum mouth opening and closing. Magnetic resonance imaging (MRI) of the TMJ showed neither displacement nor deformation of either disc during maximum opening and closing. A 6 degrees of freedom jaw movement recording system (GNATHO-HEXAGRAPH III, GC Corp., Tokyo, Japan), consisting of a head frame, facebow, light-emitting diodes, charge-coupled device cameras, and a personal computer, was used to record jaw movements. The patient was seated in an upright but relaxed position with the head unsupported and naturally oriented.[12] A head frame and facebow, each with three light-emitting diodes, were secured to the head and the connector, respectively.[12] The connector was bonded to the labial surfaces of the lower incisors and bent to ensure uninhibited movement of the mandible and lip.[13] The points of the lower central incisors and condyles were recorded on both sides using a stylus containing two light-emitting diodes. The three-dimensional positions of porion and the infraorbital points on the skin were also recorded. The maximum mouth opening, closing, protrusive, and lateral jaw movements were recorded using the jaw-tracking system. In comparison with Japanese norms, the all-path lengths of the incisors and condyles during lateral jaw movements were reduced.[12] Moreover, the path lengths of the incisors and balancing side during lateral jaw movement were

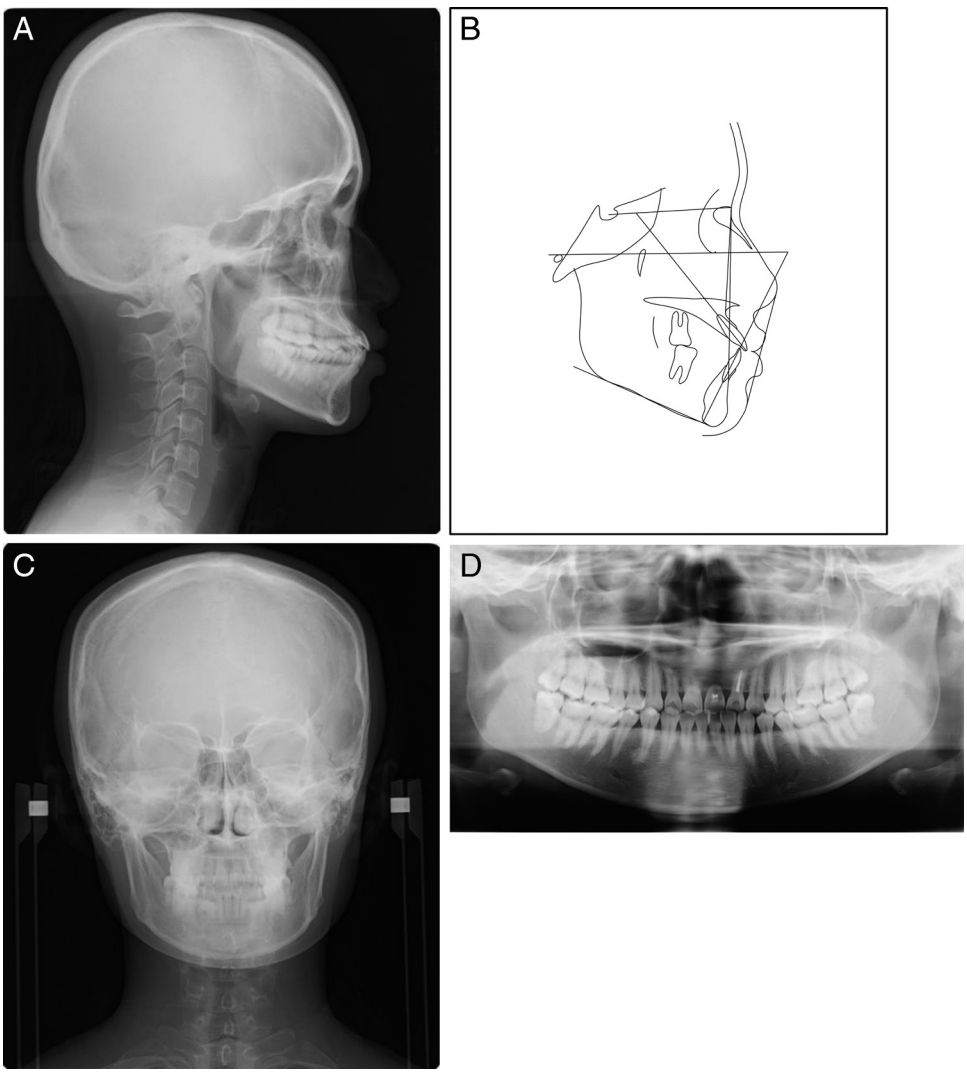


Figure 3. Pretreatment cephalograms, a tracing of lateral cephalogram and a panoramic radiograph. (A) Lateral cephalogram. (B) Tracing. (C) Posteroanterior cephalogram. (D) Panoramic radiograph.

Table I. Cephalometric summary.

	Japanese norm*	SD	Pretreatment	Posttreatment	Postretention
	(Adult female)		(23y1m)	(26y1m)	(28y6m)
Angular (°)					
SNA	80.8	3.61	83.2	83.2	83.3
SNB	77.9	4.54	85.5	85.6	85.7
ANB	2.8	2.44	-2.3	-2.4	-2.4
Mp-SN	37.1	4.64	26.9	25.8	25.5
Gonial A	122.1	5.29	117.5	117.8	117.6
U1-SN	105.9	8.79	125.1	123.1	121.4
L1-FH	56.0	8.09	63.4	71.7	69.9
L1-Mp	93.4	6.77	92.5	85.2	87.1
Inter incisal angle	123.6	10.64	115.6	126.0	126.0
Linear (mm)					
S-N	67.9	3.65	69.6	69.7	69.7
N-Me	125.8	5.04	124.7	123.2	122.9
Me/NF	68.6	3.71	69.4	67.6	67.5
Go-Me	71.4	4.14	77.0	77.2	77.1
Ar-Go	47.3	3.33	54.6	54.7	54.7
Ar-Me	106.6	5.74	117.1	117.4	117.4
U1/NF	31.0	2.34	25.3	23.5	24.4
U6/NF	24.6	2.00	24.4	24.3	24.4
L1/Mp	44.2	2.68	47.1	45.6	44.9
L6/Mp	32.9	2.50	36.1	33.4	33.4
Overjet	3.1	1.07	3.8	3.1	2.1
Overbite	3.3	1.89	1.3	1.7	1.9
E-line to Upper lip	-2.5	1.90	0.5	-1.0	-1.1
E-line to Lower lip	0.9	1.90	3.3	0.0	0.7

* Japanese norms and standard deviations from Wada et al [11].

shorter on the left side than the right side (Fig. 4, Table II).

Treatment objectives

The patient was diagnosed as having an Angle Class III dental malocclusion, a skeletal Class III jaw-base relationship, a low mandibular plane angle, and traumatic loss of the maxillary left central incisor.

The treatment objectives were to create optimal overbite and overjet relationships, obtain a Class II molar relationship on the left side and a Class I on the right side, close the space of the absent maxillary left central incisor, and improve the protrusion and crowding of mandibular anterior teeth. The use of miniscrews was planned to achieve these objectives by mesialising the maxillary left dentition and distalising the other three quadrants.

Treatment alternatives

Two alternative treatment options were considered to close the space of the lost maxillary left central incisor and improve the protrusion and crowding: orthodontic treatment using miniscrew anchorage following the extraction of the maxillary right first premolar and mandibular first premolars or non-extraction orthodontic treatment (except for the extraction of the third molars). The patient refused extraction of the first premolar teeth; therefore, the second option was selected.

Treatment progress

After the extraction of the upper right third molar and lower third molars, 0.018-inch preadjusted edgewise appliances were placed on the maxillary and mandibular arches. 0.014-inch nickel-titanium arch wires were inserted for levelling and alignment of the dentitions. Seven months after the start of treatment, miniscrews (AbsoAnchor; Dentos Inc., Taegu, Korea), 1.4 mm in diameter and 5.0 mm long, were placed in the buccal alveolar bone between the maxillary right second premolar and first molar, the mandibular second premolar and first molar on both sides, and the maxillary left canine and first premolar. 0.016 × 0.022-inch stainless steel wires were placed in the maxillary and mandibular dentitions. The mandibular dentition was distalised by sliding mechanics supported by the miniscrew anchorage (Fig. 5). Simultaneously, distalisation was performed from the maxillary right canine to the second molar. The maxillary left dentition was mesialised using the miniscrew anchorage to close the space of the lost central incisor. Finally, using elastic chain and closing-loop mechanics, the anterior teeth were retracted to close the space (Fig. 5). The attached crown of the maxillary left central incisor was continually modified and preserved in the space to improve the aesthetics. Subsequently, 0.017 × 0.025-inch stainless steel wires were inserted for detailing. The total active treatment duration was 36 months. After appliance removal, the maxillary and mandibular teeth were stabilised using a Begg-type retainer. An all-ceramic crown was placed on the maxillary left lateral incisor to represent a central incisor.

Treatment results

A harmonious facial profile was achieved due to the retracted upper and lower lips. The dental midlines were coincident with the facial midline (Fig. 6).

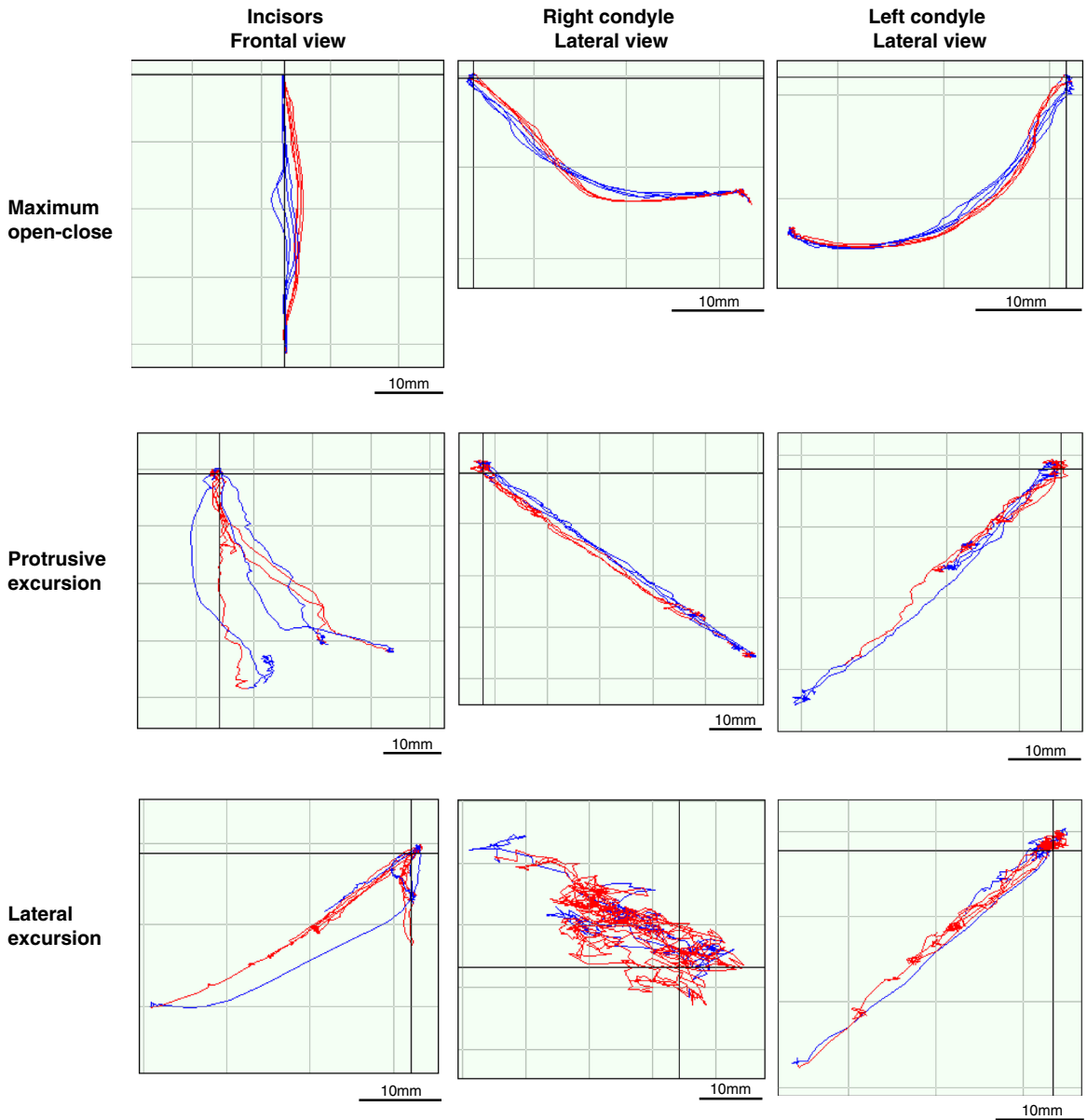


Figure 4. Pretreatment condylar movements and incisal paths as detected using a 6 degrees of freedom jaw movement recording system. Opening and closing, protrusive, and lateral jaw movements. The red line indicates the opening phase, and the blue line indicates the closing phase.

Table II. Maximum gap and displacement from the centric occlusion at each point.

	Japanese norm* (Adult female)	SD	Pretreatment (23y1m)	Posttreatment (26y1m)	Postretention (28y6m)
Maximum gap (mm)					
at right condyle	13.1	2.7	15.2	11.7	13.4
at left condyle	13.1	3.8	15.1	14.3	14.8
at lower incisor	44.8	6.4	55.2	54.0	46.0
Maximum displacement during protrusive excursive movement (mm)					
at right condyle	7.6	1.6	6.2	7.3	6.2
at left condyle	7.6	1.6	4.9	5.9	6.0
at lower incisor	7.2	1.5	5.4	6.3	5.8
Maximum displacement during right lateral excursive movement (mm)					
at left condyle	9.1	2.7	3.7	4.6	5.7
at lower incisor	8.3	2.1	3.7	3.0	4.9
Maximum displacement during left lateral excursive movement (mm)					
at right condyle	9.1	2.7	0.4	4.1	6.0
at lower incisor	8.3	2.1	1.0	2.9	4.7

* Japanese norms and standard deviations for the maximum gap based on Miyawaki et al.[12] Japanese norms and standard deviations for maximum displacement based on our unpublished findings.

Posttreatment intraoral photographs and dental casts illustrated the well-aligned arches and sound interdigitation of the teeth (Figs. 6 and 7). An adequate overjet and overbite were established. A Class II molar relationship was achieved on the left side and a Class I on the right side (Figs. 6 and 7). An all-ceramic crown with dimensions similar to the maxillary right central incisor was placed on the maxillary left lateral incisor to achieve a standard upper and lower tooth size ratio. A posttreatment panoramic radiograph showed acceptable root parallelism, without alveolar bone loss (Fig. 8). However, moderate apical root resorption was observed in the maxillary right central and lateral incisors. A posttreatment cephalometric evaluation with superimposed tracings demonstrated a counterclockwise rotation of the mandible. The maxillary right first molar was distalised by 2.0 mm and the maxillary left first molar was mesialised by 2.0 mm. The mandibular first molars were distalised by 5.0 mm and intruded by 1.0 mm. The upper incisors were intruded by 1.5 mm and retracted by 3.5 mm, and the lower incisors were lingually inclined by 7.3°, intruded by 1.0 mm, and retracted by 4.5 mm (Figs. 8 and 9, Table I). A superimposition of the dental casts before and after treatment was evaluated using a three-dimensional scanner (Geomagic Qualify 2013, Geomagic, NC, USA) (Fig. 10).[14–16] The tooth movements were similar to the movement of the upper and lower incisors and molars of the superimposed cephalometric tracings before and after treatment (Figs. 9 and 10). There were no symptoms of TMJ dysfunction and the articular disc of the TMJ revealed no changes on the posttreatment MRI. The incisal and condylar movements during lateral jaw movements were symmetric. However, the path lengths were shorter than the Japanese norm (Fig. 11, Table II).

After 2 years of retention, the occlusion and facial aesthetics of the patient remained stable. Postretention intraoral photographs and dental casts showed that the molar and canine relationships had been maintained, but there was slight relapse of the mandibular left central incisor (Figs. 12 and 13). A further cephalometric analysis demonstrated mild relapse of the maxillary and mandibular central incisors and the mandibular left first molar (Figs. 14 and 15, Table I). Stable and symmetric incisal and condylar movements were still present during maximum mouth opening and closing and protrusive and lateral jaw movements (Fig. 16, Table II). The patient was satisfied with the treatment results.



Figure 5. Intraoral photographs of the treatment progress. Retraction of the maxillary anterior teeth and distalization of the mandibular dentition.



Figure 6. Posttreatment facial and intraoral photographs.

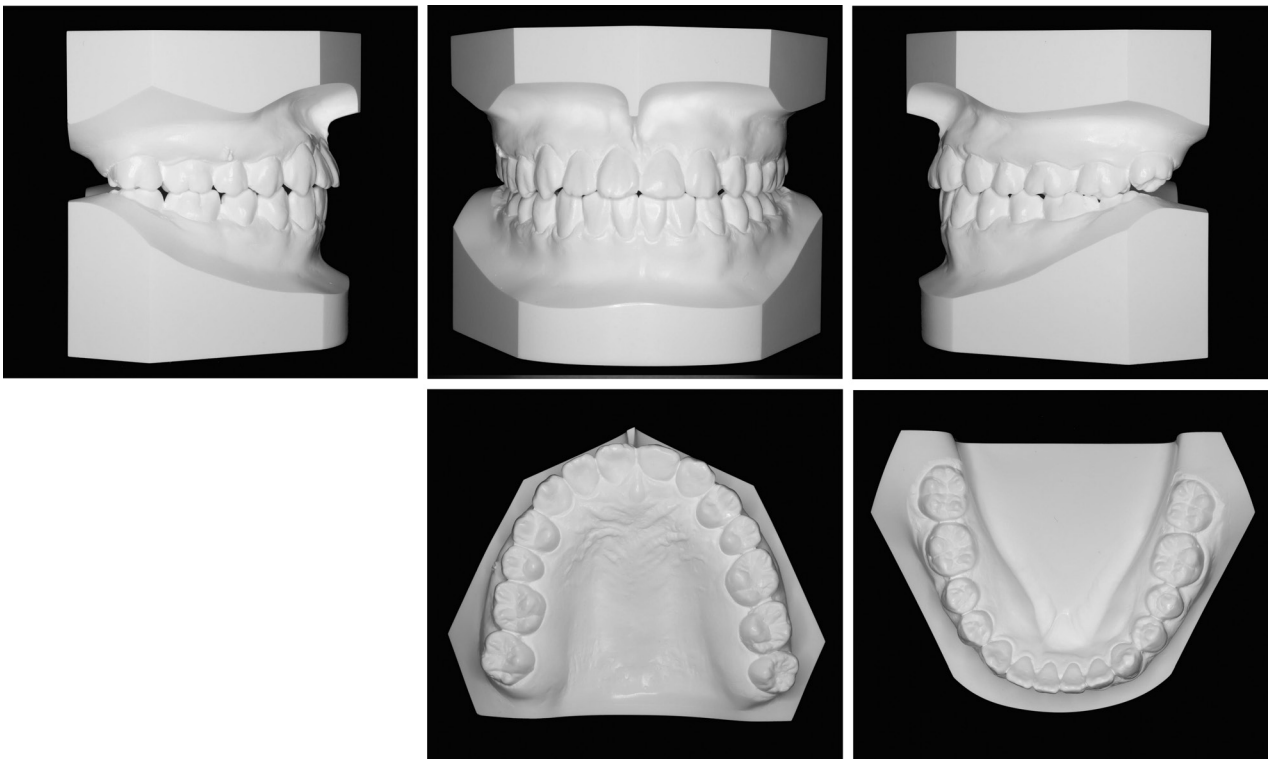


Figure 7. Posttreatment dental casts.

Discussion

Most traumatic dental injures occur during childhood and adolescence, especially in children with an overjet of greater than 3.0 mm and inadequate lip coverage.[1,17,18] The most commonly affected sites are the maxillary central incisors for both deciduous and the permanent teeth, and the most common injury type is subluxation of deciduous teeth and enamel/dentin fractures affecting the permanent teeth.[1] The correction of a malocclusion by orthodontic treatment in childhood and adolescence may reduce the risk of trauma, although contrary studies have reported no significant benefit of early treatment.[19] If the permanent teeth become affected by trauma, prosthetic treatment (e.g., a bridge or denture) has the disadvantages of preparing adjacent healthy teeth, overburdening abutment teeth, problems with cleaning the pontic area, and aesthetic impairment of the denture. In recent years, long-term problems have been identified with widely-used dental implants[20–22] and autologous tooth transplantation. However, orthodontic space closure has the disadvantage of an extended treatment time but establishes an occlusion of natural teeth and provides long-term stability without periodontal issues.[2,3] In addition, orthodontic space closure in patients with congenitally-missing lateral incisors provides functionally stable results without aesthetic concerns.[23,24]

Implant-anchored orthodontics minimises the reaction of applied force and enables orthodontic tooth movement not possible via conventional orthodontic treatment mechanics (e.g., the active-reactive anchorage between dental units).[10] Moreover, a miniscrew enables orthodontic treatment, such as anterior and posterior tooth intrusion, distalisation of the entire dentition, and improvement in the deviation of the upper and lower dental midlines.[10] In the presented patient using miniscrews as anchorage, the space of the maxillary left central incisor was efficiently closed while maintaining co-incidence of the upper and lower dental midlines. Furthermore, the patient's chief complaints of protruding teeth and crowding of the mandibular anterior segment were improved by distalisation of the entire dentition, without extracting teeth. The intrusion of the mandibular first molars by 1.0 mm during distalisation caused a counterclockwise rotation of the mandible. The initial treatment plan was to maintain

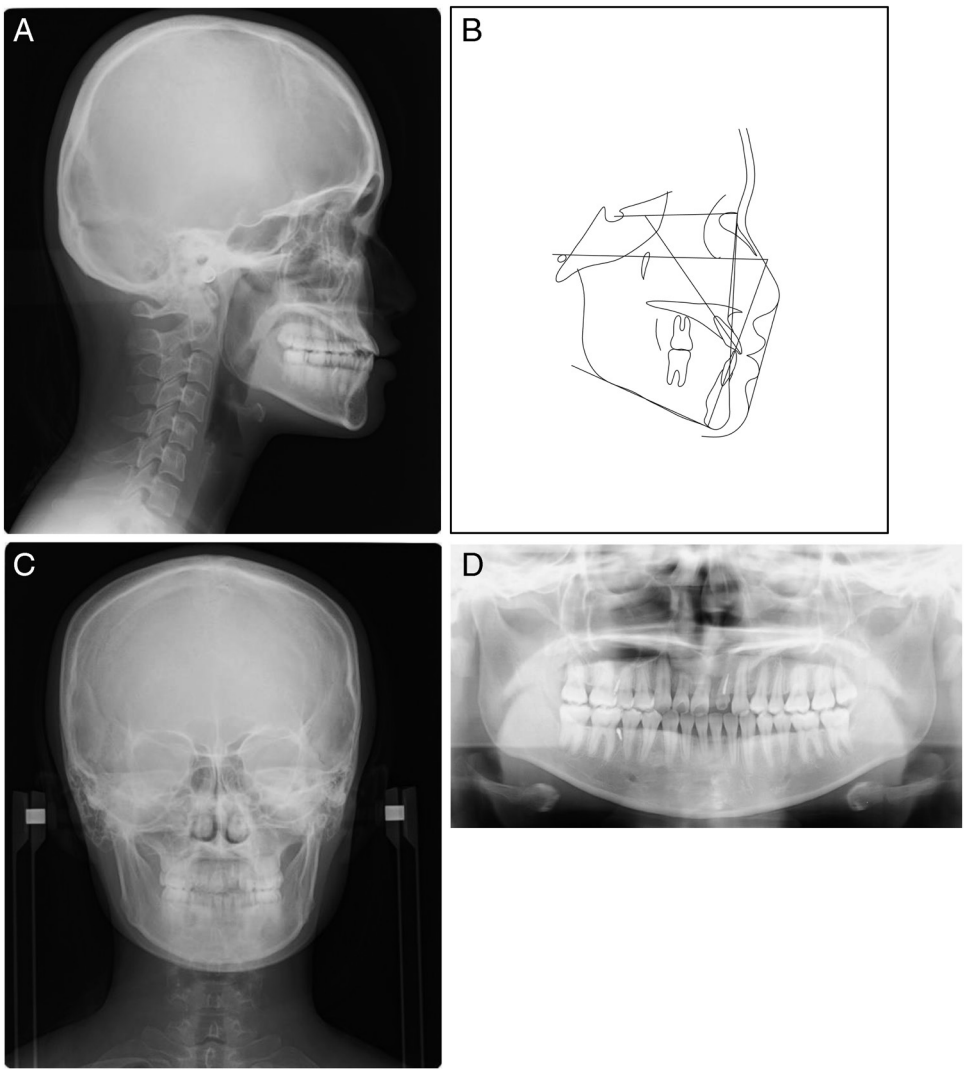


Figure 8. Posttreatment cephalograms, a tracing of lateral cephalogram and a panoramic radiograph. (A) Lateral cephalogram. (B) Tracing. (C) Posteroanterior cephalogram. (D) Panoramic radiograph.

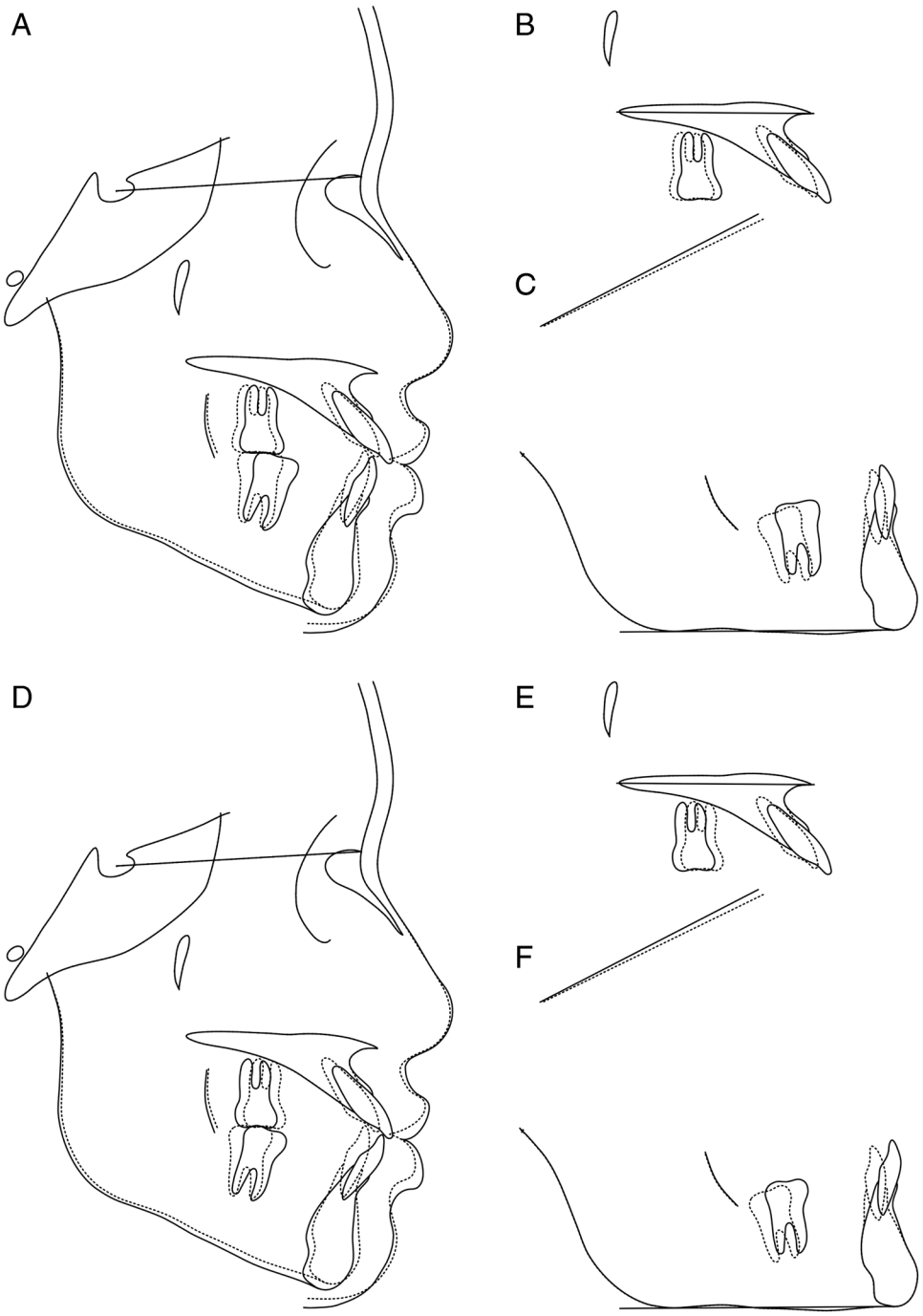


Figure 9. Superimposition of the cephalometric tracings obtained at pretreatment (solid line) and posttreatment (dotted line). (A, D) The sella-nasion plane at the sella. (B, E) The palatal plane at the ANS. (C, F) The mandibular plane at the menton. (A–C) The right incisors and molars. (D–F) The left incisors and molars.

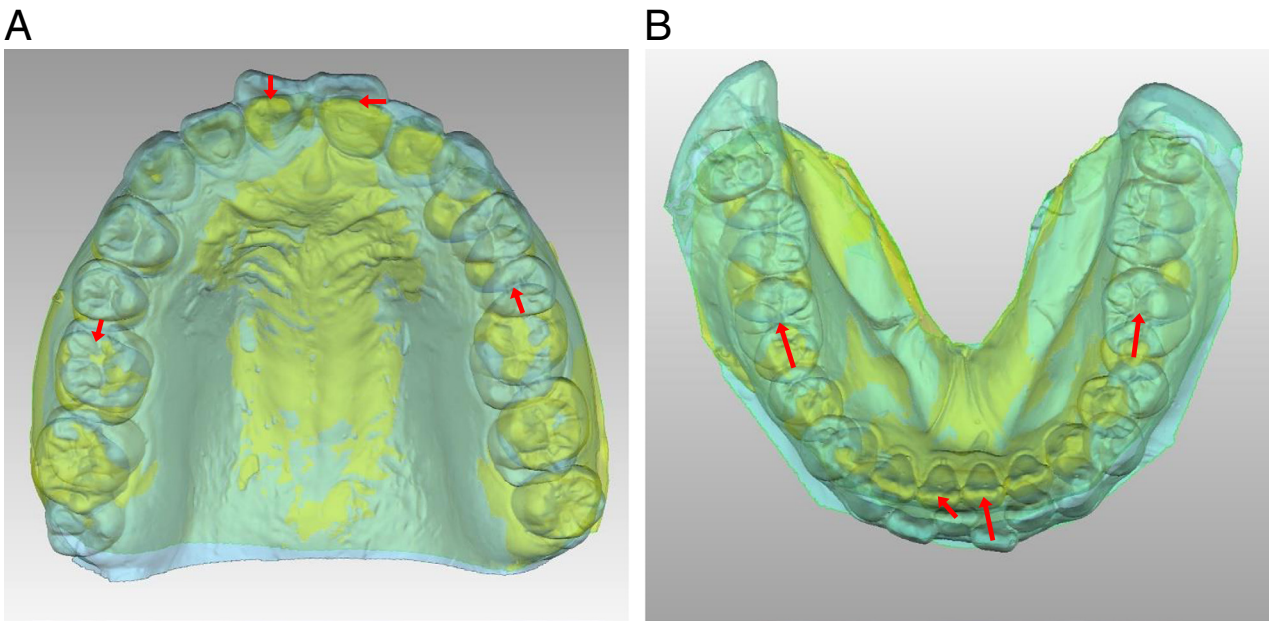


Figure 10. Superimposition of dental casts at pretreatment (light blue) and posttreatment (yellow-green) captured by a three-dimensional scanner. (A) The maxillary dental casts were superimposed at palate regions including the third palatal rugae.[13,14] (B) The mandibular dental casts were superimposed at the mandibular torus.[15] Red arrows indicate the movement of the upper and lower incisors and molars.

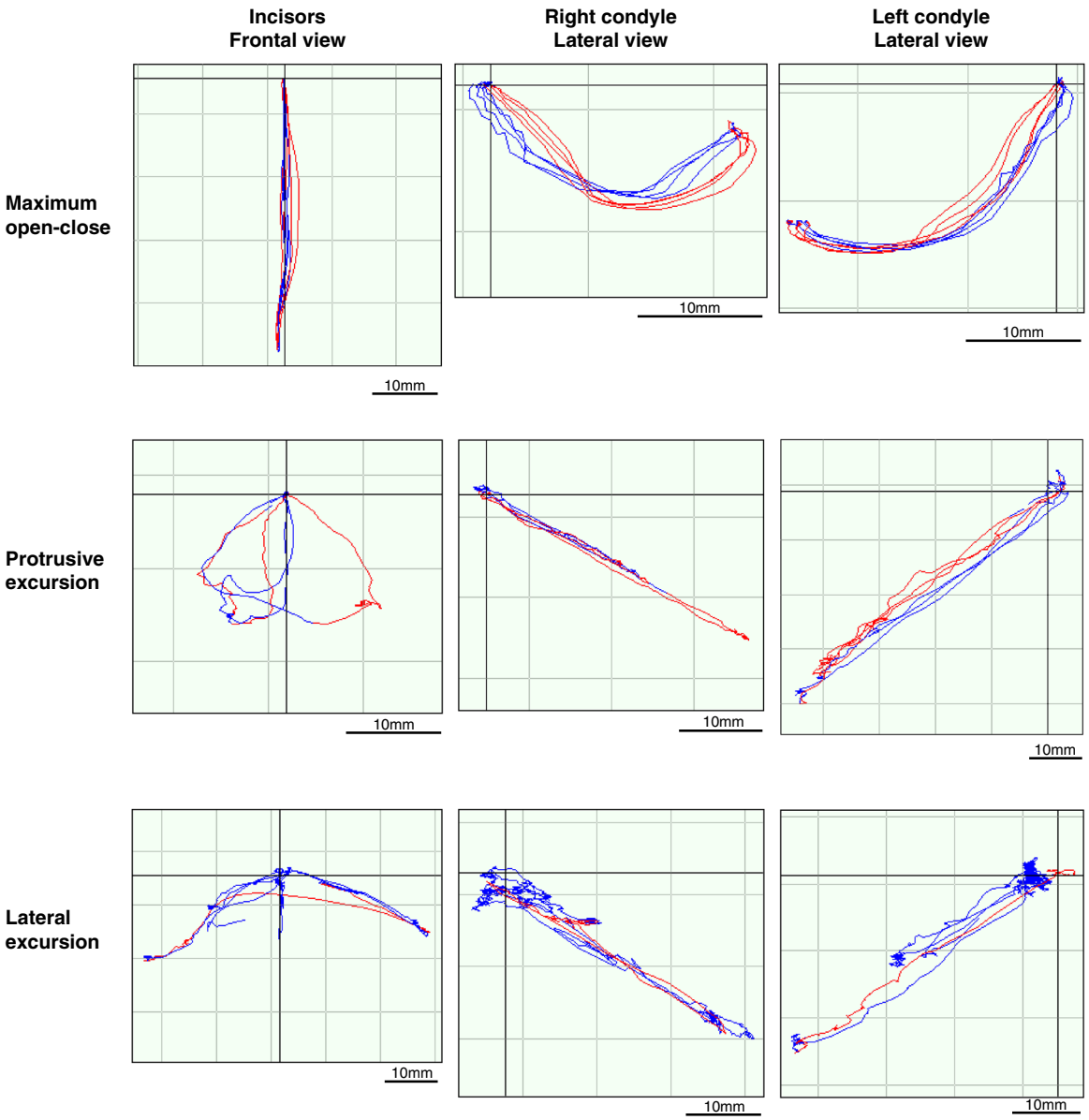


Figure 11. Posttreatment condylar movements and incisal paths as detected using a 6 degrees of freedom jaw movement recording system. Opening and closing, protrusive, and lateral jaw movements. The red line indicates the opening phase, and the blue line indicates the closing phase.



Figure 12. Postretention facial and intraoral photographs.

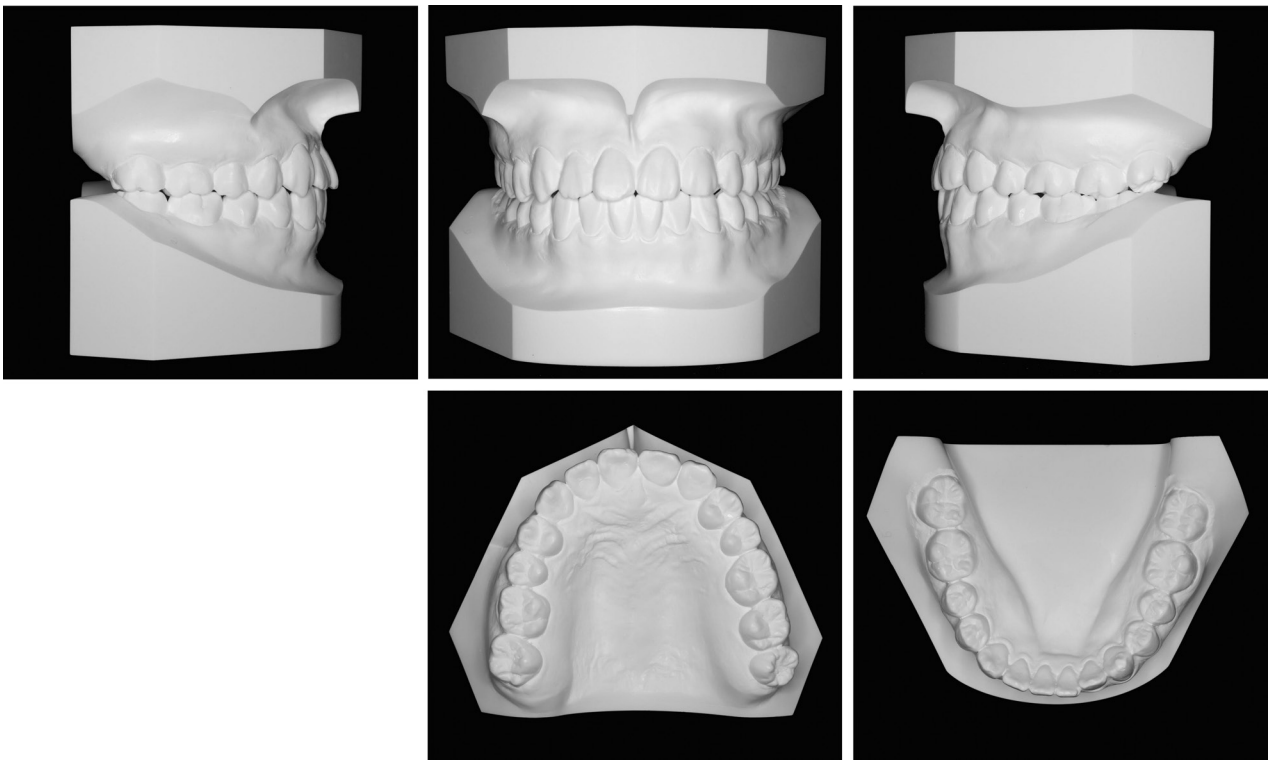


Figure 13. Postretention dental casts.

mandibular position, because the patient had a skeletal Class III jaw–base relationship. Maintenance of the vertical position of the maxillary incisors was planned because the maxillary incisal display on smiling was acceptable. However, treatment resulted in 1.5 mm intrusion of the maxillary incisors. Since the inferior edge of the upper lip rose by 1.0 mm after treatment, the decrease in the amount of maxillary incisal display on smiling was limited. During follow-up, changes in long-term retention and the counterclockwise rotation of the mandible, will need to be monitored.

While orthodontically closing the space of the avulsed maxillary central incisor, the lateral incisor was moved to the site of the central incisor and the canine substituted for the previous lateral incisor. Therefore, future attention should be paid to the aesthetic, morphological, and functional aspects related to the upper and lower tooth sizes which may be increased or decreased to harmonise the Bolton ratio. In addition, the gingival margins of the maxillary anterior teeth should be positioned appropriately and the teeth intruded or extruded to reflect the normal alignment of the gingival margins.[25–28] Torque control of the roots is also essential and often requires the canine root to be torqued palatally to reduce root prominence, whereas the first premolar root is likely torqued buccally to emphasise the canine prominence and prevent the lingual cusp from interfering during lateral jaw movements.[26] In addition, it is possible to recontour the maxillary lateral incisors and canines to optimise aesthetics.[26,28] These factors were considered during the treatment of the present patient, which contributed to the aesthetically, morphologically, and functionally sound occlusion.

Asymmetric jaw movement is a risk factor associated with TMJ dysfunction.[29,30] Therefore, it is important to evaluate the functional, along with the morphological changes, associated with orthodontic treatment. To the best of current knowledge, this is the first report of a quantitative evaluation of stomatognathic function before and after treatment resulting in an asymmetric molar relationship. Lateral jaw movement was guided by the maxillary first premolar occluding with the mandibular canine on the left side. In an evaluation of the pretreatment and postretention jaw movements, stable and symmetric

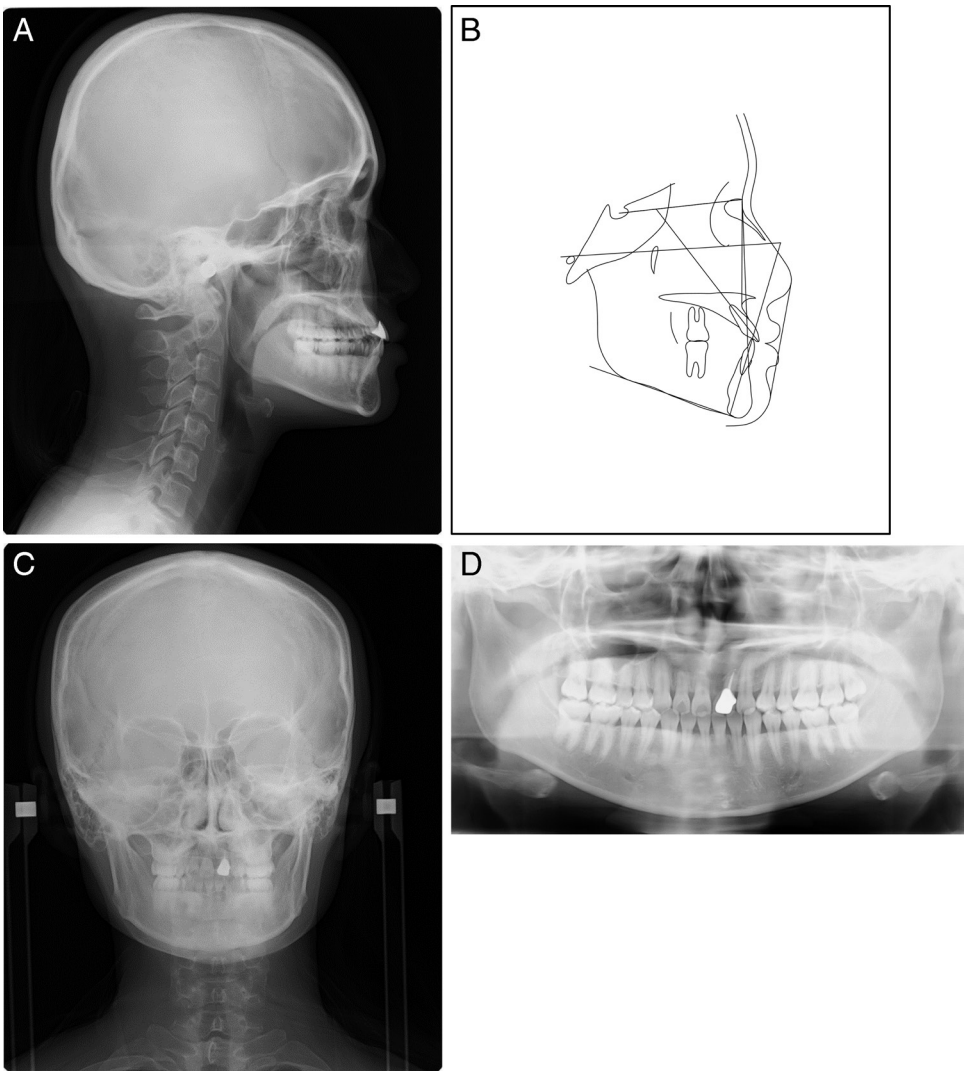


Figure 14. Postretention cephalograms, a tracing of lateral cephalogram and a panoramic radiograph. (A) Lateral cephalogram. (B) Tracing. (C) Posteroanterior cephalogram. (D) Panoramic radiograph.

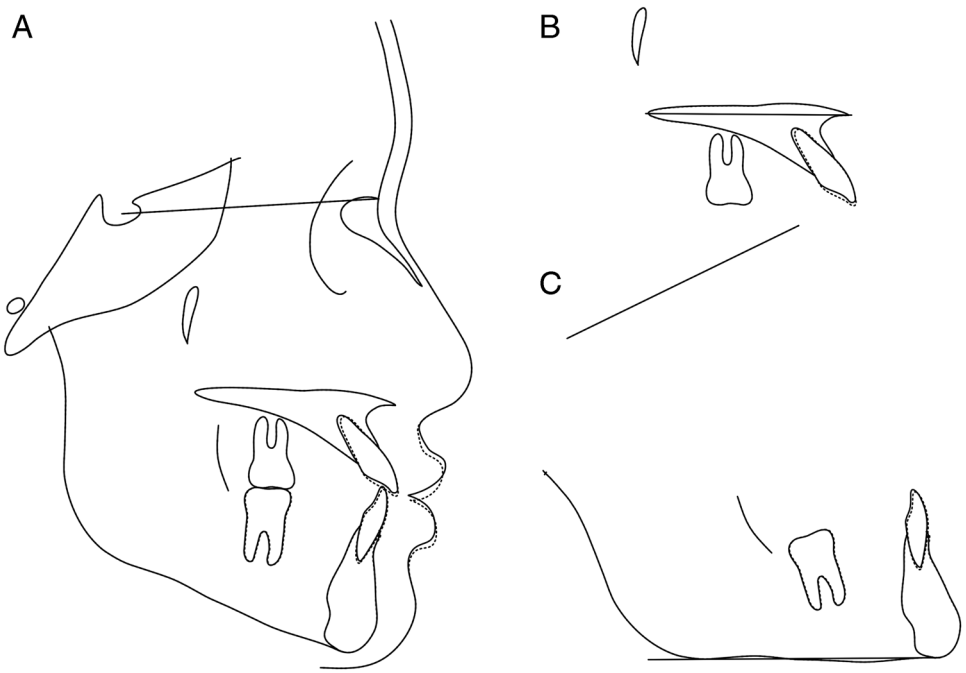


Figure 15. Superimposition of the cephalometric tracings obtained at posttreatment (solid line) and postretention (dotted line). (A) The sella-nasion plane at the sella. (B) The palatal plane at the ANS. (C) The mandibular plane at the menton.

incisal and condylar movements were noted during maximum mouth opening and closing, in addition to protrusive and lateral jaw movements. The occlusion remained stable and stomatognathic function was maintained up until 2 years after retention. It will be beneficial to review whether the sound occlusal relationship and stomatognathic function continue into the future.

Conclusions

A patient presenting with an Angle Class III malocclusion and traumatic loss of a maxillary central incisor was treated via a non-extraction approach involving space closure utilising miniscrew anchorage. The use of miniscrews is an efficient and valid treatment option for patients requiring asymmetric tooth movement.

Conflict of interest

The authors declare that there is no conflict of interest.

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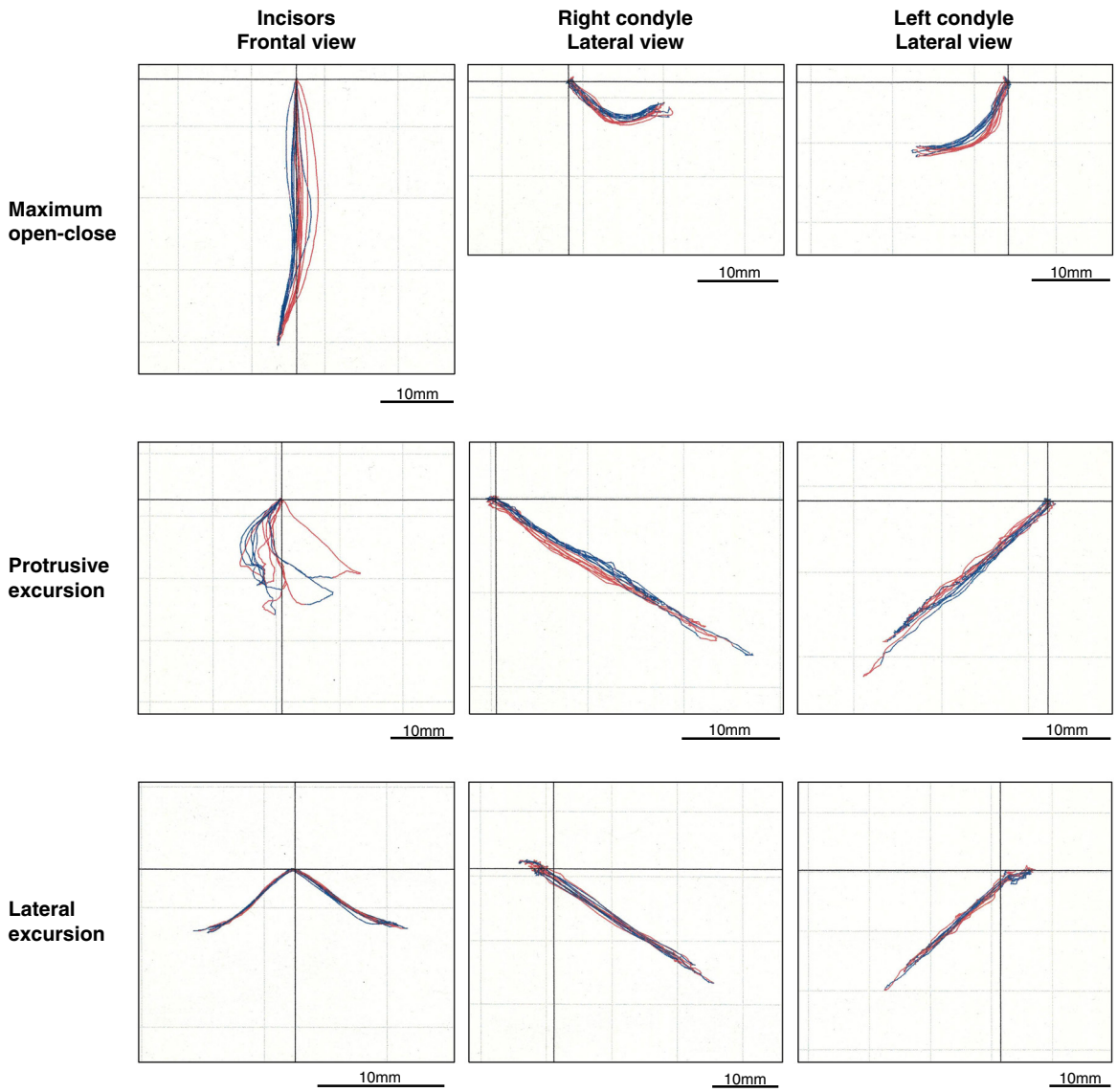


Figure 16. Postretention condylar movements and incisal paths as detected using a 6 degrees of freedom jaw movement recording system. Opening and closing, protrusive, and lateral jaw movements. The red line indicates the opening phase, and the blue line indicates the closing phase.

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